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The 19th International Conference on Industrial Engineering and Engineering Management

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ISBN 978-3-642-38390-8 ISBN 978-3-642-38391-5 (eBook)
DOI 10.1007/978-3-642-38391-5
Springer Heidelberg New York Dordrecht London

Library of Congress Control Number: 2013937993

Printed on acid-free paper

Springer is part of Springer Science+Business Media (www.springer.com)

Contents

Chapter 1
A Bayesian Learning Approach for Making Procurement Policies Under Price Uncertainty

Zhi-xue Xie and Li Zheng

Abstract In this paper we consider a procurement problem under purchase price uncertainty, which is the case encountered by companies who purchase from spot markets with fluctuating prices. We develop a procurement model by introducing the dynamics of information revelation via Bayesian learning, derive its optimal solution and identify some thresholds to improve purchase timing decisions. Using historical spot price data of crudes oils, we verify the effectiveness of proposed policies compared to the current policy of Chinese oil refineries, and find the Bayesian learning model does perform well—billions of dollars could be saved over the past several years.

Keywords Bayesian · Price uncertainty · Procurement management · Purchase timing

1.1 Introduction

Making procurement policies turns to be more and more challenging for manufacturers dealing with commodities with violent price fluctuations, such as agricultural products, precious metals, mineral and energy resources. The timing decision is a particularly hard choice for them; procurement made too early will cause unnecessary inventory holding costs and miss the opportunity to purchase at a possibly lower price in the future, while it made too late may squander the chance to purchase at an earlier cheaper price.

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E. Qi et al. (eds.), *The 19th International Conference on Industrial Engineering and Engineering Management*, DOI: 10.1007/978-3-642-38391-5_1,

This research is motivated by crude oil procurement decision-making problems faced by an oil refinery in China Petroleum & Chemical Corporation. Under current policy of importing crude oils from international market, the refinery is highly exposed to huge price risk, in that its orders are just evenly distributed along the planning horizons so the settlement prices are generally dependent on the spot prices during corresponding periods; it is actually playing as a speculator in the international crude oil market. Given the fact that crude oil procurement cost accounts for over 85 % of the overall costs of an oil refinery Jiang (2010); Yu and Fang (2005), obliviously this is not a pleasant situation.

Total cost of crude oil procurement consists of four components, the spot price of some marker crude, an adjustment factor, freight, and miscellaneous charges, but the contributions of the latter three are relatively small and less important compared to high and volatile crude spot prices (we will discuss about the freight issue a little more in the modeling part); hence it is reasonable for this research to focus on the oil price. There are two kinds of contracts in physical transactions, term contract and spot contract. The term contract in crude procurement practice, however, is quite different from commonly known long-term fixed-price contract in other supply chains; the unit price of purchased crude oil under a term contract is determined on the basis of spot prices in a certain period around its lifting time rather than settled at the time of ordering, the same as under a spot contract. Focused on the spot price issue, we do not distinguish between these two types of contracts hereafter.

Oil prices have historically tended to be notoriously difficult to predict, resulted from a combination of fundamentals and market behaviors, financial factors such as oil futures prices and exchange rates, as well as economic events, military affairs and politics. This complexity in price uncertainty, together with the fact crude oil is the most influential commodity, makes our study more significant. And this research, though aimed at Chinese refineries, provides potential benefits to worldwide manufactures in commodity industries that bear some resemblance with it.

The remainder of this paper is organized as follows. In Sect. 1.2, the relevant literature is reviewed. The procurement problem is modeled in Sect. 1.3, and the analytical solutions are provided. Next in Sect. 1.4, real-world data are used to test the effectiveness of proposed decision policies. Conclusions are given in Sect. 1.5 with some important directions for future research.

1.2 Literature Review

There are two lines of literature related to this research, procurement models under purchase price uncertainty, and operations management studies involving information updating.

1.2.1 Procurement Under Purchase Price Uncertainty

As many as procurement and inventory management researches in operations management and supply chain management literature, they generally assume constant or known purchase prices and work on fulfilling stochastic demands; studies on stochastic purchase price uncertainty are limited. Fabian et al. (1959) is probably the first inventory research that considers price uncertainty under stochastic demand and Golabi (1985) addresses a problem with random ordering prices and deterministic demands; but they both assume known and independent distribution function for future prices, which are not applicable to commodity prices. Kalymon (1971) studies an inventory model in which the purchase price follows a Markovian process, (Yi J, Scheller-Wolf A Dual sourcing from a regular supplier and a spot Market. unpublished) considers a multiple sourcing problem with a fixed-price supply mode and a stochastic price mode, and lately Berling and Martínez-de-Albéniz (2011) develops an effective procedure to characterize optimal base-stock levels based on earlier structural results. A work closely related to ours is Li and Kouvelis (1999) because we assume the same demands pattern and price processes as one of their cases does. However, former inventory control models all assume spot price value becomes known before ordering decision is made to obtain some price-dependent policies. Our study is unique in modeling the difference between spot price at the time of ordering and that at purchasing due to industrial practices, and we also incorporate information revelation dynamics within the procurement problem.

1.2.2 Information Update in Operations Management

Several authors have studied information acquisition and forecast updates in procurement problems. (Gaur V, Seshadri S, Subrahmanyam MG Optimal timing of inventory decisions with price uncertainty, unpublished) Considers an inventory timing decision with forecasts updating for correlated demand and selling price, but deterministic purchase cost. Gurnani and Tang (1999) proposes a two period procurement model for seasonal product with uncertain demand and purchase price, but only the demand is updated upon market signals between two selling instants. (Secomandi N, Kekre S Commodity procurement with demand forecast and forward price updates, unpublished) Derives the optimal procurement policy under correlated demand forecast and forward price updates in the presence of forward and spot markets. The existing literature generally focuses on the trade-off between more accurate forecasts on demand and (potentially) higher costs, while our problem is featured by deterministic demands and independent uncertain purchase prices.

Bayesian method is not popular in procurement models, but has been extensively used in inventory models [Scarf (1959); Karlin (1960); Azoury (1985)].

However, they are all about uncertain demands which distribution is periodically updated based on newly obtained demand observations. Inspiringly, Miller et al. (2005) incorporates Bayesian learning within a process design and capacity planning problem and identifies a threshold to improve decision-making; we adopt their framework and apply it to our procurement problem.

1.3 The Procurement Models

Consider an oil refinery faced with multiple dynamic but deterministic demands for crude oils, which must be met and will be purchased at spot prices, and amounts arrived before demanded trigger inventory holding costs. The assumption of known demands pattern is realistic in this problem based on three reasons. First, various kinds of oil products could serve several purposes such as generating power, providing energies to automobiles and airplanes, etc., consequently the overall oil demands arising from both life and industry do not fluctuate violently, especially compared with the volatility of crude oil price. Second, since there are industry regulations in Chinese oil markets to ensure relatively steady supply of oil products, major refineries usually report their production plans yearly to the administration and stick to them after being approved. Third, process industries such as oil refining, characterized by continuous production process that couldn't afford to be disturbed too much, generally operate according to the determined production plans out of economic considerations.

1.3.1 Basics of Cost Modeling

As researchers studying on the spot price of commodities did, we assume that the spot price of each unit (e.g., barrel) of the crude oil, S_t, follows a geometric Brownian motion with drift μ and volatility σ

$$dS_t/S_t = \mu \cdot dt + \sigma \cdot dW_t, \tag{1.1}$$

where W_t is a standard Weiner process. Note the point in time that matters is when payment is made, not when order is placed. The terms on valuation time periods are negotiable in practice, so for simplicity, the purchasing price is represented by the spot price at delivery in following derivations and by the average of spot prices during the lead time in empirical studies.

As inventory holding cost consists of cost of capital, cost of storage, insurance, breakage, and many other items, among which cost of capital is the most significant component, we assume the inventory holding cost (per unit per time) is charged at a fixed proportion, $0 < \theta < 1$, to the corresponding purchasing cost. That is,

$$h_t = \theta \cdot S_t. \tag{1.2}$$

In our problem, modeling in this way is more reasonable than commonly used stationary or independent setting, because the cost of capital is particularly high for the oil industry, which is capital-intensive.

What's more, it is realistic to assume a lead time, say, one period, i.e., the ordered quantity in current period will be delivered and paid in next period. Such a setting also emphasizes the difference between the spot price observed when the crude oils are ordered and the price to pay when they are received. Assume the time length of one period is Δt.

1.3.2 Purchasing Timing Problem

The refinery's decision is to determine when and how many units to purchase each time to minimize the total expected costs over the planning horizon, in other words, the refinery would behave risk-neutrally when making procurement decisions. Risk-aversion modeling can be found in Martínez-de-Albéniz and Simchi-Levi (2006), and it could be incorporated in the model by adjusting the drift term.

In this procurement problem, the refinery has a series of choices on ordering timings for each quantity demanded and every single period in the planning horizon is an option. Say there are n demands in the planning horizon, because supply lead times are fixed, order i will always be used to serve the ith demand, which arrival time and quantity are denoted by T_i and D_i. We want to find an optimal series of arrival times of each ordered quantity, denoting the ith order's delivery time as t_i (thus its ordering time is $t_i - \Delta t$), to obtain a minimization as

$$\min_{t_i} E\{\sum_{i=1}^{n} e^{-rt_i}[D_i \cdot S_{t_i} + D_i \cdot h_{t_i}(T_i - t_i)]\}, \tag{1.3}$$

where r is an appropriate discount rate. The procurement problem can be solved independently, as shown in Li and Kouvelis (1999) and Miller et al. (2005), for each demand as

$$\min_{t_i} E\{e^{-rt_i} D_i \cdot S_{t_i}[1 + \theta(T_i - t_i)]\}. \tag{1.4}$$

1.3.3 A Passive Decision Model

Let $F\,(t, S_t)$ be the minimum expected discounted total cost if the current time is t, the current unit price is S_t, and the firm has not made the purchase before. The Bellman equation is

$$F(t,S_t) = \min\left\{e^{-r(t+\Delta t)} \cdot D \cdot E[S_{t+\Delta t}|S_t] \cdot [1 + \theta \cdot (T - t - \Delta t)],\ E[F(t+\Delta t, S_{t+\Delta t})|S_t]\right\}, \quad (1.5)$$

where the first and second terms in braces on the right side of Eq. (1.5) are the "payoff" functions of termination and continuation, respectively. The objective function is F (0, S_0) where S_0 is the spot price of the material at time 0; the boundary condition is

$$F(T - \Delta t, S_{T-\Delta t}) = e^{-rT} \cdot D \cdot E[S_T|S_{T-\Delta t}]. \quad (1.6)$$

Now we are ready to derive the optimal timing decision, and a passive decision rule can be obtained as follows (we will come back to the meaning of "passive" later).

Property 1 *The optimal timing decision is to order at time 0 (to purchase at time Δt) if*

$$e^{(\mu-r)\,(T-\Delta t)} - \theta(T - \Delta t) - 1 > 0, \quad (1.7)$$

and to order at time $T-\Delta t$ (to purchase at time T) otherwise. Accordingly, the optimal value of objective function (minimum cost) can be derived in a straightforward way.

Note that the optimal purchasing decision for the stochastic case is the same as if the price volatility is zero, which makes sense since we are optimizing on the expectation level where the stochastic problem reduces to have the similar property as in the deterministic case. Also as interpreted by Li and Kouvelis (1999), because observing the price path of a geometric Brownian motion gives us no new information about the distribution of price changes of the material in the future, the optimal timing for the firm's purchase can be determined at time 0.

However, this "expected scenario" analysis makes an implicit assumption that the decision-maker acts passively following the decision made at the beginning of planning horizon, which can be problematic in the actual marketplace characterized by change and uncertainty, because the realization of spot prices will probably be quite different from what the decision-maker expected initially. Therefore, the passive decision models works well only when the price trend remains the same along the planning horizon, which situation is rare for crude oils in this decade.

Note the drift μ at time 0 is actually what we have estimated without any future spot prices; then a natural thought is, if some future price realizations suggest a change in price trend, we don't have to stick to the former decisions. Such flexibility of management serves as the central idea of real options literature. To address this passive management problem, we introduce Bayesian learning to actively make use of new information; that is the "active" decision model.

1.3.4 An Active Decision Model

Suppose we obtain at time 0 an estimate of future spot price that follows a log-normal distribution; its logarithm is normally distributed with an unknown mean $\tilde{\mu}$ and a known variance σ. We may regard $\tilde{\mu}$ as a random variable and learn more about it under Bayes rule. Presume the prior belief is normally distributed as N (μ_{00}, σ_{00}). Spot prices between period 0 and period 1 are observed as time evolves from 0 to Δt, denoted by s_{1k}. There could be more than one price realizations ($k > 1$) between consecutive decision points in time, because the spot price process evolves in a continuous pattern from which we can obtain several discrete realizations; for instance, we make ordering decisions per month while obtain price information per day. Then, as shown in, (Fink D A compendium of conjugate priors, unpublished) the posterior distribution of $\tilde{\mu}$ is also normal with mean and standard variance

$$\begin{gathered}\mu_{01} = \alpha_1 \mu_{00} + (1 - \alpha_1) s_1,\ \sigma_{01} = \sqrt{\alpha_1} \sigma_{00} \\ \alpha_1 = \sigma^2 \big/ (\sigma^2 + k\sigma_{00}^2),\end{gathered} \tag{1.8}$$

where s_1 is the mean statistic of logarithms of spot price data.

Now we are most concerned with whether there is any opportunity to improve the passive decision made at time 0 when additional information is gathered.

Property 2 *If the purchasing decision at time 0 is to order at time $T - \Delta t$, then at period 1 the threshold of the newly gathered information about price realizations that reverses the prior decision is*

$$s_1^* = \frac{r + \frac{\ln[\theta(T - 2\Delta t) + 1]}{T - 2\Delta t} - \frac{\sigma^2}{2} - \alpha_1 \mu_{00}}{1 - \alpha_1} \tag{1.9}$$

where $T - 2\Delta t > 0$. In other words, we should advance the ordering time to now as long as $s_1 > s_1^*$, and hold on to the prior decision otherwise.

If the prior decision remains unchanged at period 1, then after new information is obtained at later periods, similar procedure should be followed. And it is straightforward to extend Property 2 to later periods.

1.4 Case Applications

Now we apply the proposed models to the procurement problems faced by Chinese refineries, and the empirical studies are based on real-world data in crude oil spot market. The benchmark model is the current policies of Chinese refineries, under which the orders are almost evenly distributed along the planning horizons.

1.4.1 Data and Procedure

Our data set comes from public data source (Energy Information Administration) and consists of daily spot prices (USD per barrel) of WTI from 1986/1/2 to 2011/6/30 and those of Brent from 1988/1/4 to 2011/6/30. As for the quantity of crude oils China has imported from the international market, there are yearly volume data from 1994 to 2009, summing up to approximately 10.165 billion barrels.

We set half a month as the length of one period, which is also the length of lead time and decision making interval, and two months (four periods) as the length of one planning horizon. Taking case "demand for WTI at 2008/4/30" as an example, a typical data processing procedure is as follows:

(1) Set 2008/3/1 as time 0, 2008/4/30 as time T ($N = 4$), target demand to be served equals to 1; annualized risk-free rate equals to 3 %, which is approximately the one-year Treasury bond rate; annualized cost of capital as percentage to occupied capital equals to 36 %, which is relatively high because the oil industry is capital-intensive, as emphasized before.
(2) Use historical data, WTI's spot prices from 2008/1/1 to 2008/2/29, to estimate μ_{00} and σ at time 0; here we estimate from data of the past two months because we want to make decision for future two months. Make passive decision according to Property 1.
(3) For period 1 to $N-1$, if the order has not been placed before, consider spot prices data in each month as additional information; calculate parameters and statistics to make active decision according to Property 2.
(4) Use real-world price data to statistically assess the effectiveness of proposed decision models compared to the benchmark, in which the costs are calculated by taking average of the costs along the planning horizons.

1.4.2 Model Assessment

Faced with spot prices data from 1986/1988 to 2011 and volume data from 1994 to 2009, we perform rough yet reasonable calculations for the total costs by multiplying average unit purchase cost over 24/26 years by aggregate quantities of 16 years. We compare the proposed models to the current policy, and the results are summarized in Table 1.1.

Table 1.1 Effectiveness of proposed models

Marker crude	Total procurement costs[a]		
	Current policy	Passive model	Active model
WTI	369.36	370.59	364.74
Brent	374.94	377.49	371.97

[a] In billions of US dollars

Surprisingly, the passive model costs more than the current policy, perhaps because the oil price trend in the real world changes so frequently so it's no good for the refinery to act passively following the decision made at the beginning of planning horizon. However, the active model did save a lot of money for the refinery. Note all the numbers are in billions of US dollars; although they are not accurate, improvements are still considerable.

1.5 Conclusion

In this paper, we develop procurement policies, particularly for Chinese oil refineries, under purchase price uncertainty. Faced with difference between spot price at the time of ordering and that at purchasing, we formulate a procurement model and derive its optimal solution; but the model seems to be problematic when price trend changes. To address this weakness, we then incorporate Bayesian learning within the decision making process and identify a threshold of newly observed spot prices to improve the procurement timing decisions. Finally, we empirically validate the effectiveness of these proposed policies using public spot prices data for WTI from 1986 to 2011 and Brent from 1988 to 2011. Now we come to the conclusions that the order should be made at time 0 as suggested by the passive model only if the decision-maker has enough evidences to believe the oil price will increase at a relatively high rate throughout the planning horizon, otherwise the active model is worth trying, which is practically effective under not too long planning horizons.

The intrinsic logic of the Bayesian approach is that the thought process of judging oil prices to be high or low is a natural Bayesian process: when you see a realized price, you may think it as in high or low level and guess it will go up or down in the future; when the next period comes, you will see whether your judgment is right. If you have some opportunity to revise former decisions, the chance of your making good decisions would be bigger. This is the basic idea of the active model, and it indeed works well as proved by real data. However, our procurement model needs extensions to deal with some more issues. One significant direction of expending the current problem is to include an inventory capacity according to the actual constraint, then the model will be more applicable under longer planning horizons. Another direction is to address the problems of optimal hedging portfolio and its interaction with operations management, because financial hedging may be taken into consideration by Chinese oil companies in the future.

Acknowledgments This study is supported in part by the National Natural Science Foundation of China (Grant No. 70771058/60834004), and the 863 Program of China (2008AA04Z102).

The authors thank H. S. Deng, X. F. Li, A. B. Pang, and G. P. Xiao from the China Petroleum & Chemical Corporation for the detailed information on refinery procurement operations. The authors also thank Prof. C. S. Park from Auburn University for his patient instructions on Bayesian learning approach.

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Chapter 2
A Class of Robust Solution for Linear Bilevel Programming

Bo Liu, Bo Li and Yan Li

Abstract Under the way of the centralized decision-making, the linear bi-level programming (BLP) whose coefficients are supposed to be unknown but bounded in box disturbance set is studied. Accordingly, a class of robust solution for linear BLP is defined, and the original uncertain BLP was converted to the deterministic triple level programming, then a solving process is proposed for the robust solution. Finally, a numerical example is shown to demonstrate the effectiveness and feasibility of the algorithm.

Keywords Box disturbance · Linear bilevel programming · Robust optimization · Robust solution

2.1 Introduction

Bilevel programming (BLP) is the model with leader-follower hierarchical structure, which makes the parameter optimization problems as the constraints (Dempe 2002). In its decision framework, the upper level programming is connected with not only the decision variables in its level but also with the optimal solution in the lower level programming, while the optimal solution in the lower lever programming is affected by decision variables in the upper level

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E. Qi et al. (eds.), *The 19th International Conference on Industrial Engineering and Engineering Management*, DOI: 10.1007/978-3-642-38391-5_2,

programming. Due to the leader-follower hierarchical structure problems widely exist in the realistic decision-making environment, the scholars have been paying great attention to BLP and have brought about good results on the theory and algorithms (Bialas and Karwan 1982; Fortuny-Amat and McCarl 1981; Mathieu et al. 1994; Lai 1996). Some degree of uncertainty exists in realistic decision-making environment, such as the inevitable error of measuring instrument in data collection, incompleteness in data information, the approximate handle for the model and other factors; hence it is necessary to study on the uncertain Bilevel programming. For the uncertainty problem, the fuzzy optimization and stochastic optimization have been applied widely. However, it is difficult for decision-makers to give the precise distribution functions or membership functions which are required in above methods. Thus, the robust optimization become an important method, because it can seek for the best solution for the uncertain input without considering the parameter distribution of uncertain parameters and is immune from the uncertain data (Soyster 1973).

For the uncertain BLP, the definition of robust solution is influenced by the dependent degree of the upper and lower levels in the decision-making process. When the dependent degree is relative independence, the robust solution to the uncertain BLP is defined by the way of the decentralized decision-making (Li and Du 2011); when the dependent degree is relative dependence, the robust solution to the uncertain BLP is defined by the way of the centralized decision-making, that is, when the lower level seeks its own robust solution, it considers the influence to the robust solution of the upper level firstly. In the paper, the latter case will be discussed, and the coefficients of BLP are supposed to be unknown but bounded in box disturbance set. By the transform of the uncertain model, the robust solution of BLP is obtained. Finally, a numerical example is shown to demonstrate the effectiveness and feasibility of the algorithm.

2.2 The Definition of Robust BLP

2.2.1 The Model and the Definition

In this paper we consider Linear BLP formulated as follows:

$$
\begin{aligned}
&\min_x F(x,y) = c_1^T x + d_1^T y \\
&s.t.\ where\ y\ solves \\
&\quad \min_y f(x,y) = c_2^T x + d_2^T y \\
&s.t.\ Ax + By \geq h \\
&x, y \geq 0
\end{aligned}
\tag{2.1}
$$

In model (2.1),

$$x \in R^{m\times 1},\ y \in R^{n\times 1},\ c_l \in R^{m\times 1}, d_l \in R^{n\times 1},\ l \in \{1,2\},$$
$$A \in R^{r\times m},\ B \in R^{r\times n},\ h \in R^{r\times 1},$$

there is some uncertainty or variation in the parameters $c_1, d_1, c_2, d_2, A, B, h$. Let $(c_1, d_1, c_2, d_2, A, B, h) \in \mu$, μ is a given uncertainty set in Box disturbance as follows:

$$\mu := \left\{ (c_l, d_l, A, B, h) \left| \begin{array}{l} c_{li} = c^*_{li} + (u_{c_l})_i, -(u_{c_l})^*_i \le (u_{c_l})_i \le (u_{c_l})^*_i \\ d_{lj} = d^*_{lj} + (u_{d_l})_j, -(u_{d_l})^*_j \le (u_{d_l})_j \le (u_{d_l})^*_j \\ a_{ki} = a^*_{ki} + (u_A)_{ki}, -(u_A)^*_{ki} \le (u_A)_{ki} \le (u_A)^*_{ki} \\ b_{kj} = b^*_{kj} + (u_B)_{kj}, -(u_B)^*_{kj} \le (u_B)_{kj} \le (u_B)^*_{kj} \\ h_k = h^*_k + (u_h)_k, -(u_h)^*_k \le (u_h)_k \le (u_h)^*_k \\ l = \{1,2\}, \quad i \in \{1,\ldots,m\}, \\ j \in \{1,\ldots,n\}, \quad k = \{1,\ldots,r\}. \end{array} \right. \right\} \tag{2.2}$$

For $l = \{1,2\}, i \in \{1,\ldots,m\}, j \in \{1,\ldots,n\}, k = \{1,\ldots,r\}$, $c^*_{li}, d^*_{lj}, a^*_{ki}, d^*_{kj}, h^*_k$ are the given data, and $(u_{c_l})^*_i, (u_{d_l})^*_j, (u_A)^*_{ki}, (u_B)^*_{kj}, (u_h)^*_k$ are the given nonnegative data.

Under the way of the centralized decision-making, the robust solution of uncertain BLP (1) is defined as follows:

Definition 1

(1) Constraint region of the linear BLP (1):

$$\Omega = \{(x,y) | Ax + By \ge h, x, y \ge 0, (A,B,h) \in \mu\}$$

(2) Feasible set for the follower for each fixed x

$$\Omega(x) = \{y | Ax + By \ge h, x, y \ge 0, (A,B,h) \in \mu\}$$

(3) Follower's rational reaction set for each fixed x

$$M(x) = \left\{ y \left| y \in \arg\min \left\{ \begin{array}{l} c_2^T x + d_2^T y,\ y \in \Omega(x), \\ (A,B,h) \in \mu \end{array} \right\} \right. \right\}$$

(4) Inducible region:

$$IR = \{(x,y) | (x,y) \in \Omega, y \in M(x)\}.$$

Definition 2 Let

$$F := \left\{ (x, y, t) \in R^m \times R^n \times R \left| \begin{array}{r} c_1^T x + d_1^T y \leq t \\ (x, y), (c_1,\ d_1) \in \mu \end{array} \right. \right\}$$

The programming

$$\min_{x,y,t} \{ t | (x, y, t) \in F \} \tag{2.3}$$

is defined as robust counterpart of uncertain linear BLP(1); F is defined as the robust feasible set of uncertain linear BLP(1).

2.2.2 *The Transform of Uncertain BLP Model*

Under the way of the centralized decision-making, based on the original idea of robust optimization that the objective function can get the optimal solution even in the worst and uncertain situation, the transform theorem can be described as followings:

Theorem *The robust linear BLP* (1) *with its coefficients unknown but bounded in box disturbance set* μ *is equivalent to Model* (2.4) *with certain coefficients as followings:*

$$\begin{aligned}
&\min_x F(x, y) = \sum_{i=1}^{m} (c_{1i}^* + (\mu_{c_1})_i^*) x_i + \sum_{j=1}^{n} \left(d_{1j}^* + (\mu_{d_1})_j^* \right) y_j \\
&s.t. \text{ where } d_2 \text{ solves} \\
&\quad \max_{d_2} \sum_{i=1}^{m} (c_{1i}^* + (\mu_{c_1})_i^*) x_i + \sum_{j=1}^{n} \left(d_{1j}^* + (\mu_{d_1})_j^* \right) y_j \\
&\quad s.t.\, d_{2j}^* - (u_{d_2})_j^* \leq d_{2j} \leq d_{2j}^* + (u_{d_2})_j^*, \quad j = \{1, \ldots, n\}; \\
&\quad \text{where } y \text{ solves} \\
&\qquad \min_y f(x, y) = d_2^T y \\
&\quad s.t. \sum_{i=1}^{m} (a_{ki}^* - (\mu_A)_{ki}^*) x_i + \sum_{j=1}^{n} \left(b_{kj}^* - (\mu_B)_{kj}^* \right) y_j \geq h_k^* + (\mu_h)_k^*, \\
&\qquad k = \{1, \ldots, r\} \\
&\qquad x, y \geq 0.
\end{aligned} \tag{2.4}$$

Proof (1) Firstly, the constraint region Ω of the linear BLP (1) is transformed into the certain region. Consider the constraint region of the linear BLP (1):

$$\Omega = \{(x,y)|Ax + By \geq h, x, y \geq 0, \quad (A,B,h) \in \mu\}$$

According to the process of the transformation (Lobo et al. 1998), we can obtain

$$\begin{aligned}
& Ax + By \geq h, (A,B,h) \in \mu \\
& \Leftrightarrow 0 \leq \min_{\mu_A,\mu_B,\mu_h} \left\{ \sum_{i=1}^{m} a_{ki}x_i + \sum_{j=1}^{n} b_{kj}y_j - h_k \left| \begin{array}{l} a_{ki} = a^*_{ki} + (u_A)_{ki}, \\ -(u_A)^*_{ki} \leq (u_A)_{ki} \leq (u_A)^*_{ki}; \\ b_{kj} = b^*_{kj} + (u_B)_{kj}, \\ -(u_B)^*_{kj} \leq (u_B)_{kj} \leq (u_B)^*_{kj}; \\ h_k = h^*_k + (u_h)_k, \\ -(u_h)^*_k \leq (u_h)_k \leq (u_h)^*_k; \\ i \in \{1,\ldots,m\}, \quad j \in \{1,\ldots,n\}, \\ k \in \{1,\ldots,r\} \end{array} \right. \right\} \\
& \Leftrightarrow 0 \leq \sum_{i=1}^{m} a^*_{ki}x_i + \sum_{j=1}^{n} b^*_{kj}y_j - h^*_k \\
& \quad + \min_{\mu_A,\mu_B,\mu_h} \left\{ \sum_{i=1}^{m} (u_A)_{ki}x_i + \sum_{j=1}^{n} (u_B)_{kj}y_j - (u_h)_k \left| \begin{array}{l} -(u_A)^*_{ki} \leq (u_A)_{ki} \leq (u_A)^*_{ki} \\ -(u_B)^*_{kj} \leq (u_B)_{kj} \leq (u_B)^*_{kj} \\ -(u_h)^*_k \leq (u_h)_k \leq (u_h)^*_k \\ i \in \{1,\ldots,m\}, \quad j \in \{1,\ldots,n\}, \\ k \in \{1,\ldots,r\} \end{array} \right. \right\} \\
& \underset{\forall k \in \{1,\ldots,r\}}{\overset{x,y \geq 0}{\Leftrightarrow}} 0 \leq \sum_{i=1}^{m} \left(a^*_{ki} - (u_A)^*_{ki}\right)x_i + \sum_{j=1}^{n} \left(b^*_{kj} - (u_B)^*_{kj}\right)y_j - \left(h^*_k + (u_h)^*_k\right) \\
& \Leftrightarrow \sum_{i=1}^{m} \left(a^*_{ki} - (u_A)^*_{ki}\right)x_i + \sum_{j=1}^{n} \left(b^*_{kj} - (u_B)^*_{kj}\right)y_j \geq h^*_k + (u_h)^*_k, \quad k \in \{1,\ldots,r\}
\end{aligned} \tag{2.5}$$

So the linear BLP (1) is transformed into the model (2.6) as followings:

$$\begin{aligned}
&\min_{x} F(x,y) = c_1^T x + d_1^T y \\
&s.t.\, where\ y\ solves \\
&\min_{y} f(x,y) = c_2^T x + d_2^T y \\
&s.t. \sum_{i=1}^{m} \left(a_{ki}^* - (u_A)_{ki}^*\right)x_i + \sum_{j=1}^{n} \left(b_{kj}^* - (u_B)_{kj}^*\right)y_j \geq h_k^* + (u_h)_k^* \\
&k = \{1,\ldots,r\} \\
&x, y \geq 0
\end{aligned} \tag{2.6}$$

(2) Next, according the equivalent form (Lobo et al. 1998)

$$\begin{array}{c} \min_{x} f(x) \\ s.t.\, x \in D \end{array} \Leftrightarrow \begin{array}{c} \min_{x,t}\ t \\ s.t.\, f(x) \leq t \\ x \in D \end{array}$$

and the K-T method, the model (2.6) can be transform-ed into the model (2.7) (Li and Du 2011):

$$\begin{aligned}
&\min_{x,t} F(x,y) = \ t \\
&s.t.\, c_1^T x + d_1^T y \leq t \\
&where\ y\ solves \\
&\quad \min_{y}\ f(x,y) = c_2^T x + d_2^T y \\
&s.t.\ \sum_{i=1}^{m} \left(a_{ki}^* - (u_A)_{ki}^*\right)x_i + \sum_{j=1}^{n} \left(b_{kj}^* - (u_B)_{kj}^*\right)y_j \geq h_k^* + (u_h)_k^* \\
&\quad k = \{1,\ldots,r\} \\
&\quad x, y \geq 0
\end{aligned} \tag{2.7}$$

(3) Similar to the transformation (2.5),

$$c_1^T x + d_1^T y \leq t, (c_1, d_1) \in \mu \overset{x,y\geq 0}{\Leftrightarrow} \sum_{i=1}^{m} \left(c_{1i}^* + \left(\mu_{c_1}\right)_i^*\right)x_i + \sum_{j=1}^{n} \left(d_{1j}^* + \left(\mu_{d_1}\right)_j^*\right)y_j \leq t$$

So the model (2.7) can be transformed to the model (2.8) as follows:

$$
\begin{aligned}
&\min_{x,t} F(x,y) = \sum_{i=1}^{m} \left(c_{1i}^{*} + \left(\mu_{c_1}\right)_i^{*}\right)x_i + \sum_{j=1}^{n} \left(d_{1j}^{*} + \left(\mu_{d_1}\right)_j^{*}\right)y_j \\
&s.t.\, where\ y\ solves \\
&\quad \min_{y} f(x,y) = c_2^T x + d_2^T y \\
&s.t. \sum_{i=1}^{m} \left(a_{ki}^{*} - (u_A)_{ki}^{*}\right)x_i + \sum_{j=1}^{n} \left(b_{kj}^{*} - (u_B)_{kj}^{*}\right)y_j \geq h_k^{*} + (u_h)_k^{*}, \\
&\quad k \in \{1,\ldots,r\}; \\
&\quad x, y \geq 0
\end{aligned} \tag{2.8}
$$

(4) Next, because the optimal solution of BLP (1) is not influenced by the value of c_2, we only consider how to choose the value of d_2. Based on the original idea of robust optimization, the model (2.8) is transformed into the model (2.4) above.

2.3 Solving Process of the Model

The deterministic triple level programming (2.4) can be written as the following programming (2.9) by the K-T method.

$$
\begin{aligned}
&\min_{x} \max_{d_2,y,u,v} F(x,y) = \sum_{i=1}^{m} \left(c_{1i}^{*} + \left(\mu_{c_1}\right)_i^{*}\right)x_i + \sum_{j=1}^{n} \left(d_{1j}^{*} + \left(\mu_{d_1}\right)_j^{*}\right)y_j \\
&s.t.\, d_{2j} = \sum_{k=1}^{r} u_k \left(b_{kj}^{*} - (u_B)_{kj}^{*}\right) + v_j \\
&\quad d_{2j}^{*} - (u_{d_2})_j^{*} \leq d_{2j} \leq d_{2j}^{*} + (u_{d_2})_j^{*} \\
&\quad u_k \left[\sum_{i=j}^{m} \left(a_{kj}^{*} - (\mu_A)^{*}\right)x_i + \sum_{j=1}^{n} \left(b_{kj}^{*} - (\mu_B)_{kj}^{*}\right)y_j - \left(h_k^{*} + (\mu_h)_k^{*}\right)\right] = 0 \\
&\quad v_j y_j = 0 \\
&\quad \sum_{i=1}^{m} \left(a_{ki}^{*} - (\mu_A)_{ki}^{*}\right)x_i + \sum_{j=1}^{n} \left(b_{kj}^{*} - (\mu_B)_{kj}^{*}\right)y_j \geq h_k^{*} + (\mu_h)_k^{*}, \\
&\quad j = \{1,\ldots,n\}, k = \{1,\ldots,r\}; \\
&\quad x, y, u, v \geq 0.
\end{aligned} \tag{2.9}
$$

According to the literature (Wang 2010), the model (2.9) can be transformed into the model (2.10) as follows

$$\begin{aligned}
&\min_{x,d_2,y,u,v} \ t \\
&s.t. \sum_{i=1}^{m} \left(c_{1i}^* + \left(\mu_{c_1}\right)_i^*\right)x_i + \sum_{j=1}^{n} \left(d_{1j}^* + \left(\mu_{d_1}\right)_j^*\right)y_j \le t \\
&\quad d_{2j} = \sum_{k=1}^{r} u_k\left(b_{kj}^* - (u_B)_{kj}^*\right) + v_j, \\
&\quad d_{2j}^* - \left(u_{d_2}\right)_j^* \le d_{2j} \le d_{2j}^* + \left(u_{d_2}\right)_j^*, \\
&\quad u_k\left[\sum_{i=1}^{m} \left(a_{ki}^* - (\mu_A)_{ki}^*\right)x_i + \sum_{j=1}^{n} \left(b_{kj}^* - (\mu_B)_{kj}^*\right)y_j - \left(h_k^* + (\mu_h)_k^*\right)\right] = 0, \\
&\quad v_j y_j = 0, \\
&\quad \sum_{i=1}^{m} \left(a_{ki}^* - (\mu_A)_{ki}^*\right)x_i + \sum_{j=1}^{n} \left(b_{kj}^* - (\mu_B)_{kj}^*\right)y_j \ge h_k^* + (\mu_h)_k^*, \\
&\quad j = \{1,\ldots,n\}, k = \{1,\ldots,r\}, \\
&\quad x, y, u, v \ge 0.
\end{aligned} \tag{2.10}$$

By introducing a large constant M, the model (2.10) above can be transformed into a mixed integer programming as follows (Fortuny-Amat and McCarl 1981):

$$\begin{aligned}
&\min_{x,d_2,y,u,v,t,w} \ t \\
&s.t. \sum_{i=1}^{m} \left(c_{1i}^* + \left(\mu_{c_1}\right)_i^*\right)x_i + \sum_{j=1}^{n} \left(d_{1j}^* + \left(\mu_{d_1}\right)_j^*\right)y_j \le t \\
&\quad d_{2j} = \sum_{k=1}^{r} u_k\left(b_{kj}^* - (u_B)_{kj}^*\right) + v_j, \\
&\quad d_{2j}^* - \left(u_{d_2}\right)_j^* \le d_{2j} \le d_{2j}^* + \left(u_{d_2}\right)_j^*, \\
&\quad y_j \le M t_j, \\
&\quad v_j \le M\left(1 - t_j\right), \\
&\quad u_k \le M w_k, \\
&\quad \sum_{i=1}^{m} \left(a_{ki}^* - (\mu_A)_{ki}^*\right)x_i + \sum_{j=1}^{n} \left(b_{kj}^* - (\mu_B)_{kj}^*\right)y_j - \left(h_k^* + (\mu_h)_k^*\right) \le M(1 - w_k) \\
&\quad \sum_{i=1}^{m} \left[a_{ki}^* - (\mu_A)_{ki}^*\right] \cdot x_i + \sum_{j=1}^{n} \left[b_{kj}^* - (\mu_B)_{kj}^*\right] \cdot y_j \ge h_k^* + (\mu_h)_k^*, \\
&\quad j = \{1,\ldots,n\}, k = \{1,\ldots,r\}, t_j \in \{0,1\}, w_k \in \{0,1\}, \\
&\quad x, y, u, v \ge 0.
\end{aligned} \tag{2.11}$$

The model (2.11) can be solved by the software Lingo 9.0

2.4 A Numerical Example

We give a numerical example to demonstrate the proposed approach as follows:

$$
\begin{aligned}
&\min_x F = c_{11}x + d_{11}y_1 + d_{12}y_2\\
&s.t.\ 2.5 \le x \le 8\\
&\quad where\ y_1,\ y_2\ solve\\
&\quad \min_{y_1,y_2} f = d_{21}y_1 + d_{22}y_2\\
&\quad s.t.\ a_{11}x_1 + b_{11}y_1 + b_{12}y_2 \ge h_1\\
&\qquad a_{21}x_1 + b_{21}y_1 + b_{22}y_2 \ge h_2\\
&\qquad a_{31}x_1 + b_{31}y_1 + b_{32}y_2 \ge h_3\\
&\qquad a_{41}x_1 + b_{41}y_1 + b_{42}y_2 \ge h_4\\
&\qquad y_1 \ge 0,\\
&\qquad y_2 \ge 0
\end{aligned}
$$

where $a_{11} = 0,\ b_{21} = 1,\ a_{31} = 0,\ a_{41} = 0,\ b_{41} = 0,\ b_{42} = -1.$
And the others are the uncertain data, the given variables and disturbances are

$$c_{11}^* = 1.5,\ d_{11}^* = -1.5,\ d_{12}^* = -2,$$

$$d_{21}^* = 1.5,\ d_{22}^* = -3.5,$$

$$b_{11}^* = 1.75,\ b_{12}^* = -1.15,\ h_1^* = 2.5,$$

$$a_{21}^* = -3.5,\ b_{22}^* = -1.5,\ h_4 = 5.75.$$

$$h_2^* = -11, b_{31}^* = -3.5, b_{32}^* = -1.25, h_3^* = -23,$$

$$(u_{c_1})_1^* = 0.5, (u_{d_1})_1^* = 0.5, (u_{d_1})_2^* = 3, (u_{d_2})_1^* = 0.5, (u_{d_2})_2^* = 0.5,$$

$$(u_b)_{11}^* = 0.25, (u_b)_{12}^* = 0.15, (u_h)_1^* = 0.5,$$

$$(u_a)_{21}^* = 0.5, (u_b)_{22}^* = 0.5, (u_h)_2^* = 1,$$

$$(u_b)_{31}^* = 0.5, (u_b)_{32}^* = 0.25, (u_h)_3^* = 1, (u_h)_4^* = 0.25.$$

According to the theorem and these data above, robust model transformed is demonstrated as

$$
\begin{aligned}
&\min_{x,y,u,v,\eta,z} \; t \\
&s.t.\; 2x - y_1 + y_2 \le t \\
&\quad 2.5 \le x \le 8, \\
&\quad y_2 \le 5.5, \\
&\quad 1.5y_1 - 1.3y_2 \ge 3, \\
&\quad -4x + y_1 - 2y_2 \ge -10, \\
&\quad -4y_1 - 1.5y_2 \ge -22, \\
&\quad -1 \le 1.5u_1 + u_2 - 4u_3 + v_1 \le 2, \\
&\quad -4 \le -1.3u_1 - 2u_2 - 1.5u_3 - u_4 + v_2 \le -3, \\
&\quad y_1 \le M\eta_1, y_2 \le M\eta_2, \\
&\quad v_1 \le M(1-\eta_1),\; v_2 \le M(1-\eta_2), \\
&\quad u_k \le Mz_k, \quad k = 1,2,3,4. \\
&\quad 1.5y_1 - 1.3y_2 - 3 \le (1 - z_1), \\
&\quad -4x + y_1 - 2y_2 + 10 \le (1 - z_2),
\end{aligned}
$$

$$
\begin{aligned}
&-4y_1 - 1.5y_2 + 22 \le (1 - z_3), \\
&-y_2 + 5.5 \le (1 - z_4), \\
&x, y, u, v, \eta, z \ge 0, \\
&\eta_1, \eta_2 \in \{0.1\}, z_k \in \{0.1\}, \quad k = 1,2,3,4.
\end{aligned}
$$

By the software Lingo 9.0, the robust solution is obtained as follows:

$$(x, y_1, y_2) = (2.5201, 4.6443, 2.2819),$$

The robust optimal value is $F_{\min} = 2.6779$.

2.5 Conclusion and Future Work

Under the way of the centralized decision-making, a class of robust solution for uncertain linear BLP is defined, which expands further the application of BLP in different circumstances. And based on the original idea of robust optimization, the uncertain BLP was converted to the deterministic triple level programming. The solving process is proposed to obtain the robust solution of uncertain linear BLP. Finally, a numerical example is shown to demonstrate the effectiveness and feasibility of the algorithm.

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Chapter 3
A Comparison of the Modified Likelihood-Ratio-Test-Based Shewhart and EWMA Control Charts for Monitoring Binary Profiles

Chao Yin, Yihai He, Zhen Shen and Chun-hui Wu

Abstract Profile monitoring is used to check and evaluate the stability of the functional relationship between a response variable and one or more explanatory variables known as profile over time. Many studies assume that the response variable follows a continuous and normal distribution, while in fact it could be discrete, for example binary profiles. However, at present, there are few researches in this field. Based on an in-control binary dataset, this paper uses the logistic regression model to estimate the parameters in Phase I. And in Phase II, we apply bi-sectional search method to modifying the UCL's calculation of the likelihood-ratio-test-based Shewhart and EWMA control charts. Moreover, according to the estimated parameters, ARL's performances of the two modified control charts under different parameters' deviation are compared.

Keywords Binary profile · Logistic regression model · Bi-sectional search · ARL

3.1 Introduction

In many applications, the quality process is characterized and summarized by a functional relationship between a response variable and one or more explanatory variables, which is known as profile. Many studies have been done here, for example, according to the different types of profiles, Refs. Kim et al. (2003), Mahmoud and Woodall (2004), Zou et al. (2007) and Refs. Kazemzadeh et al. (2009), Amiri et al. (2009) respectively discussed the characteristics of linear profiles and polynomial profiles, nonlinear profiles' issues were talking about in Refs. Eric et al. (2009), Yu et al. (2006), Williams et al. (2007). However, in the

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E. Qi et al. (eds.), *The 19th International Conference on Industrial Engineering and Engineering Management*, DOI: 10.1007/978-3-642-38391-5_3,

aforementioned researches, they often assume the response variable follows a continuous distribution but not discrete, such as binary profiles. Meanwhile, there are some papers discussing the binary process in profile monitoring, Ref. (Yeh et al. 2009) proposed 5 T^2 based methods to monitor binary profiles in Phase I, Refs. Koosha and Amiri (2011a, b), Koosha and Amiri (2012) conducted researches on other Phase I issues among binary profiles, such as autocorrelation problems between profiles, effects of various types of profiles' link function and so on. However, they put more emphasis on Phase I analysis while few considerations were made for Phase II process. This paper compares the performances of two Phase II monitoring schemes based on the estimated parameters in Phase I. The rest of this paper is structured as follows: Sect. 3.2 introduces a method called logistic regression model, which is used to estimate parameters in Phase I. The parameters estimating process is achieved in Sect. 3.3 based on an in-control binary dataset. Sections 3.4 and 3.5 propose two Phase II monitoring modified schemes. Section 3.6 compares the performances of these two control charts according to estimated parameters in Sect. 3.3. Conclusion is explained in the last section.

3.2 Logistic Regression Model

Suppose there are n independent profiles, in each profile, m_i experiments will be conducted and the explanatory variable with p dimensions could be denoted by $X_i = \left(x_{i1}, x_{i2}, \ldots, x_{ip}\right)^T$, where $i = 1, 2, \ldots, n$ and $j = 1, 2, \ldots, p$, meanwhile, Y_i is the response variable following a Bernoulli distribution with a probability of success π_i. To describe the link function in binary profiles, the logistic regression model is applied:

$$\log \frac{\pi_i}{1 - \pi_i} = \beta_1 x_{i1} + \beta_2 x_{i2} + \ldots + \beta_p x_{ip} \tag{3.1}$$

where $\beta = (\beta_1, \beta_2, \ldots, \beta_p)^T$ is the model's parameter that needs to be estimated, normally, x_{i1} will be assumed to be 1 and β_1 serves as the intercept of the model. Yeh et al. (2009) applied a Maximum Likelihood Estimation (M.L.E.) method to estimate the parameters and got an updated estimate of β:

$$\hat{\beta} = (X^T \hat{W} X)^{-1} X^T \hat{W} q \tag{3.2}$$

where

$$\hat{W} = diag\{m_1 \hat{\pi}_1 (1 - \hat{\pi}_1), m_2 \hat{\pi}_2 (1 - \hat{\pi}_2), \ldots, m_n \hat{\pi}_n (1 - \hat{\pi}_n)\},$$
$$q = \hat{\eta}_i + (\hat{W})^{-1} (y - \hat{\mu}) = X \hat{\beta} + (\hat{W})^{-1} (y - \hat{\mu}), \text{ and}$$
$$\hat{\mu} = (m_1 \hat{\pi}_1, m_2 \hat{\pi}_2, \ldots, m_n \hat{\pi}_n)^T.$$

Still, an iterative algorithm was used here to obtain a more accurate value of β according to (Yeh et al. 2009), steps were as listed below.

(1) Initialize the estimate of $\beta = \hat{\beta}^0$, and $\hat{\beta}^0$ can be acquired by the ordinary least squares (O.L.S.) estimation. Set i = 0;

(2) According to $\hat{\beta}^i$, calculate $\hat{\eta}^i$, $\hat{\pi}^i$, $\hat{\mu}^i$, $\hat{W}^i$;

(3) Calculate $\hat{q}^i = \hat{\eta}^i + (\hat{W}^i)^{-1}(y - \hat{\mu}^i)$;

(4) Update the estimate of β by calculating $\hat{\beta}^{(i+1)} = (X^T \hat{W}^i X)^{-1} X^T \hat{W}^i \hat{q}^i$, and set i = i + 1;

(5) Repeat steps (3.2) through (3.4) for l times, until $\left\| \hat{\beta}^l - \hat{\beta}^{l-1} \right\| / \left\| \hat{\beta}^{l-1} \right\| \le \alpha$, where is the Euclidean norm and α is a sufficiently small constant (α is equal to 10^{-5} here). Then $\hat{\beta} = \hat{\beta}^l$ is the desired estimator of β.

3.3 Parameters Estimation

We use an in-control dataset to complete the parameters estimation process. In this case, 10 independent binary profiles are generated and the number of observations in each level of the explanatory variable is set as 120, the values of x ranges from 2500, 2700, 2900,…, 4300. To describe the functional relationship between the explanatory and response variable, the first-order model is set as:

$$\log(\pi/[1 - \pi]) = \beta_0 + \beta_1 \log(x) \tag{3.3}$$

where π is the probability of success in the binary process, and $\beta = (\beta_0, \beta_1)^T$ is the parameters that needs to be estimated. According to the methods displayed previously, we use Matlab 7.1.0.246 to finish the calculations and the result of the O.L.S. initialization of β is valued as:

$$\hat{\beta}^0 = (-42.0575, 5.1709)^{\mathrm{T}} \tag{3.4}$$

and Fig. 3.1 as listed below is showing that the effect of the estimation is fitting well.

After the calculation of the iterative algorithm running in Matlab, the final result could be obtained:

$$\hat{\beta} = \hat{\beta}^l = (-42.0537, 5.1704)^T \tag{3.5}$$

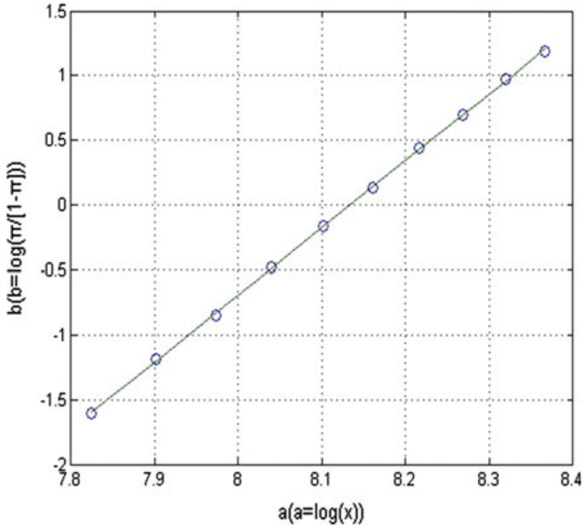

Fig. 3.1 Performance of the ordinary least squares estimation

and $a = 8.0889 \times 10^{-9} << 10^{-5}$.

In the end, we need to judge whether the binary dataset satisfies the second-order model or not, thus $\log(\pi/[1-\pi]) = \beta_0 + \beta_1 \log(x) + \beta_2(\log(x))^2$. The deviance statistic turns out to be :

$$2.7954 \times 10^{-9} << \chi^2_{1,0.05} = 3.841$$

which shows the second-order model is not fit to apply for the binary dataset and the first-order model we set here is suitable.

3.4 Phase II Likelihood Ratio Test for Binary Profiles

The binary profiles' functional relationship between x and Y can be concluded as $\log\frac{\pi}{1-\pi} = \beta_1 + \sum_{j=2}^{p} \beta_j x_j, j = 1, 2, \cdots, p$. Zhou (2008) proposed a likelihood ratio test method to evaluate the model parameters β in Phase II, and the likelihood ratio test statistic λ will be applied in the control charts process we discussed.

$$\mathrm{H}_0 : \mathrm{Y} \sim \mathrm{Bernoulli}(\pi(\mathrm{x})) \qquad \mathrm{H}_1 : \mathrm{Y} \sim \mathrm{Bernoulli}(\pi^*(\mathrm{x})) \tag{3.6}$$

Where $\pi(\mathrm{x}) = \frac{\exp\left(\beta_1 + \sum_{j=2}^{p} \beta_j x_j\right)}{1+\exp\left(\beta_1 + \sum_{j=2}^{p} \beta_j x_j\right)}$

and $\pi^*(\mathrm{x}) = \frac{\exp\left(\beta_1^* + \sum_{j=2}^{p} \beta_2^* x_2\right)}{1+\exp\left(\beta_1^* + \sum_{j=2}^{p} \beta_2^* x_2\right)}$.

After the calculation process explained in Zhu (2008), the likelihood ratio test statistic can be defined as:

$$\lambda = \ell_{H_1} - \ell_{H_0} \tag{3.7}$$

where ℓ_{H_1} and ℓ_{H_0} are the log-likelihoods, and λ will be compared with a critical value that is determined by a pre-defined type-I error rate a, if λ is greater than the critical value, then it means at least one parameter has a shift.

3.5 The Modified Control Charts

Zhou and Lin (2010) proposed a Shewhart-type LRT-based control chart to monitor the generalized linear profiles; we can call it Shewhart.LRT control chart. During its process, 2λ will have a distribution of χ^2 with k degrees of freedom under H_0, k is the total number of parameters in the profile function model. To monitor binary dataset, the LCL will be set as 0, and because of the binary distribution increasing the complexity of calculating the UCL of Shewhart.LRT control chart, a modification applying the bi-sectional search method can be made to calculate it.

(1) Based on the pre-defined type-I error rate a, set the needed in-control average run length (ARL). Then select a temporary value for the lower and upper limit of UCL_l and UCL_u, calculate the corresponding ARL_l and ARL_u respectively, and it needs to satisfy the condition that $ARL_l < ARL_{IC} < ARL_u$.
(2) Let $UCL_{temp} = \frac{UCL_l + UCL_u}{2}$, calculate ARL_{temp}. And if $ARL_{temp} > ARL_{IC}$, set $UCL_u = UCL_{temp}$ and $ARL_u = ARL_{temp}$. Otherwise set $UCL_l = UCL_{temp}$.
(3) If the absolute value of "ARL_u-ARL_l" is less than a pre-defined threshold, here the value is settled as 1, then the desired $UCL = \frac{UCL_l + UCL_u}{2}$, otherwise go back to step (2).

Yeh et al. (2004) proposed a likelihood-ratio-based EWMA control chart to monitor multivariate normal processes, also, we can call it EWMA.LRT control chart. To monitor binary dataset, the EWMA statistic can be defined as:

$$EWMA_i = \theta * 2\lambda_i + (1 - \theta)\, EWMA_{i-1} \tag{3.8}$$

where θ is the smoothing constant, and $EWMA_0$ is set as k. Similarly, LCL is assumed as 0, for the UCL of EWMA.LRT modification control chart, also apply the bi-sectional search method to calculate it.

3.6 Performances of the Modified Control Charts in Phase II

In Phase I, the fitted logistic regression model has been set: $\log(\pi/[1-\pi]) = \beta_0 + \beta_1 \log(x)$, and the obtained parameters is valued as: $\overset{\wedge}{\beta} = (\beta_0, \beta_1)^T = (-42.0537, 5.1704)^T$.

In Phase II, we generate deviations on parameters β_0 and β_1 to evaluate the ARL's performances of the modified Shewhart.LRT and EWMA.LRT control charts and to investigate which parameter is more sensitive under given deviations. The pre-defined Type I error rate (a) is set as 0.005 which will yield an in control ARL as 200, and for EWMA.LRT control chart, the smoothing constant θ is assumed as 0.2. Results of ARL's values of two modification control charts are both based on 10,000 Monte-Carlo simulations, results are as shown below in Table 3.1.

In Table 3.1, we define that ARL_1 and ARL_2 separately represent the ARL's values of Shewhart.LRT and EWMA.LRT control charts, and we can see that with the parameters' deviation becoming larger, the ARL's result of the modified control charts are getting more and more smaller, and the ARL's results of EWMA.LRT control chart are smaller than Shewhart.LRT control chart under the same level of parameter's deviation, which shows that it has a better performance than Shewhart.LRT control chart to monitor the binary process here.

Meanwhile, between the parameters β_0 andβ_1, β_1 is more sensitive than β_0 when a deviation happens, which can be seen obviously from the ARL's result. Table 3.1 only shows the performance of the increasing shift of deviation parameters; moreover, similar results happen in the decreasing shift of deviation parameters which is not shown here.

Table 3.1 Arl's performance of the modified control charts under parameters' deviation

$\Delta\beta_0$	ARL_1	ARL_2	$\Delta\beta_1$	ARL_1	ARL_2
0	201.443	200.632	0	202.206	20.468
0.002	173.541	152.457	0.002	93.632	80.653
0.006	149.675	107.453	0.006	27.184	24.339
0.01	115.058	84.445	0.01	9.547	6.542
0.014	98.246	65.994	0.014	4.429	3.875
0.018	82.882	41.123	0.018	2.460	2.087
0.022	70.253	33.682	0.022	1.650	1.456
0.026	60.620	22.546	0.026	1.278	0.897
0.03	52.553	18.578	0.03	1.095	0.786
0.034	45.207	12.125	0.034	1.043	0.743
0.038	38.162	11.557	0.038	1.001	0.725
0.042	35.511	8.546	0.042	1.002	0.708
0.046	29.484	6.078	0.046	1.000	0.704
0.05	25.953	5.271	0.05	0.998	0.698

3.7 Conclusion

In this paper, the ARL's performances of the modified Shewhart.LRT and EWMA.LRT control charts are compared, and the result shows that the latter scheme has a better effect on monitoring the binary process and parameter β_1 is more sensitive than β_0 when a deviation happens according to the estimated parameters. The further researches could be focused on proposing new methods to estimate the parameters in Phase I and apply other types of control charts to monitor Phase II process in binary profiles.

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Chapter 4
A Decision-Making Model of Price Control for Administering Authority

Chong-yi Jing

Abstract There are few quantitative studies on decision making of air ticket price control problem. In this paper we establish a game decision making model of price control for government by introducing two new factors: consumer's surplus (the public welfares) and the passenger load rate (LR). We get some interesting conclusions from modeling and discussion. The administering authority, CAAC (Civil Aviation Administration of China) is inclined to ignore the public welfares when setting a higher control price and the airlines are always inclined to disobey the control price of CAAC for achieving a higher passenger load rate and strengthening the competition edge. As a whole, the optimal strategy of CAAC is to set an inter-zone control price and the optimal strategy of airlines is to self determinate a price between the inter-zone prices. The reason of decision dissonance is that the cost evaluation of ticket pricing for the two players has tremendous difference.

Keywords Air ticket · Decision making · Game theory · Price control

4.1 Introduction

There are many studies on air ticket control, which are almost limited to qualitative analysis. Some use natural monopoly theory (Zhang 2005; Liu 2006) and some use welfare economics Liu (2002) to analyze the problem, and the result is almost similar that the government should release control to air ticket price and be unnecessary to intervene in operation or management of airlines (Liu 2002). Li and Deng (2003), Min and Yang (2003) conclude that the civil aviation of China has many pertinacious problems such as ticket price simplification, cut-throat

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E. Qi et al. (eds.), *The 19th International Conference on Industrial Engineering and Engineering Management*, DOI: 10.1007/978-3-642-38391-5_4,

competition and so on basing on an economics point of view, and analyze the reasons from all conceivable angles Li and Deng (2003), Min and Yang (2003). And there are also some studies using game theory to analyze the price control of CAAC to airlines (Mei et al. 2006; Yang and Zhang 2002), and the conclusions are that the control could cause lose of society welfare and ticket pricing should be marketization (Mei et al. 2006; Yang and Zhang 2002). Another train of thought is to advocate control, Zipping (Kang and Du 2006) approve of moderate control (Kang and Du 2006), Qiu (2001) points out that releasing control should be implemented gradually through comparing civil aviation development course of China with that of USA (Qiu 2001). Han (2000) indicates that the government should take some long-term measures to manage the special industry (Han 2000).

In a word, there're few quantitative studies on the problem and even in some quantitative literatures there are also some advancements to deserve promoting, for example, CAAC just emphasizes the economic revenue maximization (Mei et al. 2006; Yang and Zhang 2002). However, CAAC, as a government department, has a very important society function, which is protecting social welfare from being damaged. On the other hand, it is probably not appropriate to suppose that the airlines in China get into price war just for achieving economic profit maximization. The airlines may attach much more importance to increasing passenger load factor, market share, and strengthening their competitive edge. In reality, both CAAC and airlines might fall into prisoner's dilemma easily, and it's very difficult to get away the vicious circle (Wang 2004; Yang 2002). For these problems, we introduce consumer's surplus factor and passenger load rate factor into our game model to establish a ticket price control model for government.

4.2 Modeling

4.2.1 Hypothesis for Modeling

Hypothesis1: the game process is repetitive and limited, and the information for each other is imperfect. (For example, cost, intension and so on).

Hypothesis2: the CAAC and airlines in China have some common interests and close relations although the former is supervisor of the industry (for example, at aspects of finance and political achievements).

Hypothesis3: at present in China, the general ticket demand is price inelastic.

4.2.2 Construct Price Control Model

As one player of the game, CAAC has two pure strategies: one is "Consider the public welfare" (hereinafter called "Consider"), the lower price is p_1 and the

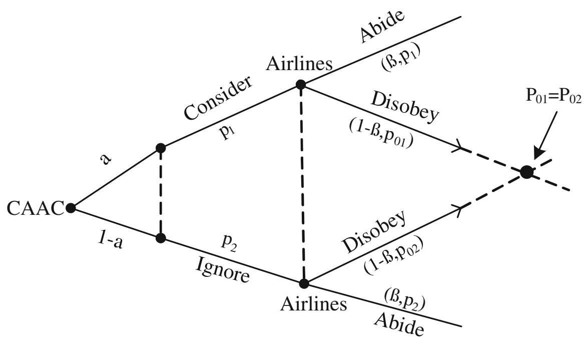

Fig. 4.1 Extensive game between CAAC and airlines

probability is α; another strategy is "Ignore the public welfare" (hereinafter called "Ignore"), the higher price is $p_2(p_2 > p_1)$, and the probability is $1 - \alpha$. Airlines as another player of the game also have two pure strategies: one is "Abide the price control" (hereinafter called "Abide"), the price is p_1 and the probability is β; another strategy is "Disobey the price control" (hereinafter called "Disobey"), the price they set will be $p_{0i}(i = 1, 2)$ that means the self-determinate price of airlines on condition that the control price is $p_i(i = 1, 2)$, and the probability is $1 - \beta$. Figure 4.1 shows the players' game decision tree with imperfect information, which means airlines could not distinguish whether the control price contains the public welfare or not, and CAAC also could not identify airlines' cost information and competition intention easily (shown as the broken line in Fig. 4.1).

The following is other some denotations used herein below.

- TS Social welfare equals to sum of CS and $ES.TS = CS + ES$
- CS Public welfare, also called customers' surplus
- ES Enterprise welfare, also called enterprise surplus
- $f(p)$ Inverse demand function when the price is P, meanwhile, the equilibrium demand can be defined as $\mathrm{d}(p)^{\mathrm{k}}$, here d denotes conversion operator, k denotes price elasticity (absolute value)
- $LR(p)$ Load rate of airlines when the ticket price is p, it's decreasing function of price p. It is supposed to be reasonable that airlines increase the passenger load rate and strengthen competitive edge by cutting down price
- TCL Transportation Capacity Limitation of airlines in a given period, it keeps stable during a determinate period of time and irrelevant with price
- c_1 The unit cost of airlines estimated by CAAC
- c_2 The unit cost of airlines estimated by airlines themselves

Figure 4.2 is payoff matrix of the two players. We define their payoff functions as bellows:

$\pi_{CAAC}(CA)$: The payoff of CAAC when CAAC considers the public welfare and airlines abide the price control. Essentially, the payoff equals to TS, which should contain CS and ES. And $CS = \int_0^{d(p_1)^k} f(p)dp$, here d denotes derivative symbol, $ES = (p_1 - c_1) \cdot d(p_1)^k$, so the payoff of CAAC is

CAAC \ airlines	Abide		Disobey	
Consider	$\pi_{CAAC}(CA)$	$\pi_{ailines}(CA)$	$\pi_{CAAC}(CD)$	$\pi_{ailines}(CD)$
Ignore	$\pi_{CAAC}(IA)$	$\pi_{ailines}(IA)$	$\pi_{CAAC}(ID)$	$\pi_{ailines}(ID)$

Fig. 4.2 Payoff matrix of game players

$$\pi_{CAAC}(CA) = \int_0^{d(p_1)^k} f(p)dp + (p_1 - c_1) \cdot d(p_1)^k$$

$\pi_{airlines}(CA)$: The payoff of airlines when airlines abide the price control and CAAC considers the public welfare. Under the circumstances, the payoff of airlines is.

$$\pi_{airlines}(CA) = (p_1 - c_2) \cdot d(p_1)^k$$

$\pi_{CAAC}(CD)$: The payoff of CAAC when CAAC considers the public welfare and airlines disobey the price control. p_{01} is self-determinate price of airlines on condition that the control price of CAAC is p_1. Like $\pi_{CAAC}(CA)$, the payoff equals to *TS*, which should contain *CS* and *ES*. So

$$\pi_{CAAC}(CD) = \int_0^{d(p_{01})^k} f(p)dp + (p_{01} - c_1) \cdot d(p_{01})^k$$

$\pi_{airlines}(CD)$: The payoff of airlines when airlines disobey the price control and CAAC considers the public welfare. The payoff of airlines is

$$\pi_{airlines}(CD) = (p_{01} - c_2) \cdot LR(p_{01}) \cdot TCL$$

$\pi_{CAAC}(IA)$: The payoff of CAAC when CAAC ignores the public welfare and airlines abide the price control. Then the payoff just contains *ES*, so

$$\pi_{CAAC}(IA) = (p_2 - c_1) \cdot d(p_2)^k$$

$\pi_{airlines}(IA)$: The payoff of airlines when airlines abide the price control and CAAC ignores the public welfare. The payoff of airlines is

$$\pi_{airlines}(IA) = (p_2 - c_2) \cdot d(p_2)^k$$

$\pi_{CAAC}(ID)$: The payoff of CAAC when CAAC ignores the public welfare and airlines disobey the price control. p_{02} is self-determinate price of airlines on condition that the control price of CAAC is p_2. The payoff of CAAC is.

$$\pi_{CAAC}(ID) = (p_{02} - c_1) \cdot d(p_{02})^k$$

$\pi_{airlines}(ID)$: The payoff of airlines when airlines disobey the price control and CAAC ignores the public welfare. The payoff of airlines is.

$$\pi_{airlines}(ID) = (p_{02} - c_2) \cdot LR(p_{02}) \cdot TCL$$

4.2.3 Analyzing and Calculating for Model

According to the model above, the mixed strategy of CAAC is $\theta_1 = (\alpha,\ 1-\alpha)$, and the mixed strategy of airlines is $\theta_2 = (\beta,\ 1-\beta)$. The payoff function of CAAC can be expressed as.

$$\begin{aligned}\mu_1(\theta_1,\theta_2) = \alpha &\left[\begin{array}{l}\beta\left(\int_0^{d(p_1)^k} f(p)dp + (p_1 - c_1)\cdot d(p_1)^k\right) + \\ (1-\beta)\left(\int_0^{d(p_{01})^k} f(p)dp + (p_{01} - c_1)\cdot d(p_{01})^k\right)\end{array}\right] \\ &+ (1-\alpha)\left[\begin{array}{l}\beta\left((p_2 - c_1)(p_2)^k\right) + \\ (1-\beta)\left((p_{02} - c_1)\cdot d(p_{02})^k\right)\end{array}\right]\end{aligned} \tag{4.1}$$

The first order condition of (4.1) is

$$\begin{aligned}\frac{\partial \mu_1}{\partial \alpha} &= \beta\left(\int_0^{d(p_1)^k} f(p)dp + (p_1 - c_1)\cdot d(p_1)^k\right) \\ &\quad + (1-\beta)\left(\int_0^{d(p_{01})^k} f(p)dp + (p_{01} - c_1)\cdot d(p_{01})^k\right) \\ &\quad - \beta\left((p_2 - c_1)\cdot d(p_2)^k\right) - (1-\beta)\left((p_{02} - c_1)\cdot d(p_{02})^k\right) \\ &= 0\end{aligned}$$

So we can get β from $\frac{\partial \mu_1}{\partial \alpha} = 0$

$$\beta = \frac{(p_{02} - c_1)\cdot d(p_{02})^k - \int_0^{d(p_{01})^k} f(p)dp - (p_{01} - c_1)\cdot d(p_{01})^k}{\begin{array}{c}\int_0^{d(p_1)^k} f(p)dp + (p_1 - c_1)\cdot d(p_1)^k - \int_0^{d(p_{01})^k} f(p)dp - \\ (p_{01} - c_1)\cdot d(p_{01})^k - (p_2 - c_1)\cdot d(p_2)^k + (p_{02} - c_1)\cdot d(p_{02})^k\end{array}} \tag{4.2}$$

The payoff function of airlines can be expressed as:

$$\mu_2(\theta_1,\theta_2) = \beta\begin{bmatrix}\alpha\Big((p_1-c_2)(p_1)^k\Big)+ \\ (1-\alpha)(p_2-c_2)\cdot d(p_2)^k\end{bmatrix} + (1-\beta)\begin{bmatrix}\alpha(p_{01}-c_2)\cdot LR(p_{01})+ \\ (1-\alpha)(p_{02}-c_2)(p_{02})\cdot TCL\end{bmatrix} \tag{4.3}$$

The first order condition of (4.3) is

$$\frac{\partial\mu_2}{\partial\beta} = \alpha(p_1-c_2)\cdot d(p_1)^k + (1-\alpha)(p_2-c_2)\cdot d(p_2)^k - \alpha(p_{01}-c_2)\cdot LR(p_{01})\cdot TCL - (1-\alpha)(p_{02}-c_2)\cdot LR(p_{02})\cdot TCL = 0$$

So we can get α from $\frac{\partial\mu_2}{\partial\beta} = 0$

$$\alpha = \frac{(p_{02}-c_2)\cdot LR(p_{02})\cdot TCL - (p_2-c_2)\cdot d(p_2)^k}{(p_1-c_2)\cdot d(p_1)^k - (p_2-c_2)\cdot d(p_2)^k - (p_{01}-c_2)\cdot LR(p_{01})\cdot TCL + (p_{02}-c_2)\cdot LR(p_{02})\cdot TCL} \tag{4.4}$$

According to Hypothesis1, the game is limited and imperfect information, airlines cannot distinguish whether the control price is set basing on public welfare or not, and CAAC also cannot pry about cost information and competition intention of airlines easily. In a limited period, CAAC sets a control price, if airlines intend to disobey, they are inclined to set self-determination price as p_0 uniformly, so $p_{01} = p_{02} = p_0$, which can be substituted into (4.2) and (4.4), then we can get new α and β.

$$\beta = \frac{-\int_0^{d(p_0)^k} f(p)dp}{\int_0^{d(p_1)^k} f(p)dp + (p_1-c_1)\cdot d(p_1)^k - \int_0^{d(p_0)^k} f(p)dp - (p_2-c_1)\cdot d(p_2)^k} \tag{4.5}$$

$$\alpha = \frac{(p_0-c_2)\cdot LR(p_0)\cdot TCL - (p_2-c_2)\cdot d(p_2)^k}{(p_1-c_2)\cdot d(p_1)^k - (p_2-c_2)\cdot d(p_2)^k} \tag{4.6}$$

4.3 Discussion

4.3.1 The Discussion of Optimal Decision of CAAC

Make some conversion to (4.5), β can be rewritten as:

$$\beta = 1 \bigg/ \left[1 + \frac{(p_2 - c_1) \cdot d(p_2)^k - (p_1 - c_1) \cdot d(p_1)^k - \int_0^{d(p_1)^k} f(p)dp}{\int_0^{d(p_0)^k} f(p)dp} \right]$$

, because $0 \le \beta \le 1$, so

$$\frac{(p_2 - c_1) \cdot d(p_2)^k - (p_1 - c_1) \cdot d(p_1)^k - \int_0^{d(p_1)^k} f(p)dp}{\int_0^{d(p_0)^k} f(p)dp} \ge 0,$$

and therefore $(p_2 - c_1) \cdot d(p_2)^k - (p_1 - c_1) \cdot d(p_1)^k \ge \int_0^{d(p_1)^k} f(p)dp$, and here.

$$(p_2 - c_1) \cdot d(p_2)^k \ge (p_1 - c_1) \cdot d(p_1)^k + \int_0^{d(p_1)^k} f(p)dp \qquad (4.7)$$

The left part of (4.7) is $\pi_{CAAC}(IA)$, while the right part of (4.7) is $\pi_{CAAC}(CA)$, so (4.7) is $\pi_{CAAC}(IA) \ge \pi_{CAAC}(CA)$, CAAC has no motivation to improve and consider the public welfare, that is to say, CAAC is apt to maintain a higher industry price unilaterally rather than decreasing the control price for the public. Actually, CAAC has transferred the public welfare to enterprises and civil aviation industry by pricing at a higher level (Shaffer 2001). According to Hypothesis2, CAAC and airlines in China have many common interests and close relations, not only the finance aspects, but also the politics achievements of CAAC have to rely on development and stability of the civil aviation industry. At this point of view, the result is corresponding to Hypothesis2, and also corresponds with the reality.

4.3.2 The Discussion of Optimal Decision of Airlines

Because the ticket demand is price inelastic (Hypothesis3), and $p_1 < p_2$, for parameter α, it is supposed to follow the restrictions as bellow:

$$\begin{cases} \alpha = \dfrac{(p_0 - c_2) \cdot LR(p_0) \cdot TCL - (p_2 - c_2) \cdot d(p_2)^k}{(p_1 - c_2) \cdot d(p_1)^k - (p_2 - c_2) \cdot d(p_2)^k} \\ (p_1 - c_2) \cdot d(p_1)^k - (p_2 - c_2) \cdot d(p_2)^k < 0 \\ 0 \le \alpha \le 1 \end{cases} \qquad (4.8)$$

Referring to (4.8), we get the calculation result:

$$(p_1 - c_2) \cdot d(p_1)^k \le (p_0 - c_2) \cdot LR(p_0) \cdot TCL \le (p_2 - c_2) \cdot d(p_2)^k \qquad (4.9)$$

The middle part of (4.9) is $\pi_{airlines}(CD)$, and also $\pi_{airlines}(ID)$, the left part of (4.9) is $\pi_{airlines}(CA)$ and the right part of (4.9) is $\pi_{airlines}(IA)$. So (4.9) can also be rewritten as:

$$\pi_{airlines}(CA) \leq \pi_{airlines}(CD) = \pi_{airlines}(ID) \leq \pi_{airlines}(IA)$$

Airlines cannot observe whether CAAC has considered the public welfare or not when setting control price, and obviously the self-determination price p_0 could produce more profits than the lower control price p_1 could, and theoretically speaking, abiding a higher control price p_2 could get more profits than self determining price p_0 could, but there may be two reasons at least to make them depart from the "optimization path": one is that airlines cannot stand a very low passenger load rate because of a higher price, which is a big waste of resources; another is that when a competitor reduce the price, the others have to fallow the decreasing price strategy, or they may suffer much more lost, which results from product homogeneity of air transportation in China.

4.3.3 The Discussion of Decision Dissonance of Two Players

Basing on the discussion A, the optimal strategy payoff of CAAC is $(p_2 - c_1) \cdot d(p_2)^k$, of which the first order condition is $\frac{\partial\left[(p_2 - c_1)\cdot d(p_2)^k\right]}{\partial p_2} = 0$, so $p_2 = \frac{k}{1+k}c_1$; Basing on the discussion B, the optimal strategy payoff of airlines is $(p_0 - c_2) \cdot LR(p_0) \cdot TCL$, of which the first order condition is $\frac{\partial[(p_0 - c_2)\cdot LR(p_0)\cdot TCL]}{\partial p_0} = 0$, so $p_0 = c_2 - \frac{LR}{LR'}$, LR' is the derivative of $LR(p)$ at $p = p_0$, $LR(p)$ is decreasing function of price p, so $LR' < 0$, simultaneously $0 < LR(p) \leq 1$, so $p_0 = c_2 - \frac{LR}{LR'} > c_2$. Then the restriction condition is

$$\begin{cases} p_2 = \dfrac{k}{1+k}c_1 \\ p_0 = c_2 - \dfrac{LR}{LR'} > c_2 \\ p_2 > p_0 \end{cases}, \text{ so } \frac{k}{1+k}c_1 > c_2, \text{ because}$$

$0 < \frac{k}{1+k} < 1$, the calculation result is $c_1 > c_2$. CAAC sets the control price basing on the cost evaluation of c_1, which is usually the average cost of civil aviation industry. While airlines self determinate competitive price basing on the cost evaluation of c_2, which is probably the margin cost of the company. The tremendous difference between c_1 and c_2 causes decision dissonance of the two players. So as long as $p_0 > c_2$, airlines always have the motivation of disobeying and cutting down control price.

4.4 Decision Making

For CAAC, the optimal strategy is setting a higher control price without considering the public welfares because it has many underlying common interests with airlines and the civil aviation industry, for example, at aspects of finance and political achievements. But airlines are always inclined to disobey the control price and get into price war. The reason is that airlines in China have to face furious competitions after the so called "deregulation", while the property rights of leading airlines still belong to administrative departments. For this kind of natural monopoly industry of civil aviation, fixed costs are very high while the margin costs are very low, so for airlines there always has been pressure and space of cutting down price. And we have proved that when the self-determination price p_0 is lower than the control price p_2, airlines could become more competitive such as getting a higher passenger load rate, a bigger market share and so on. However, when $p_0 < c_2$, (it is possible because of the unusual structure of property rights) the air transport market will be in disorder and the whole industry welfares will be seriously damaged.

And then CAAC has to set a lower boundary for the control price to prevent this phenomenon form happening, so that the self-determination price of airlines cannot be under the lower boundary of control price on any account.

p_1 is a lower control price when CAAC considers the public welfares, when $p_0 > p_1$, the airlines can get excess profit, or else they will go into red. So the optimal strategy for CAAC is setting an inter-zone control price, for example $[p_1, p_2]$, and the optimal strategy for airlines is self-pricing between p_1 and p_2. Basing on the decisions above, CAAC could get balance among the industry welfares, healthy development of the market and the public welfares, airlines could get balance between the profits and competitive edges. Lastly it is necessary to note that the final decision makings of the two players are both based on the present special structure of property rights of civil aviation in China, which could not be reformed or changed in a short time period.

4.5 Conclusion

Unlike many qualitative analyses on air ticket price control problem, we build a quantitative price control model based on game theory by introducing two new decision factors: *CS* (customer's surplus, also called the public welfares) and LR (passenger load rate). Through modeling and discussing, we get some interesting results and conclusions: CAAC is inclined to ignore the public welfares when setting the control price of air ticket, which may be a higher price p_2, whereas, airlines are always inclined to disobey the control price of CAAC for achieving a higher passenger load rate and strengthening the competition edge, which may be a self-determination price p_0, and $p_1 < p_0 < p_2$, where p_1 is a lower control price when CAAC considers the public welfares.

At present, main airlines of China have very special structure of property rights, that is to say airlines face dual pressures of administrative regulations and market competitions, which may cause airline's dumping price for market shares and competition edge, even may lead to $p_0 < c_2$, so CAAC has to define a lower boundary for the control price to prevent this kind of vicious competition behavior. As a result, CAAC sets an inter-zone control price for achieving to keep enough industry welfares, ensure healthy development of the civil aviation industry and consider moderate public welfares. And when $p_0 \in [p_1, p_2]$, airlines can get balance between the revenues and competition edge, and CAAC can also get balance between the industry welfares and the public welfares.

The reason of decision dissonance between the two players is tremendous difference of cost evaluation for air ticket pricing ($c_1 > c_2$, shown as discussion *C*). c_1 is the cost evaluation of CAAC, usually an average cost of the whole industry, and c_2 is the cost evaluation of airlines, usually a margin cost of the product. In terms of economics and competitions, as long as $p_0 > c_2$, airlines are always inclined to disobey and decrease the control price for a higher passenger load rate, i.e. for competitive edge.

Acknowledgments We thank all the sponsors for their financial support. And especially, Chongyi Jing Author thanks his dear friend Dr Bin Zhou for his thoughtful comments, suggestions and helpful data resources, which greatly enhanced the accomplishment of this paper.

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Chapter 5
A Method for Multiple Attribute Decision Making without Weight Information but with Preference Information on Alternatives

Yun-fei Li

Abstract A kind of uncertain multiple attribute decision making problems with preference information on alternatives is studied, in which the information about the attribute weights is unknown and the attribute values are interval numbers. Based on the deviation degree between the comprehensive attribute value of alternatives and the preference of decision-maker for alternatives, an optimum model is constructed and a simple formula for obtaining the attribute weights is given, then a new method to get the priorities of alternatives is presented. An example is given to show the application about the method.

Keywords Deviation degree · Interval number · Multiple attribute decision making · Preference information

5.1 Introduction

Multiple attribute decision making (MADM) is an important area in modern decision theory. The methods for the MADM with complete weight information have been widely studied (Cheng 1987; Chen and Zhao 1990; Hwang and Yoon 1981). However, in fact, the decision maker may have uncertain knowledge about the attribute weight information and preference information on alternatives. So, the research on the MADM with preference information on alternatives has important theoretical significance and practical value.

Park and Kim (1997), Kim and Choi (1999), Kim and Ahn (1999) have researched the MADM problem with incomplete weight information. Based on introducing the preference degree, Gao (2000) has studied the MADM problem

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E. Qi et al. (eds.), *The 19th International Conference on Industrial Engineering and Engineering Management*, DOI: 10.1007/978-3-642-38391-5_5,

with incomplete weight information expressed by interval number and preference information on alternatives. Under the situations where the decision maker has preference information on alternatives, which takes the form of reciprocal judgement matrix and complementary judgement matrix, Xu (2004) has established two objective programming models to research the MADM problem under partial weight information expressed by interval number. Based on a projection method, Xu (2004) has studied the MADM problem with incomplete weight information and preference information expressed by real numbers on alternatives. Jiang and Fan (2005) have constructed an objective programming model to analyze the MADM problem with partial weight information and preference information expressed by interval numbers on alternatives. Based on the grey relational coefficients between objective preference and subjective preference, Wei and Wei (2008) have proposed a method to discuss the MADM problem with interval numbers and preference information on alternatives. Fan et al. (2008) have researched the MADM problem without weight information and the decision maker expresses his preference information on alternatives by a fuzzy relation. Based on the research of Xu (2003) has constructed an optimal model by using a linear translation function to study the MADM problem, in which the weight information is completely unknown, the attribute values are real numbers and the decision maker has preference on alternatives. However, from the above researches, we can find few researches on the MADM problem, in which weight information is completely unknown, the attribute values are expressed by interval numbers and the decision maker has preference information expressed by interval numbers on alternatives. The aim of this paper is to establish an optimal model to solve the above problem.

5.2 Preliminaries

In the following, we will introduce some important concepts and algorithms about interval numbers (Xu and Da 2003).

Let $\tilde{a} = [a^-, a^+] = \{x | a^- \leq x \leq a^+, a^-, a^+ \in R\}$, $\tilde{a}$ is an interval number. Specially, if $a^- = a^+$, $\tilde{a}$ is a real number.

The algorithms related to interval numbers are following: if $\tilde{a} = [a^-, a^+]$ and $\tilde{b} = [b^-, b^+]$, $\beta \geq 0$, then

(1) $\tilde{a} = \tilde{b}$ if and only if $a^- = b^-$, $a^+ = b^+$,

(2) $\tilde{a} + \tilde{b} = [a^- + b^-, a^+ + b^+]$,

(3) $\beta\tilde{a} = [\beta a^-, \beta a^+]$, specially, if $\beta = 0$, then $\beta\tilde{a} = 0$.

Let $X = \{X_1, X_2, \cdots, X_n\}$ $(n \geq 2)$ be the set of alternatives and $U = \{u_1, u_2, \cdots, u_m\}$ $(m \geq 2)$ be the set of attributes. Suppose the decision maker gives his subjective preference information on alternative $X_i \in X$ by $\tilde{\theta}_i = [\theta_i^-, \theta_i^+]$ $(0 \le \theta_i^- \le \theta_i^+ \le 1)$. Let $\tilde{A} = (\tilde{a}_{ij})_{n \times m}$ be the decision matrix, $\tilde{a}_{ij} = [a_{ij}^-, a_{ij}^+]$ is the attribute value of alternative X_i with respect to the attribute u_j, $i = 1, 2, \cdots\cdots, n$, $j = 1, 2, \cdots, m$.

In order to avoid the influence of different dimensions on the decision making results, the decision matrix $\tilde{A} = (\tilde{a}_{ij})_{n \times m}$ should to be normalized into the dimensionless decision matrix $\tilde{R} = (\tilde{r}_{ij})_{n \times m}$, in which $\tilde{r}_{ij} = [r_{ij}^-, r_{ij}^+] = \{t | 0 \le r_{ij}^- \le t \le r_{ij}^+ \le 1\}$ $(i = 1, 2, \cdots, n j = 1, 2, \cdots, m)$. Therefore following proportion transformations is employed (Goh et al. 2003):

If $\tilde{a}_{ij}$ is for the benefit, then

$$r_{ij}^- = \frac{a_{ij}^-}{\sqrt{\sum_{i=1}^{n} (a_{ij}^+)^2}}, \quad r_{ij}^+ = \frac{a_{ij}^+}{\sqrt{\sum_{i=1}^{n} (a_{ij}^-)^2}} \tag{5.1}$$

If $\tilde{a}_{ij}$ is for the cost, then

$$r_{ij}^- = \frac{1 \big/ a_{ij}^+}{\sqrt{\sum_{i=1}^{n} (1 \big/ a_{ij}^-)^2}}, \quad r_{ij}^+ = \frac{1 \big/ a_{ij}^-}{\sqrt{\sum_{i=1}^{n} (1 \big/ a_{ij}^+)^2}} \tag{5.2}$$

In order to compare the similarity degree of two interval numbers and realize the order of alternatives, we will introduce the concepts about deviation degree and possibility degree of interval number.

Definition 1 (*Xu and Da* 2003): Suppose

$$\tilde{a} = [a^-, a^+], \ \tilde{b} = [b^-, b^+]$$

are two interval numbers, let

$$d(\tilde{a}, \tilde{b}) = \|\tilde{a} - \tilde{b}\| = \sqrt{(b^- - a^-)^2 + (b^+ - a^+)^2}$$

be the deviation degree between $\tilde{a}$ and $\tilde{b}$.

Definition 2 (*Xu and Da* 2003): Suppose $\tilde{a} = [a^-, a^+], \ \tilde{b} = [b^-, b^+]$ are two interval numbers and $l_{\tilde{a}} = a^+ - a^-, \ \ l_{\tilde{b}} = b^+ - b^-$, let

$$p(\tilde{a} \ge \tilde{b}) = \frac{\min\{l_{\tilde{a}} + l_{\tilde{b}}, \max(a^+ - b^-, 0)\}}{l_{\tilde{a}} + l_{\tilde{b}}} \tag{5.3}$$

be the possibility degree of $\tilde{a} \ge \tilde{b}$ and $\tilde{a} \ge \tilde{b}$ be the order relationship between $\tilde{a}$ and $\tilde{b}$.

In this paper, we will research how to rank $X_i (i = 1, 2, \cdots, n)$ according to the decision matrix $\tilde{A}$ and the preference information $\tilde{\theta}_i (\tilde{\theta}_i = [\theta_i^-, \theta_i^+])$.

5.3 Model and Method

According to the normalized matrix $\tilde{R} = (\tilde{r}_{ij})_{n\times m}$, the attributes weight vector $w = (w_1, w_2, \cdots, w_m)^T$ and the algorithms related to interval numbers, the comprehensive attribute value of X_i is

$$\tilde{z}_i = \sum_{j=1}^{m} \tilde{r}_{ij} w_j = [\sum_{j=1}^{m} r_{ij}^- w_j, \sum_{j=1}^{m} r_{ij}^+ w_j] \quad (i = 1, 2, \cdots, n) \tag{5.4}$$

where w_j is the weight of the attribute u_j and $\sum_{j=1}^{m} w_j = 1 (w_j \geq 0 j = 1, 2, \cdots, m)$.

The preference information of the decision maker is subjective judgment to the comprehensive attribute values of alternatives. But because of the limitations of many real factors, there are deviations between the preference information of the decision maker and the comprehensive attribute values of alternatives. In view of the rationality of the decision making, the attributes weight vector $w = (w_1, w_2, \cdots, w_m)^T$ will minimize the total deviation between the preference information of the decision maker and the comprehensive attribute values of alternatives. So, we will give the following optimal model:

$$\begin{cases} \min D(w) = \sum_{i=1}^{n} d_i^2(\tilde{z}_i, \tilde{\theta}_i) = \sum_{i=1}^{n} [(\sum_{j=1}^{m} r_{ij}^- w_j - \theta_i^-)^2 + (\sum_{j=1}^{m} r_{ij}^+ w_j - \theta_i^+)^2] \\ s.t \quad \sum_{j=1}^{m} w_j = 1 \quad w_j \geq 0 j = 1, 2, \cdots, m \end{cases}$$

Where

$$d_i(\tilde{z}_i, \tilde{\theta}_i) = \sqrt{(\sum_{j=1}^{m} r_{ij}^- w_j - \theta_i^-)^2 + (\sum_{j=1}^{m} r_{ij}^+ w_j - \theta_i^+)^2}$$
$$(i = 1, 2, \cdots, n) \tag{5.5}$$

be the deviation degree between the subjective preference information of X_i and the comprehensive attribute values of X_i.

We construct the Lagrange function:

$$L(w, \lambda) = \sum_{i=1}^{n} [(\sum_{j=1}^{m} r_{ij}^- w_j - \theta_i^-)^2 + (\sum_{j=1}^{m} r_{ij}^+ w_j - \theta_i^+)^2] + 2\lambda(\sum_{j=1}^{m} w_j - 1) \tag{5.6}$$

Let $\frac{\partial L(w,\lambda)}{\partial w_k} = 0 \quad (k = 1, 2, \cdots, m)$, we have

$$\sum_{i=1}^{n}[(\sum_{j=1}^{m}r_{ij}^{-}w_j-\theta_i^{-})r_{ik}^{-}+(\sum_{j=1}^{m}r_{ij}^{+}w_j-\theta_i^{+})r_{ik}^{+}]+\lambda=0$$

$$(k=1,2,\cdots,m) \tag{5.7}$$

i.e.

$$\sum_{j=1}^{m}[\sum_{i=1}^{n}(r_{ij}^{-}r_{ik}^{-}+r_{ij}^{+}r_{ik}^{+})]w_j=\sum_{i=1}^{n}(\theta_i^{-}r_{ik}^{-}+\theta_i^{+}r_{ik}^{+})-\lambda$$

$$(k=1,2,\cdots,m) \tag{5.8}$$

Let $e_m=(1,1,\cdots,1)^T,\ \eta=(\eta_1,\eta_2,\cdots,\eta_m)^T,\ Q=(q_{kj})_{m\times m}$,

Where

$$\eta_k=\sum_{i=1}^{n}(\theta_i^{-}r_{ik}^{-}+\theta_i^{+}r_{ik}^{+})\ \ (k=1,2,\cdots,m) \tag{5.9}$$

$$q_{kj}=\sum_{i=1}^{n}(r_{ij}^{-}r_{ik}^{-}+r_{ij}^{+}r_{ik}^{+})\ \ (k,j=1,2,\cdots,m) \tag{5.10}$$

Then (8) will transform to the matrix formation

$$Qw=\eta-\lambda e_m \tag{5.11}$$

Theorem 1 *The matrix Q is a positive definite matrix.*

Proof From (5.10), we know $q_{kj}=q_{jk}(k,j=1,2,\cdots,m)$, i.e. the matrix Q is a symmetric matrix. Suppose $Y=(y_1,y_2,\cdots,y_m)^T$ is a nonzero vector, then

$$Y^TQY=\sum_{k=1}^{m}\sum_{j=1}^{m}[\sum_{i=1}^{n}(r_{ij}^{-}r_{ik}^{-}+r_{ij}^{+}r_{ik}^{+})]y_ky_j$$

$$=\sum_{i=1}^{n}\sum_{k=1}^{m}[(r_{ik}^{-})^2+(r_{ik}^{+})^2]y_k^2+\sum_{i=1}^{n}\sum_{j=1}^{m}\sum_{\substack{k=1\\k\neq j}}^{m}(r_{ij}^{-}r_{ik}^{-}+r_{ij}^{+}r_{ik}^{+})y_ky_j$$

$$=\sum_{i=1}^{n}[(\sum_{k=1}^{m}r_{ik}^{-}y_k)^2+(\sum_{k=1}^{m}r_{ik}^{+}y_k)^2]>0$$

So, the matrix Q is a positive definite matrix.

From the theorem 1, we know the matrix Q^{-1} is existent, so

$$w=Q^{-1}(\eta-\lambda e_m) \tag{5.12}$$

Because $e_m^T \cdot w = 1$, so, we can conclude

$$\lambda = \frac{e_m^T Q^{-1} \eta - 1}{e_m^T Q^{-1} e_m} \tag{5.13}$$

So,

$$w = Q^{-1}(\eta - \frac{e_m^T Q^{-1} \eta - 1}{e_m^T Q^{-1} e_m} e_m) \tag{5.14}$$

The optimal weight vector $w = (w_1, w_2, \cdots, w_m)^T$ can be calculated by (5.14), and then the comprehensive attribute values $\tilde{z}_i$ $(i = 1, 2, \cdots, n)$ of all the alternatives can be calculated by (5.4). Because $\tilde{z}_i$ $(i = 1, 2, \cdots, n)$ are still interval numbers, it is inconvenient to rank the alternatives, so we will calculate the possibility degree of $\tilde{z}_i$ $(i = 1, 2, \cdots, n)$ by using formula (5.3) and establish the possibility degree matrix $P = (p_{il})_{n \times n}$, where $p_{il} = p(\tilde{z}_i \geq \tilde{z}_l)(i, l = 1, 2, \cdots, n)$.

The matrix $P = (p_{il})_{n \times n}$ is a complementary judgement matrix, the priority vector $\omega = (\omega_1, \omega_2, \cdots, \omega_n)^T$ of P can be given by using the following formula (Da and Xu 2002)

$$\omega_i = \frac{1}{n(n-1)} \left(\sum_{l=1}^{n} p_{il} + \frac{n}{2} - 1 \right) \quad (i = 1, 2, \cdots, n) \tag{5.15}$$

And further, the best alternative will be given if we rank all the alternatives based on the components of the priority vector $\omega = (\omega_1, \omega_2, \cdots, \omega_n)^T$.

Based on the above discussion, we develop a new method to analyze the MADM problem, in which weight information is unknown, the attribute values are expressed by interval numbers and the decision maker has preference information expressed by interval numbers on alternatives. There are six steps in the new method:

Step 1. Let $X = \{X_1, X_2, \cdots, X_n\}$ $(n \geq 2)$ be the set of alternatives, $U = \{u_1, u_2, \cdots, u_m\}$ $(m \geq 2)$ be the set of attributes and $\tilde{A} = (\tilde{a}_{ij})_{n \times m}$ be the decision matrix where $\tilde{a}_{ij} = [a_{ij}^-, a_{ij}^+]$ is the attribute value of alternative X_i with respect to the attribute u_j $(i = 1, 2, \cdots, n, j = 1, 2, \cdots, m)$;

Step 2. According to (5.1) and (5.2), the decision matrix $\tilde{A} = (\tilde{a}_{ij})_{n \times m}$ normalized into the dimensionless decision matrix $\tilde{R} = (\tilde{r}_{ij})_{n \times m}$;

Step 3. According to (5.14), we obtain the optimal weight vector $w = (w_1, w_2, \cdots, w_m)^T$;

Step 4. Utilize (5.4) to get the comprehensive attribute values $\tilde{z}_i$ $(i = 1, 2, \cdots, n)$;

Step 5. Utilize (5.3) to get the possibility degree of $\tilde{z}_i$ $(i = 1, 2, \cdots, n)$ and establish the possibility degree matrix $P = (p_{il})_{n \times n}$;

Step 6. We calculate the priority vector $\omega = (\omega_1, \omega_2,$

$\cdots, \omega_n)^T$ of the possibility degree matrix $P = (p_{il})_{n\times n}$ and rank all the alternatives based on the components of the priority vector $\omega = (\omega_1, \omega_2, \cdots, \omega_n)^T$, then get the best alternative.

5.4 Illustrative Example

When the decision maker select cadres, on one hand, he wants to select capable cadres, on the other hand, he also wants to select his preferred cadres. Hence, there is preference information on alternatives. Now, suppose some company faces how to select cadres. Firstly, the company built an index system with six attributes: u_1 -morality, u_2 -attitude to work, u_3 -style of work, u_4 -levels of culture and knowledge structure, u_5 -ability of leadership and u_6- ability of innovation; secondly, the company determines five candidates $x_i (i = 1, 2, \cdots, 5)$ based on the recommendation and evaluation of the masses and statistical treatment. Because the evaluation results about the same candidate are different, so, the attribute values after statistical treatment are expressed by interval numbers, as listed in the following Table 5.1:

To select the best cadre, the six steps are included:

Step 1. We utilize (5.1), (5.2) to transform the decision matrix $\tilde{A}$ into the dimensionless decision matrix

$$\tilde{R} = \begin{pmatrix} [0.378, 0.405] & [0.394, 0.414] & [0.398, 0.423] & [0.407, 0.432] & [0.394, 0.410] & [0.415, 0.437] \\ [0.394, 0.429] & [0.389, 0.410] & [0.394, 0.415] & [0.394, 0.415] & [0.411, 0.438] & [0.394, 0.419] \\ [0.395, 0.420] & [0.377, 0.396] & [0.408, 0.433] & [0.408, 0.433] & [0.386, 0.410] & [0.408, 0.424] \\ [0.385, 0.405] & [0.413, 0.433] & [0.385, 0.410] & [0.390, 0.414] & [0.395, 0.419] & [0.417, 0.433] \\ [0.384, 0.410] & [0.402, 0.414] & [0.402, 0.414] & [0.407, 0.419] & [0.402, 0.414] & [0.380, 0.391] \end{pmatrix}$$

Step 2. Suppose the decision maker's subjective preference value (after normalized) on the five candidates $x_i (i = 1, 2, \cdots, 5)$ as follows:

$$\tilde{\theta}_1 = [0.3, 0.5],\ \tilde{\theta}_2 = [0.5, 0.6],\ \tilde{\theta}_3 = [0.3, 0.4],$$

$$\tilde{\theta}_4 = [0.4, 0.6],\ \tilde{\theta}_5 = [0.4, 0.5]$$

Utilize (5.14) to get the optimal weight vector:

Table 5.1 Decision matrix $\tilde{A}$

	u1	u2	u3	u4	u5	u6
$x1$	[0.85,0.90]	[0.90,0.92]	[0.91,0.94]	[0.93,0.96]	[0.90,0.91]	[0.95,0.97]
$x2$	[0.90,0.95]	[0.89,0.91]	[0.90,0.92]	[0.90,0.92]	[0.94,0.97]	[0.90,0.93]
$x3$	[0.88,0.91]	[0.84,0.86]	[0.91,0.94]	[0.91,0.94]	[0.86,0.89]	[0.91,0.92]
$x4$	[0.93,0.96]	[0.91,0.93]	[0.85,0.88]	[0.86,0.89]	[0.87,0.90]	[0.92,0.93]
$x5$	[0.86,0.86]	[0.90,0.92]	[0.90,0.95]	[0.91,0.93]	[0.90,0.92]	[0.85,0.87]

$$w = (0.1639, 0.1658, 0.1666, 0.1681, 0.1674, 0.1682)^T$$

Step 3. Utilize (5.4) to get the comprehensive attribute values of the five candidates $x_i (i = 1, 2, \cdots, 5)$ as follows:

$$\tilde{z}_1 = [0.3978,\ 0.4202],\ \ \tilde{z}_2 = [0.3960,\ 0.4210],$$

$$\tilde{z}_3 = [0.3970,\ 0.4194],\ \ \tilde{z}_4 = [0.3975,\ 0.4190],$$

$$\tilde{z}_5 = [0.3962,\ 0.4103]$$

Step 4. Utilize (5.3) to calculate the possibility degree of $\tilde{z}_i\ (i = 1, 2, \cdots, 5)$ and built the possibility degree matrix:

$$P = \begin{pmatrix} 0.5 & 0.5105 & 0.5179 & 0.5171 & 0.6575 \\ 0.4895 & 0.5 & 0.5063 & 0.5054 & 0.6343 \\ 0.4821 & 0.4937 & 0.5 & 0.4989 & 0.6356 \\ 0.4829 & 0.4946 & 0.5011 & 0.5 & 0.6405 \\ 0.3425 & 0.3657 & 0.3644 & 0.3595 & 0.5 \end{pmatrix}$$

Step 5. Utilize (5.15) to get the priority vector of the possibility degree matrix P;

$$\omega = (0.2102, 0.2068, 0.2055, 0.2059, 0.1716)^T$$

Step 6. Rank all the alternatives $x_i (i = 1, 2, \cdots, 5)$ and select the best one according to the $\omega_i (i = 1, 2, \cdots, 5)$:

$$x_1 \succ x_2 \succ x_4 \succ x_3 \succ x_5$$

Thus the most desirable candidate is x_1.

5.5 Conclusions

In this paper, a new method is proposed to discuss the MADM problem with expert's preference information expressed by interval numbers on alternatives, in which the attribute weights information is unknown completely and the attribute values are interval numbers. Considering the preference information of the decision maker is subjective judgment to the comprehensive attribute values of alternatives, hence the weight vector of attributes will minimize the total deviation between the preference information values of the decision maker and the comprehensive attribute values of alternatives. In order to get the attribute weights, in according to the above idea, we have established an optimal model based on the deviation degree between the comprehensive attribute values of alternatives and the preference information values of the decision maker. Solving the above model, we can obtain the attribute weights and we utilize the priority vector of the possibility degree matrix to compare the comprehensive attribute values of the alternatives, and then rank the alternatives. The method is practical and effective because it organically combines the subjective information and objective information. Finally, an illustrative example is given to show the application of the method.

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Chapter 6
A Prediction of the Container Throughput of Jiujiang Port Based on Grey System Theory

Yan Du

Abstract Container handling system can be regarded as a grey system. Since the grey GM (1,1) prediction model is applicable to small samples of data, the port container throughout of Jiujiang port in the next 5 years can be predicted on the basis of the relative data from 2006 to 2011. According to the predicted result, feasible suggestions and available measures may be given to the development of Jiujiang port, and scientific data may also be provided for it.

Keywords Container throughput · GM (1,1) model · Jiujiang port · Prediction

6.1 Introduction

A port is served as the joint and shipping center of the land, sea and air. It plays an important role in the entire logistics network. Meanwhile, as an integrated transport hub and the main distribution center of import and export, the port's economic growth take an inevitably great position in the urban economy and regional development. Jiujiang port is the only port connecting Yangtze River and seas in Jiangxi Province, which has rather obvious advantage. The international container cargoes in Jiangxi are mainly transported to the coastal ports through Jiujiang port. As a feeder port of Shanghai port, the cargoes are first shipped from Jiujiang port to Shanghai and then exported to the other cities and countries in the world. In 2008, the two ports established a closer cooperation. The Shanghai Port provided the Jiujiang Port with the advanced management experience, ideas and other sorts of resources. A new Jiujiang port is growing bigger and better with the rapid development of Jiangxi's economy, its role is increasingly evident in recent years (Du 2011).

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E. Qi et al. (eds.), *The 19th International Conference on Industrial Engineering and Engineering Management*, DOI: 10.1007/978-3-642-38391-5_6,

The throughput prediction of the container has extremely important influence on the future of a container port. The method of the prediction consists of qualitative and quantitative method. Qualitative prediction method includes Delphi Method, the Subjective Probability Method and Supply Survey Method. Quantitative prediction method includes Regression Analysis, Exponential Smoothing, Gary Prediction Method, the Neural Network Method, Elastic Prediction Method and Combined Prediction Method. The above models vary a lot in the scope of application, complexity and accuracy. Therefore, specific analysis of the specific objectives is required (Chen and Gao 2008; Zhou 2007).

Several factors influence a port's container throughput, such as the economic development of the hinterland, the port's operation, its infrastructure, market demand and so on (Liu and Wang 2005). The relationship among them is comparatively complicated and changeable, which is quite in line with the characteristics of the grey system. In this paper, the grey prediction model is applied to predict Jiujiang port's container throughput based on the data in the past 6 years.

6.2 The Gray Prediction Model of Container Throughput

The Grey System Theory was built by Professor Deng Julong, a famous scholar in China in 1982. It is a new method to study a problem of less data, poor information and uncertainty. Gray System Theory specializes studying in the uncertain system, which is a small sample of poor information by extracting valuable information through the development of some of the known information to realize correct description and effective monitoring and control system operation behavior and evolution (Deng 2002). In this theory, "black" means information is unknown, "white" indicates information is completely clear, and "grey" describes some of the information is clear and some information is not clear. Accordingly, the system whose information is unknown is called a BlackSystem. The system whose information is completely clear is called the WhiteSystem. The system between them is called a Gray System (Liu and Xie 2008).

Gray System Model has a broad range of applications because there are no special requirements and restrictions on the observed experimental data. Currently, the most widely used Grey Prediction Model is GM (1,1) model, which contains a variable, first derivative to predict the data.

The GM (1,1) model is based on a random time of the original sequence, formed by the cumulative chronological time sequence showing the law can be used first-order linear differential equations to approximate. In this paper, the grey prediction GM (1,1) model, namely, the first-order linear differential equation model in a variable model prediction is applied hereby.

6.2.1 GM (1,1) model

The gray system modeling is the use of discrete time series data to establish the approximate continuous differential equation model. In this process, the Accumulated Generating Operator (AGO) is the basic means. Its generating function is the basis of gray modeling and predictable (Liu and Deng 1999).

Equipped with the original sequence:

$$\mathrm{x}^{(0)}(\mathrm{t}) = \left\{\mathrm{x}^{(0)}(1), \mathrm{x}^{(0)}(2), \ldots\ldots, \mathrm{x}^{(0)}(\mathrm{n})\right\}$$

(n is the length of time series of samples)

Coefficient column accumulated generating the AGO incremental series:

$$\mathrm{x}^{(1)}(\mathrm{t}) = \left\{\mathrm{x}^{(1)}(1), \mathrm{x}^{(1)}(2), \ldots\ldots, \mathrm{x}^{(1)}(\mathrm{n})\right\}$$

And $\mathrm{x}^{(1)}(\mathrm{k}) = \sum_{i=1}^{k} \mathrm{x}^{(0)}(\mathrm{i})$ $\mathrm{K} = 1, 2, \ldots, \mathrm{n}$

$\mathrm{x}^{(1)}(\mathrm{k})$ GM (1,1) model for the albino form of the differential equation as follows:

$$\frac{\mathrm{dx}^{(1)}}{\mathrm{dt}} + a\mathrm{x}^{(1)} = u \tag{6.1}$$

a, u: Undetermined parameters

Differential to replace the differential, differential convenient variable transformed into

$$\begin{vmatrix} \mathrm{x}^{(0)}(2) \\ \mathrm{x}^{(0)}(3) \\ \cdots \\ \mathrm{x}^{(0)}(\mathrm{n}) \end{vmatrix} = \begin{vmatrix} -1/2\left[\mathrm{x}^{(1)}(1) + \mathrm{x}^{(1)}(2)\right] & 1 \\ -1/2\left[\mathrm{x}^{(1)}(2) + \mathrm{x}^{(1)}(3)\right] & 1 \\ \cdots & \cdots \\ -1/2\left[\mathrm{x}^{(1)}(\mathrm{n}-1) + \mathrm{x}^{(1)}(\mathrm{n})\right] & 1 \end{vmatrix} + \begin{vmatrix} a \\ u \end{vmatrix} \tag{6.2}$$

Abbreviated as follows:

$$Y_N = \mathrm{B} \times \alpha \tag{6.3}$$

Using the least square method, you can get the solution of the equations are:

$$\alpha = \begin{vmatrix} a \\ u \end{vmatrix} = \left(\mathrm{B}^{\mathrm{T}}\mathrm{B}\right)^{-1}\mathrm{B}^{\mathrm{T}}\mathrm{Y}_{\mathrm{N}} \tag{6.4}$$

Into the original differential equations, you can have the formula:

$$\mathrm{x}^{(1)}(k+1) = \left[x^{(0)}(1) - \frac{u}{a}\right]^{-ak} + \frac{u}{a} \tag{6.5}$$

And then by the formula
$x^{(0)}(k) = x^{(1)}(k) - x^{(1)}(k-1)$ to restore:
Series $x^{(0)}(k)$ is the calculated value of the original series.

6.2.2 Inspection of the Model

In order to determine whether it is a reasonable and qualified model, a variety of inspection is required. Only the model which goes through the test can be used as predictors. A posteriori differential is used here to test the model commonly (Wang 2006; Xiong and Xu 2005).

The steps are as follows:

(1) Seek the mean of raw data and residuals

$$\bar{x} = \frac{1}{n}\sum\nolimits_{k=1}^{n} x^{(0)}(k) \tag{6.6}$$

$$\bar{q} = \frac{1}{n}\sum\nolimits_{k=1}^{n} q(k) \tag{6.7}$$

(2) Find the variance of the raw data and residuals:

$$s_1^2 = \frac{1}{n}\sum\nolimits_{k=1}^{n} \left[x^{(0)}(k) - \bar{x}\right]^2 \tag{6.8}$$

$$s_2^2 = \frac{1}{n}\sum\nolimits_{k=1}^{n} [q(k) - \bar{q}]^2 \tag{6.9}$$

(3) The calculation of a posteriori differential ratio c and the small error probability p:

$$c = \frac{s_2}{s_1} \tag{6.10}$$

$$p = p\{|q(k) - \bar{q}| < 0.6745 s_1\} \tag{6.11}$$

Accuracy of the model is determined by c and p. A posteriori differential ratio c as small as possible (The small c show that s_2 is small and s_1 is big. The variance of residual is small. The variance of the raw data is big, Description of residual is more concentrated, Small swings. Raw data is more scattered, large swings. So, if you want to simulate effect, requires that s_2 small as possible compared to s_1). Small error probability is the bigger the better. Accuracy level is in Table 6.1.

Table 6.1 A posteriori differential checklist

Prediction accuracy	P	c
Good	>0.95	<0.35
Qualified	>0.80	<0.40
Reluctantly	>0.70	<0.45
Failure	≤0.70	≥0.45

6.3 A Prediction of the Container Throughput of Jiujiang Port

6.3.1 Calculation

The container throughput of Jiujiang Port in recent years is in Table 6.2. It shows that from 2006 to 2011, the container throughput of Jiujiang Port is growing rapidly overall, only in 2008 declined compared to 2007 because of the international financial crisis. In 2009, the volume grew again and has maintained a good momentum of sustained growth in 2010 and 2011 (Shao 2010).

We can see from Table 6.2:

$$x^{(0)} = (7.38, 8.80, 8.09, 10.07, 12.06, 14.00)$$

Cumulative, $x^{(0)}$ time accumulated generating operation sequence,

$$x^{(1)} = (7.38, 16.18, 24.27, 34.34, 46.40, 60.40)$$

Modeling $\frac{dx^{(1)}}{dt} + ax^{(1)} = u$

Calculate a and u using the least squares method, to determine the parameter vector:

$$\alpha = (a, u)^T = \left(B^T B\right)^{-1} B^T Y_N$$

$$B = \begin{vmatrix} -1/2\left[x^{(1)}(1) + x^{(1)}(2)\right] & 1 \\ -1/2\left[x^{(1)}(2) + x^{(1)}(3)\right] & 1 \\ -1/2\left[x^{(1)}(3) + x^{(1)}(4)\right] & 1 \\ -1/2\left[x^{(1)}(4) + x^{(1)}(5)\right] & 1 \\ -1/2\left[x^{(1)}(5) + x^{(1)}(6)\right] & 1 \end{vmatrix} = \begin{vmatrix} -11.78 & 1 \\ -20.225 & 1 \\ -29.305 & 1 \\ -40.37 & 1 \\ -53.4 & 1 \end{vmatrix}$$

Table 6.2 Container throughput and cumulative data table of Jiujiang port over the years (Unit: Million TEU)

Years	2006	2007	2008	2008	2010	2011
Throughput	7.38	8.80	8.09	10.07	12.06	14.00
Cumulative	7.38	16.18	24.27	34.34	46.40	60.40

TEU Twenty-foot Equivalent Unit

Table 6.3 The actual values and predicted values (Unit: Million TEU)

Years	2006	2007	2008	2009	2010	2011
Actual value	7.38	8.80	8.09	10.07	12.06	14.00
Predictive value	7.38	7.80	8.98	10.35	11.92	13.72

Year	2012	2013	2014	2015	2016
Actual value	–	–	–	–	–
Predictive value	18.22	20.99	24.18	27.85	32.08

$$Y_N = [8.80,\ 8.09,\ 10.07,\ 12.06,\ 14.00]$$

$$\mathrm{B}, \mathrm{Y}_N \text{ into } \alpha = (a, \mathrm{u})^T = \left(\mathrm{B}^\mathrm{T}\mathrm{B}\right)^{-1}\mathrm{B}^\mathrm{T}\mathrm{Y}_\mathrm{N},$$

Get $\alpha = [-0.1414 \quad 6.2195]^T$
(With the help of MATLAB) (Lee and Ruan 2013; Shi and Teng 2004)
Take parameter vector α into the differential equation:

$$\frac{\mathrm{dx}^{(1)}}{\mathrm{dt}} - 0.1414\mathrm{x}^{(1)} = 6.2195$$

Get prediction model as follows:

$$\begin{aligned}\mathrm{x}^{(1)}(k+1) &= \left[x^{(0)}(1) - \frac{u}{a}\right]e^{-ak} + \frac{u}{a} \\ &= \left[51.37 \times e^{0.1414k}\right] - 43.99\end{aligned}$$

And then by the formula:

$$\mathrm{x}^{(0)}(k) = x^{(1)}(k) - x^{(1)}(k-1) \text{ to restore}$$

Thus available the container throughput predictive value of Jiujiang port from 2006 to 2011 (Table 6.3), forecast and actual values is close.

6.3.2 Test the Accuracy of the Model

Posteriori difference inspection carried out for the model: The mean of the original data for: $\bar{\mathrm{x}} = 10.067$; The mean of the residuals is: $\bar{\mathrm{q}} = 0.0416$; The variance of the original data for: $\mathrm{s}_1^2 = 4.47$; $\mathrm{s}_1 = 2.114$; Variance of the residuals: $\mathrm{s}_2^2 = 0.337$; $\mathrm{s}_2 = 0.58$; the ratio of a posteriori difference: $\mathrm{c} = \frac{s_2}{s_1} = 0.27$; Small probability of error: $\mathrm{p} = 1$.

According to Table 6.1, $\mathrm{p} = 1 > 0.95$, $\mathrm{c} = 0.27$, it can be judged that the prediction is comparatively accurate. Therefore, this prediction model can predict the container throughput of Jiujiang Port in the next few years, which is shown in Table 6.3.

The calculated results show that Gray System Theory is more accurate to predict the container throughput of Jiujiang port. The calculations and statistics are very close. From the predicted results can be seen, the growth rate of the container throughput of Jiujiang port in the next 5 years is fast and stable. It can be inferred that the container transport of Jiujiang port will be greatly developed. The basic data of the model is established on the basis of the 2006–2011 objective statistics. In 2012 and the coming years, there are some unknown factors, which are difficult to determine and affect the economic environment and the development of logistics industry. Objectively speaking, the model also has a certain degree of uncertainty, but as the development of the industry prediction, it has a relatively reliable reference.

6.4 Suggestions to Jiujiang Port

Taking the development needs of the Jiujiang port, container throughput prediction and the actual situation of Jiujiang port into account, specific measures for the development of port logistics to Jiujiang port are provided as following.

6.4.1 Strengthening the Policy Guidance and Support of the Government of the Port Logistics

During the "Eleventh Five-Year" period, make good use of the national implementation of the riverside development strategy to promote the construction of the Yangtze golden waterway and to speed up port construction and port opening to create the Jiujiang logistics distribution center, which will become the focus of infrastructure investment in Jiangxi Province in order to enhance the Jiangxi external the level of openness.

6.4.2 Paying More Attention to the Construction of Supporting Transportation Network

A port's development requires a rational and scientific layout and construction. Therefore, full attention should be given supporting the construction of integrated transport network of railways, highways, waterways and other modes of transportation, which can be brought into full play of the advantage of port throughput. Dock construction is the leading part to strengthen the railways, highways supporting system (Zheng 2011; Jiao and Huang 2008).

6.4.3 Enhancing Service Awareness and Improving the Management Level

Establishing the concept of logistics services, providing customers with safe, cheap, fast and punctual container transportation and logistics services is the key to form the mutual trust and to achieve a win–win situation. The port is able to provide customers with a multi-functional container logistics services to meet the logistics needs of the personalized customers. Great efforts must be made to train and preserve all kinds of talents, who are required for the development of the port.

Improving the status and responsibility distribution system, giving full play to the enthusiasm of the staff of the enterprise is also needed to form a good corporate culture and provide a strong backing for the further development of Jiujiang port.

6.4.4 Expanding the Economic Hinterland to Promote the Establishment of Cooperation Mechanisms

An economic hinterland is an area which the economic center can be touched and can promote their economic development. Under the concept of modern logistics, these factors which affect the development of the port are growing, such as ports and the hinterland, the degree of value-added services capacity. After the opening of the Beijing-Kowloon Railway, the hinterland economy of Jiujiang port will be even broader. Jiujiang port is not only responsible for loading and unloading tasks for the pillar industries transit in Jiangxi Province but also gradually expands to inland provinces such as Hubei, Sichuan and Henan. In the strategy of opening up along the river, Jiujiang must strengthen the cooperation of the adjacent regional cities inside and outside the province and promote the establishment of cooperation mechanisms (Yanbing and Liang 2003).

In summary, Jiujiang port should integrate existing resources to strengthen infrastructure construction, to accelerate the chain structures of port container logistics services, and to improve the efficiency of service operations to container stations and operational management level. The goal is to provide a powerful guarantee for the rapid development of Jiujiang port container transport.

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Chapter 7
A Rapid Data Processing and Assessing Model for "Scenario-Response" Types Natural Disaster Emergency Alternatives

Daji Ergu, Gang Kou and Yong Zhang

Abstract In the processes of assessing the emergency alternatives of "scenario-response" types natural disaster by Analytic Hierarchy (Network) Process (AHP/ANP), the elements or data of the scenario itself, the real-time data and the trend factors of the evolution of "scenario-response" types natural disaster emergencies etc. are usually inconsistent and intangible, which increase the difficulty of emergency alternatives assessment and delay the speed of emergency response. Therefore, in this paper, a logarithm mean induced bias matrix (LMIBM) model is proposed to quickly process the inconsistent data of "scenario-response" type's natural disaster when AHP/ANP is used to assess the natural disaster emergency alternatives and evolution trend factors of natural disaster emergency accidents. Two numerical examples are used to illustrate the proposed model, and the results show that LMIBM can quickly identify the inconsistent natural disaster data and improve the speed of emergency alternatives assessment and natural disaster response by AHP/ANP.

Keywords AHP/ANP · Data processing · Emergency alternatives assessment · Logarithm mean induced bias matrix · Natural disaster

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E. Qi et al. (eds.), *The 19th International Conference on Industrial Engineering and Engineering Management*, DOI: 10.1007/978-3-642-38391-5_7,

7.1 Introduction

In recent years, a number of studies on unexpected natural disaster emergency alternatives assessment from different perspectives have been conducted by many scholars since natural disasters have caused significant economic, social, financial, property and infrastructure damages as well as tragic loss of human lives worldwide (Xu and Lu 2009; Zhong et al. 2010; Wei et al. 2004; Bina and Edwards 2009). Quick assessment and scenario-response are very important for disaster managers to save lives and reduce the property losses in unexpected natural disaster emergency management (Tsai and Chen 2010, 2011). Therefore, "scenario-response" type's unexpected natural disaster emergency management is becoming a new hot research topic.

However, the involved attributes of "scenario-response" types natural disasters are different and usually intangible, which need to be quantified into quantitative values. The elements or data of the scenario itself, the real-data and the trend factors of the evolution of "scenario-response" type's natural disaster emergencies etc. are also usually inconsistent and intangible, which increase the difficulty of emergency alternatives assessment and delay the speed of emergency response. In addition, emergency management is regarded as a complex multi-objective optimization problem, e.g. selecting the best emergency response alternatives or emergency recovery alternatives and reasonably allocates relief resources etc., (Tufekci and Wallace 1998).

Furthermore, the unconventional characteristic of natural disaster evolution law increases the difficulty of quick assessment and response. The pairwise comparison technique, displayed as a positive reciprocal matrix in the Analytic Hierarchy Process (AHP) (Saaty 1994) and Analytic Network Process (ANP) (Levy and Taji 2007), is a well-established and widely used technique to deal with the intangible disaster attributes and assess the natural disaster emergency alternatives. However, the consistency issue in a positive reciprocal matrix is a big challenge that the emergency managers are facing, and it has been extensively studied over the past few decades, e.g. Koczkodaj and Szarek developed distance-based inconsistency reduction algorithms for pairwise comparisons (Koczkodaj and Szarek 2010; Cao et al. 2008) proposed a heuristic approach to modify the inconsistent comparisons in analytic hierarchy process, Li and Ma employed a Gower plot to detect ordinal and cardinal inconsistencies (Li and Ma 2007). Ergu et al. (2011b) proposed an induced bias matrix (IBM) model to improve the consistency ratio and further extended it to process data consistency in emergency management (Ergu et al. 2012) and in risk assessment and decision analysis (Ergu et al. 2011a). Based on the proposed induced bias matrix (IBM) model, in this paper, a logarithm mean induced bias matrix (LMIBM) model is proposed to process the inconsistent disaster data and simplify the observed numbers in order to improve the speed of disaster assessment and response when AHP/ANP is used.

The rest of this paper is organized as follows. The next section presents the theorems, corollary as well as the identifying processes of LMIBM. Two numerical examples are used to test the proposed model in Sect. 7.3. Section 7.4 concludes the paper.

7.2 Logarithm Mean Induced Bias Matrix (LMIBM)

7.2.1 The Theorem of LMIBM

Definition 7.1 Matrix $A = [a_{ij}]_{n \times n}$ is said to be perfectly cardinal consistency if $a_{ij} = a_{ik}a_{kj}$ holds for all *i, j* and *k*, where $a_{ij} > 0$ *and* $a_{ij} = 1/a_{ji}$ for all *i*, *j*, and *k*.

Theorem 7.1 *The logarithm mean induced bias matrix (LMIBM) C should be a zero matrix if matrix A is perfectly consistent, that is,*

$$\begin{cases} C = \frac{1}{n}\log\prod A - \log A = 0 \\ \left(c_{ij}\right) = \left(\frac{1}{n}\log\prod\limits_{k=1}^{n} a_{ik}a_{kj} - \log a_{ij}\right) = 0 \end{cases} \tag{7.1}$$

Proof Since matrix A is perfectly consistent, namely, $a_{ik}a_{kj} = a_{ij}$ holds for all *i*, *j* and *k*, we have

$$\begin{aligned} c_{ij} &= \frac{1}{n}\log\prod_{k=1}^{n} a_{ik}a_{kj} - \log a_{ij} \\ &= \frac{1}{n}\log a_{ij}^{n} - \log a_{ij} = 0 \end{aligned}$$

Therefore, all values in matrix C are zeroes, and matrix C is a zero matrix if matrix A is perfectly consistent. □

Obviously, the above model can be transformed to the following models in terms of the properties of logarithm function:

$$\begin{cases} C = \log\sqrt[n]{\prod A} + \log A^{T} = 0 \\ \left(c_{ij}\right) = \left(\log\sqrt[n]{\prod\limits_{k=1}^{n} a_{ik}a_{kj}} + \log a_{ji}\right) = 0 \end{cases} \tag{7.2}$$

$$\begin{cases} C = \log\sqrt[n]{\prod A} \circ A^{T} = 0 \\ \left(c_{ij}\right) = \left(\log\sqrt[n]{\prod\limits_{k=1}^{n} a_{ik}a_{kj} \cdot a_{ji}}\right) = 0 \end{cases} \tag{7.3}$$

Theorem 7.2 *The logarithm mean induced bias matrix (LMIBM) C is an anti symmetric matrix if matrix A is inconsistent, that is,*

$$\begin{cases} C = -C^T \\ c_{ij} = -c_{ji} \end{cases} \tag{7.4}$$

Proof By formula (7.1) and the reciprocal property, we have

$$\begin{aligned} c_{ji} &= \frac{1}{n}\log\prod_{k=1}^{n} a_{jk}a_{ki} - \log a_{ji} = \frac{1}{n}\log\prod_{k=1}^{n}\frac{1}{a_{kj}a_{ik}} - \log\frac{1}{a_{ij}} \\ &= \frac{1}{n}\left(-\log\prod_{k=1}^{n} a_{kj}a_{ik} + \log a_{ij}\right) = -c_{ij} \end{aligned}$$

□

Corollary 7.1 *There must be some inconsistent entries in the logarithm mean induced bias matrix (LMIBM) C deviating from zero if the matrix A is inconsistent. Especially, any row or column of matrix C contains at least one non-zero entry.*

Proof by contradiction: Assume all entries in matrix C are zeroes even if the judgment matrix A is inconsistent, that is, $a_{ik}a_{kj} \neq a_{ij}$ holds for some i, j and k, but $c_{ij} = 0$, $(i, j = 1, \ldots, n)$, namely

$$c_{ij} = \frac{1}{n}\log\prod_{k=1}^{n} a_{ik}a_{kj} - \log a_{ij} = 0$$

We can get

$$a_{ij} = \sqrt[n]{\prod_{k=1}^{n} a_{ik}a_{kj}} = \sqrt[n]{\prod_{l=1}^{n} a_{il}a_{lj}}$$

Since $a_{lk} = 1/a_{kl}$, we can obtain

$$\begin{aligned} a_{ij} &= \sqrt[n]{\prod_{l=1}^{n} a_{il}a_{lk}a_{kl}a_{lj}} = \sqrt[n]{\prod_{l=1}^{n} a_{il}a_{lk}} \cdot \sqrt[n]{\prod_{l=1}^{n} a_{kl}a_{lj}} \\ &\Rightarrow a_{ij} = a_{ik}a_{kj} \end{aligned}$$

The result contradicts the previous assumption that $a_{ij} \neq a_{ik}a_{kj}$ for some j and k, and $c_{ij} = 0$. Therefore, any row or column of matrix C contains at least one non-zero entry. □

Based on Corollary 7.1, the most inconsistent data in matrix A can be identified by observing the largest value in the logarithm mean induced bias matrix C. According to *Theorem 7.2*, there are two equal absolute largest values in matrix C since the values are anti symmetric, therefore, one can either observe the absolute largest value above or below the main diagonal in the matrix C, which simplify the observing number of times to $n(n - 1)/2$ and improve the speed of disaster assessment.

7.2.2 The Processes of Inconsistency Identification by LMIBM

In this section, the processes of inconsistency identification by LMIBM are proposed based on above *Theorems* and *Corollary*, including three steps:

Step 1: Compute a column matrix L and a row matrix R, as shown in the two edges of matrix A.

$$L =$$

$$A = \begin{pmatrix} a_{11} & \cdots & a_{1i} & \cdots & a_{1j} & \cdots & a_{1n} \\ & \vdots & & \vdots & & \vdots & \\ a_{i1} & \cdots & a_{ii} & \cdots & a_{ij} & \cdots & a_{in} \\ & \vdots & & & & \vdots & \\ a_{j1} & \cdots & a_{ji} & & a_{jj} & \vdots & a_{jn} \\ & & & & & & \\ a_{n1} & \cdots & a_{ni} & \cdots & a_{nj} & \cdots & a_{nn} \end{pmatrix} \begin{matrix} \prod_{k=1}^{n} a_{1k} \\ \prod_{k=1}^{n} a_{ik} \\ \prod_{k=1}^{n} a_{jk} \\ \prod_{k=1}^{n} a_{nk} \end{matrix}$$

$$R = \prod_{k=1}^{n} a_{k1}, \cdots \prod_{k=1}^{n} a_{ki}, \cdots \prod_{k=1}^{n} a_{kj}, \cdots \prod_{k=1}^{n} a_{kn}$$

where

$$\begin{cases} L = \left(\prod_{k=1}^{n} a_{1k}, \quad \cdots \quad \prod_{k=1}^{n} a_{ik}, \quad \cdots, \quad \prod_{k=1}^{n} a_{jk}, \quad \cdots, \quad \prod_{k=1}^{n} a_{nk} \right)^{T} \\ R = \left(\prod_{k=1}^{n} a_{k1}, \quad \cdots \quad \prod_{k=1}^{n} a_{ki}, \quad \cdots \quad \prod_{k=1}^{n} a_{kj}, \quad \cdots, \quad \prod_{k=1}^{n} a_{kn} \right) \end{cases} \tag{7.5}$$

Step 2: Compute logarithm mean induced bias matrix (LMIBM) C by formula,

$$\begin{cases} C = \frac{1}{n} \log \prod A - \log A \\ \left(c_{ij}\right) = \left(\frac{1}{n} \log \prod_{k=1}^{n} a_{ik} a_{kj} - \log a_{ij} \right) \end{cases} \tag{7.6}$$

where

$$\prod A = L \times R = \left(\prod_{k=1}^{n} a_{ik} a_{kj} \right)_{n \times n}$$

Step 3: Observe the absolute largest values above or below the main diagonal of matrix C, here denoted as $c_{ij}^{\max}$, then we can easily identify the corresponding a_{ij} in matrix A as the most inconsistent data. If there are other entries whose values are close to $c_{ij}^{\max}$, they can be identified as the most inconsistent entries.

7.2.3 The Processes of Inconsistency Adjustment by LMIBM

In above section, the most inconsistent data is identified. In the following, the estimating formula of identified inconsistent data is derived to adjust the identified inconsistent data. Assume a_{ij} is the identified inconsistent data, which is corresponding to the $c_{ij}^{\max}$ in matrix C, we have

$$\begin{aligned} c_{ij}^{\max} &= \frac{1}{n}\log\prod_{k=1}^{n} a_{ik}a_{kj} - \log a_{ij} \\ &= \frac{1}{n}\log a_{ij}^2 \prod_{lk=1\neq i,j}^{n} a_{ik}a_{kj} - \log a_{ij} \\ &= \frac{1}{n}\log a_{ij}^2\tilde{a}_{ij}^{n-2} - \log a_{ij} \end{aligned}$$

We can get

$$\begin{aligned} nc_{ij}^{\max} &= \log a_{ij}^2\tilde{a}_{ij}^{n-2}/a_{ij} \\ \Rightarrow \tilde{a}_{ij} &= a_{ij}\sqrt[n-2]{10^{nc_{ij}^{\max}}} = a_{ij}10^{\frac{nc_{ij}^{\max}}{n-2}} \end{aligned} \tag{7.7}$$

Therefore, the identified inconsistent can be estimated by formula (7.7).

7.3 Illustrative Examples

Assume a decision maker needs to quickly assess the disaster degree of four places attacked by earthquake with respect to the indirect economic loss to make a "scenario-response" types relief resource allocation, the 4×4 matrix A with $CR = 0.173 > 0.1$ used in Ergu et al. (2011b) and Liu (1999) is assumed to be the collected judgment matrix by emergency expert in this paper, that is,

$$A = \begin{pmatrix} 1 & 1/9 & 3 & 1/5 \\ 9 & 1 & 5 & 2 \\ 1/3 & 1/5 & 1 & 1/2 \\ 5 & 1/2 & 2 & 1 \end{pmatrix}$$

Apply the LMIBM to this matrix.

7.3.1 Step I: Inconsistency Identification

Step 1: Compute the column matrix L and the row matrix R by formula (7.5),

$$L = \begin{pmatrix} 0.0667 & 90 & 0.0333 & 5 \end{pmatrix}^T$$

,

$$R = \begin{pmatrix} 15 & 0.0111 & 30 & 0.2 \end{pmatrix}$$

Step 2: Compute LMIBM C by formula (7.6), we get

$$C = \frac{1}{4}\log(L \times R) - \log A = \begin{pmatrix} 0 & 0.1717 & -0.4019 & 0.2302 \\ -0.1717 & 0 & 0.1589 & 0.0128 \\ 0.4019 & -0.1589 & 0 & -0.2430 \\ -0.2302 & -0.0128 & 0.2430 & 0 \end{pmatrix}$$

Step 3: Identify the absolute largest value $c_{ij}^{\max}$ either above the main diagonal in matrix C or below it. Here the data below the main diagonal are used, and we obtain that $c_{ij}^{\max} = c_{31}^{\max} = 0.4019$, then the corresponding element a_{31} in matrix A is regarded as the most inconsistent entry.

7.3.2 *Step II: Inconsistency Adjustment*

Applying formula (7.7) to estimate the possible proper value of a_{31}, we get

$$\tilde{a}_{31} = a_{31}10^{\frac{4}{4-2}c_{31}} = \frac{1}{3}10^{2\times 0.4019} = 2.1217 \approx 2$$

Therefore, the identified inconsistent data and its estimated value are the same as the ones in (Ergu et al. 2011b) and (Liu 1999), whose $CR = 0.0028 < 0.1$, but the number of observed entries is reduced to 6 entries.

In the following, an 8 × 8 pair-wise comparison matrix A introduced in Cao et al. (2008), Ergu et al. (2011b) and Xu and We (1999) is introduced to test the proposed model for matrix with high order.

$$A = \begin{bmatrix} 1 & 5 & 3 & 7 & 6 & 6 & 1/3 & 1/4 \\ 1/5 & 1 & 1/3 & 5 & 3 & 3 & 1/5 & 1/7 \\ 1/3 & 3 & 1 & 6 & 3 & 4 & 6 & 1/5 \\ 1/7 & 1/5 & 1/6 & 1 & 1/3 & 1/4 & 1/7 & 1/8 \\ 1/6 & 1/3 & 1/3 & 3 & 1 & 1/2 & 1/5 & 1/6 \\ 1/6 & 1/3 & 1/4 & 4 & 2 & 1 & 1/5 & 1/6 \\ 3 & 5 & 1/6 & 7 & 5 & 5 & 1 & 1/2 \\ 4 & 7 & 5 & 8 & 6 & 6 & 2 & 1 \end{bmatrix}$$

Applying the LMIBM to this matrix.

7.3.3 Step I: Inconsistency Identification

Step 1: The column matrix L and the row matrix R by formula (7.5) are,

$$L = (315 \quad 0.0857 \quad 86.4 \quad 0 \quad 0.0009 \quad 0.0037 \quad 218.75 \quad 80640)$$

$$R = (0.0032 \quad 11.6667 \quad 0.0116 \quad 141120 \quad 1080 \quad 270 \quad 0.0046 \quad 0)$$

Step 2: Compute LMIBM C by formula (7.6), we get

$$C = \frac{1}{8}\log(L \times R) - \log A$$
$$= \begin{pmatrix} 0 & -0.2533 & -0.4069 & 0.1109 & -0.0867 & -0.1619 & 0.4969 & 0.3010 \\ 0.2533 & 0 & 0.1017 & -0.1886 & -0.2313 & -0.3066 & 0.2731 & 0.0984 \\ 0.4069 & -0.1017 & 0 & 0.1076 & 0.1441 & -0.0561 & -0.8286 & 0.3277 \\ -0.1109 & 0.1886 & -0.1076 & 0 & 0.2126 & 0.2623 & -0.0911 & -0.3539 \\ 0.0867 & 0.2313 & -0.1441 & -0.2126 & 0 & 0.2258 & 0.0273 & -0.2143 \\ 0.1619 & 0.3066 & 0.0561 & -0.2623 & -0.2258 & 0 & 0.1026 & -0.1391 \\ -0.4969 & -0.2731 & 0.8286 & 0.0911 & -0.0273 & -0.1026 & 0 & -0.0198 \\ -0.3010 & -0.0984 & -0.3277 & 0.3539 & 0.2143 & 0.1391 & 0.0198 & 0 \end{pmatrix}$$

Step 3: The absolute largest value $c_{ij}^{\max}$ above the main diagonal in matrix C is $c_{37}^{\max} = -0.8286$, then the corresponding element a_{37} in matrix A is regarded as the most inconsistent entry.

7.3.4 Step II: Inconsistency Adjustment

Applying formula (7.7) to estimate the possible proper value of a_{37}, we get

$$\tilde{a}_{37} = a_{37}10^{\frac{8}{8-2}c_{37}} = 610^{8/6\times(-0.8286)} = 0.4714 \approx 1/2$$

The identified inconsistent data are the same as the ones in Cao et al. (2008), Ergu et al. (2011b) and Xu and We (1999), whose $CR = 0.0828 < 0.1$, but the number of observed entries is reduced to 28 entries instead of 56.

7.4 Conclusion

In this paper, a logarithm mean induced bias matrix (LMIBM) is proposed to quickly process the inconsistent disaster data when AHP and ANP are used to assess the “scenario-response” type’s natural disaster emergency alternatives. The processes of inconsistency identification of LMIBM and estimating formula are proposed and derived. Two numerical examples are used to illustrate the proposed model. Since LMIBM is not only based on the original matrix and independent to the way of deriving the priority weights, but also can reduce the observed number of the induced bias data, therefore, the proposed model can speed up the processes of inconsistent disaster data identification in a judgment matrix and improve the speed of "scenario-response" types disaster emergency alternatives assessment and response.

Acknowledgments This research has been supported by grants from the talent research plan of Foxconn Technology Group (11F81210001).

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Chapter 8
A Research on Value of Individual Human Capital of High-Tech Enterprises Based on the BP Neural Network Algorithm

Xiu-fen Li and Ping Zhang

Abstract Based on the review of relevant research, this paper combines with the characteristics of individual human capital of high-tech enterprises and constructs a comprehensive evaluation index system including four first-level indicators and sixteen secondary indicators. Using the BP algorithm of neural network model, based on thirty equipment manufacturing enterprises, this paper also establishes an evaluation model of the value of individual human capital for the chief engineer. It holds that although there exist many approaches to evaluating individual human capital value, many problems still remain unresolved, such as: too broad concept definition, a lack of understanding of the specificity of evaluation object, a single evaluation method and inadequacy of practicability or improper model design, and among others the critical problem in the evaluation of human capital value lies in the fact that the system cannot be truly applied to practice.

Keywords BP neural network algorithm · High-tech enterprises · Human capital

8.1 Introduction

Discussion on value of managers has been derived from the practice of early human activities. The famous ancient Greek philosopher Plato has divided people (according to their social values) in his *Utopia* into three classes, deeming it was determined by the talent of man's character. Ancient Roman slave-owners and thinkers Gato and Varro focused on the selection criteria of the chamberlain in *On Agriculture,* while in the eighteenth century, the father of "free economy" Adam Smith has already regarded human as a form of capital. According to Neo-classical

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E. Qi et al. (eds.), *The 19th International Conference on Industrial Engineering and Engineering Management*, DOI: 10.1007/978-3-642-38391-5_8,

economics, capital refers specifically to "useful" production items, such as machines and buildings, and the human is seen as two parts: ordinary labor and entrepreneur's talent (Guo 2003). To Marx, the concept of capital is not an urgent problem to be resolved, rather, it is "but a ridiculous problem derived from the cumbersome economics itself." Marx explained the definition of labor (or laboring ability), namely, "the human body, living exists in the human body, whenever a person the production of a use value, the use of physical and mental sum of" (Marx 1975).

Modern human capital theory is usually recognized as being from Schultz (1990), who believe that human capital is an embodiment of productive capacity, skills and knowledge on the workers and one of the forms of capital as well. Evaluation of the value of human capital initiates from the American Accounting scientist Flamholtz (1986). Schultz (1961) and Becker (1962) laid a measure system of human capital from the methodology. Currently, The currency measure system in terms of the value of human capital can be divided into two kinds: methods adopted from the aspects of the cost, such as historical cost, replacement cost method, cost of investment in education (Zhang 2007); methods adopted from the aspects of the value measurement, such as random pay, future earnings, discounted future wage adjusted discounted, non-purchased goodwill method, economic value measurement method, workers' rights, producers' rights, options method (Yang and Kong 2005).

Particularity of the high-tech enterprises human capital, namely, the high proportion of knowledge staff, is determinant for the type of capital in exerting lasting and significant impact on business growth (Dai 2006). To tap, utilize and stabilize human capital, to improve the composition of human capital aggregates, thus forming an advantage of human capital in enhancing the core competitiveness of enterprises, a scientific evaluation must be done to the value of human capital. A study of the assessment of high-tech human capital is of great significance in terms of scientifically determining the human capital status, attracting, retaining and training talents, and exerting advantage of high-tech enterprises human capital.

8.2 Methodology

8.2.1 Conformation of the Index System

Based on the latest research results from domestic and foreign scholars (Fu 2007), combined with the characteristics of individual human capital of high-tech enterprises, the present paper holds that the value of human capital in this sort of enterprises includes four parts: the existing value of human capital, the value of the contribution of human capital, the ongoing costs and opportunity cost of human capital. Their relationship is as follows:

$$\begin{aligned}\text{the total value of Human capital } = & \text{ the existing value of human capital} \\ & + \text{the potential value of human capital} \\ & - \text{replacement costs of human capital} \\ & - \text{opportunity cost of human capital}\end{aligned} \tag{8.1}$$

Among them: the existing value of human capital is from the external (or past) factors of the enterprises, determined by the staff's physiological conditions, abilities, education status, work experience and the previous contributions to the enterprise. The potential value of human capital stands for the present value of the expected contribution value of employees in the enterprise. The ongoing costs of human capital stands for the must investment in human capital making contribution continually, including the expenditure of the staff's recruitment, training, and physiology, and so on. The opportunity cost of human capital is the maximum possible gains brought by other options based on the same cost. Evaluation index system of high-tech enterprise human capital value is shown in Tables 8.1, 8.2.

Table 8.1 Evaluation index system

The target layer	First-level indicators	Second-level indicators
Human capital value	Existing value of human capital	Education
		Work experience
		Professional knowledge and skills
		Age
		Gender
		State of health
		Assessment of the previous contribution
	Potential value of human capital	Improvement of the enterprise's social reputation
		Average growth rate of the general output value
		Improvement of the collaboration of teamwork
	Ongoing costs of human capital	Total cost of the recruitment
		Total cost of investment in training
		Vacation, entertainment costs
		Wage income
		Other income
	Opportunity cost of human capital	Average contribution of similar personnel

Table 8.2 Quantified description of related indicators

The existing value of human capital
Education: divided into three level, represented respectively by the dummy variable "−1", "0", "1"
Work experience: service year of same type work × 1 + service year of different types of work × 0.5
Professional knowledge and skills: divided into three level, represented respectively by the dummy variables "−1", "0" and "1"
Age: divided into two levels, represented respectively by the dummy variables "0" and "1"
Gender: represented respectively by the dummy variables "0", "1"
Health status: divided into two levels, represented respectively by the dummy variables "0" and "1"
Evaluation of previous contribution: staff's previous average economic contribution
Potential value of human capital
Improvement of the enterprise's social reputation: represented by the dummy variable "0" and "1"
Average growth rate of the general output value: the contribution of the staff should at least not below the average level, represented by the enterprise's average growth rate of total output value of the latest three years
Improvement of the collaboration of teamwork: divided into three levels, represented respectively by dummy variables "−1", "0" and "1"
Ongoing costs of human capital
Total cost of the recruitment: covers various recruiting costs
Total cost of investment in training: covers various personnel training costs
Vacation, entertainment costs: represented by the gains from assumed normal work
Wage income: covers various wage earnings
Other income: covers various non-salary earnings
Opportunity cost of human capital
Average contribution of similar personnel: It's a conservative estimate, i.e., the greatest value of contribution from other personnel, should at least not be less than the average economic contribution

8.2.2 The Evaluation Approaches of Bp Neural Network

At present, the neural network model has been developed into many types, of which the most representative is the multi-layer perception neural network. In 1985, Rume jhart proposed the error back-pass learning algorithm, realizing Minsky's multi-layer network assumption, which can be shown in (Cheng et al. 2008) (Fig. 8.1).

BP neural network algorithm not only has the input layer nodes and output layer nodes, but also has one or more hidden layer contacts. For the input signal, it should first of all pass forward to the hidden layer nodes, after the role of function, then pass the output signal at the hidden layer nodes to the output layer nodes, and finally give the output. The S-shaped function is usually chosen as the activation function at the node.

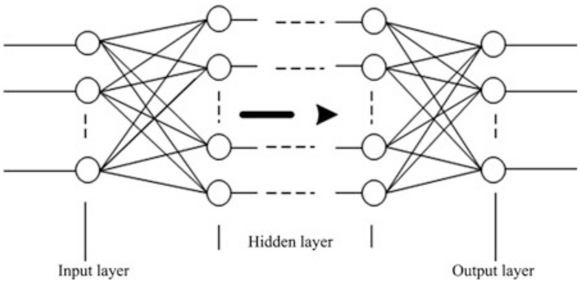

Fig. 8.1 Neural network algorithm structure

Such as:

$$f(X) = \frac{1}{1 + e^{-x/Q}},$$

where Q is the Sigmoid parameter adjusting the form of activation function. The learning process of the algorithm consists of forward propagation and back propagation. In the forward propagation process, the input information from the input once the hidden layer, processing layer by layer, and transferring to the output layer. State of each layer of neurons will influence the state of next layer of neurons. If the output layer fails to receive the desired output, then it will switch to back propagation, returning the error signal along the connection channel, and by modifying the right values of all layers of neurons, making the minimum error signal.

Set an arbitrary network containing n nodes, each node is of Sigmoid type. Set the network has only one output y, the output of any node i O_i, and set N samples (X_k, Y_k) (k = 1, 2, 3,…, N), to a particular input X_k, the network output Y_k of node i for O_{ik}, then the input of node j is:

And the error function is defined as

$$E = \frac{1}{2}\sum_{k=1}^{N}\left(y_k - y_k^1\right)^2,$$

where y_k^1 is the actual output of the network, define $E_k = \left(y_k - y_k^1\right)^2, \quad \&_{jk} = \frac{\partial E_k}{\partial net_{jk}}, \quad net_{jk} = \sum_i W_{ij} O_{ik},$

And $O_{jk} = f\left(net_{jk}\right)$, so, $\frac{\partial E_k}{\partial W_{ij}} = \frac{\partial E_k}{\partial net_{jk}} \frac{\partial net_{jk}}{\partial W_{ij}} = \frac{\partial E_k}{\partial net_{jk}} O_{ik} = \&_{jk} O_{ik}$

When j is the output node, $O_{jk} = \widehat{y}_k$,

$$\delta_{jk} = \frac{\partial E_k}{\partial \widehat{y}_k} \frac{\partial \widehat{y}_k}{\partial net_{jk}} = -(y_k - \widehat{y}_k) f'(net_{jk})$$

If j is not the output node, then:

$$\delta_{jk} = \frac{\partial E_k}{\partial net_{jk}} = \frac{\partial E_k}{\partial O_{jk}} \frac{\partial O_{jk}}{\partial net_{jk}} = \frac{\partial E_k}{\partial O_{jk}} f'(net_{jk})$$

$$\begin{aligned}\frac{\partial E_k}{\partial O_{jk}} &= \sum_m \frac{\partial E_k}{\partial net_{mk}} \frac{\partial net_{mk}}{\partial O_{jk}} \\ &= \sum_m \frac{\partial E_k}{\partial net_{mk}} \frac{\partial}{\partial O_{jk}} \sum_i W_{mi} O_{ik} \\ &= \sum_m \frac{\partial E_k}{\partial net} \sum_i W_{mj} \\ &= \sum_m \delta_{mk} W_{mj}\end{aligned}$$

Thus:

$$\begin{cases} \delta_{jk} = f'(net_{jk}) \sum_m \delta_{mk} W_{mj} \\ \frac{\partial E_k}{\partial W_{ik}} = \delta_{mk} O_{ik} \end{cases}$$

The above algorithm indicates that the BP model converts the I/O problem of a set of samples to a nonlinear optimization problem, reaching an effective dimension reduction effect.

In the human capital evaluation index system of high-tech enterprises, individual variables and overall enterprise variables, the relative indicators and absolute indicators are taken into consideration, besides, dummy variables are also introduced. By adopting BP artificial neural network approach and standardizing the data, a dimensionless comprehensive result of evaluation can be drawn. In the process of learning about Network model itself, network parameters should be constantly adjusted until gaining desired output to meet the requirements.

8.3 Results

The Original empirical data come from the survey questionnaire of “the technological innovation power of Lanzhou city in 2006”. The survey had 148 valid questionnaires returned, and the choosing of industry was based on the criteria for the classification of “high-tech industry” from the classification categories of high-tech industry released in 2002 by National Bureau of Statistics. To make the sample data strong in comparability, the present paper selected 30 equipment manufacturing enterprises, established for the chief engineer an evaluation model of individual human capital value.

Normalize the 30 groups of sample observations the data between 0 and 1, 15 of which as model building data, and the rest 15 as model test data. The input parameters of BP neural network model are: input nodes being 17, the intermediate layer being 1, the middle layer nodes being 12, the minimum training rate being 0.1, the dynamic parameters being 0.6, the Sigmoid parameter being 0.9,

Table 8.3 Final fitting state of model

The fitting of the modeling samples				The fitting of the testing samples		
Number	Expert ratings	Model ratings	Error	Expert ratings	Model ratings	Error
1	0.9091	0.9100	0.0009	0.9697	0.9698	0.0001
2	0.9697	0.9688	0.0009	0.9194	0.9190	0.0004
3	0.9394	0.9399	0.0005	0.9683	0.9693	0.001
4	0.9495	0.9499	0.0004	0.9545	0.9544	0.0001
5	0.9293	0.9300	0.0007	0.9191	0.9159	0.0032
6	0.9394	0.9400	0.0006	0.9094	0.9084	0.0010
7	0.9697	0.9684	0.0013	0.9698	0.9696	0.0002
8	0.9394	0.9400	0.0006	0.9694	0.9698	0.0004
9	0.9495	0.9500	0.0005	0.9693	0.9697	0.0004
10	0.9697	0.9683	0.0014	0.9694	0.9676	0.0018
11	0.9293	0.9301	0.0008	0.9672	0.9675	0.0003
12	0.899	0.9012	0.0022	0.9194	0.9197	0.0003
13	0.9394	0.9401	0.0007	0.9693	0.9671	0.0022
14	0.9697	0.9680	0.0017	0.9699	0.9684	0.0015
15	0.9596	0.9600	0.0004	0.9694	0.9698	0.0004

permissible error being 0.001, and the maximum number of iterations being 1000. After 280 iterations, the error of neural network comes close to zero, the fitting residuals of the model are about 0.0001677, and thus the training result is desirable. Weights of each node in the Model are shown in Table 8.2.

The final fitting state of the model is shown in Table 8.3. The average error of the 15 groups of modeling samples is 0.000979, while the average error of the 15 groups of testing samples is 0.000887. The learning result of the whole model is desirable, and also fits the testing samples well. Therefore, the above model can be used for the chief engineer in other similar enterprises to conduct the evaluation on the individual human capital value.

8.4 Conclusion

At present, there are many approaches in terms of the study of human capital value, mainly for the following three reasons:

First, the definition of the concept of human capital value is overly broad. It is commonly believed that human capital value is derived from labor and creativity, but in reality the embodiment of these factors is different and specific. As is often the case, the newly recruited talents with high education and high titles have not yet created new value, but they are still seen as part of increase of the stock of the enterprise' human capital. In addition, there is a relatively high discrepancy between the potential value of human capital (or expected value) and the actual value.

Second, the object of the evaluation of human capital value has its particularity. While some argue that general human capital evaluation criteria can be established, but due to the variety of evaluation object, the conclusions are quite different. From the point of view of scientific research, the conclusion simply from induction will cause the "problem of induction" (Liang 2007). Owing to the fact that the testing data fail to meet the demands of "random sampling assumes" or "law of large numbers", and "the central limit theorem", those research trying to draw the value of general human capital can mostly lead to a generalization problem (Wooldridge 2003). But the systematic analysis of non-equilibrium random variable regression conducted by Clive Grange (1974) shows that, regardless of the causal relationship between the random variables, the more unstable the variables are, the better the fitting of the regression equation will be.

Third, part of the evaluation approaches to the human capital value is too simple, and its practicability is not enough or the model design is unreasonable, thus it can not be widely adopted in practice because of many problems, such as inadequate of valid indicators, lack of uniqueness of the overall model set, insufficiency of the statistical test of correlative relations, and so forth (Li 2008).

In view of the above problems, this paper holds that the value of human capital evaluation should first define the scope of the study, analyze the characteristics of the evaluation object in order to establish an evaluation index system and construct an evaluation model.

Acknowledgments This paper is supported by the Humanities and Social Science Fund of the Ministry of Education (09XJC790014; 11XJC630008).

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Chapter 9
A Stochastic Programming Model for Evaluating Real Options in Wind Power Investment Projects

Han Qin and L. K. Chu

Abstract This study is concerned with the evaluation of wind power projects under the Clean Development Mechanism (CDM), not only for the purpose of CDM verification, but also for the financing of the project. A real options model is developed in this paper to evaluate the investment decisions on wind power project. The model obtains the real value of the project and determines the optimal time to invest wind power project. Stochastic programming is employed to evaluate the real options model, and a scenario tree, generated by path-based sampling method and LHS discretization, is constructed to approximate the original stochastic program.

Keywords Clean Development Mechanism (CDM) · Stochastic programming · Real options · Wind power investment

9.1 Introduction

Environmental issues have received global attention and carbon trading is considered to be a primary solution to reduce greenhouse gas (GHG) emissions. As a developing country, China is mainly involved in the Clean Development Mechanism (CDM), which is one of the instruments created by the Kyoto Protocol to facilitate carbon trading, and China's corporations related to environmental investments are facing the decision problems under the uncertainty of carbon price.

According to the statistics of international wind energy committee, over 80 % of carbon emissions come from the energy industry, of which 40 % is due to the

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E. Qi et al. (eds.), *The 19th International Conference on Industrial Engineering and Engineering Management*, DOI: 10.1007/978-3-642-38391-5_9,

generation of electricity. Wind energy holds huge potential in emission reduction since it produces no greenhouse gas. Despite the fact that the production of a windmill itself consumes a significant amount of energy (about 3–6 months of power generated by the plant) and hence causing carbon emission, the average life length of wind turbine can last 20 years or so. Since the implementation of CDM, wind power in China gets substantial development. In 2008, there were 314 wind power projects in China, ranking first in the world, amidst the world total of 647.

However, recent wind power project applications have suffered a major setback due to policy changes of the CDM Executive Board (CDM EB). In 2010, up to 14 wind power projects from China were rejected by the CDM EB. For a wind power project to be approved, the applicant has to show that the project can effectively reduce carbon emission and that the project will be profitable—the argument of 'additionality'. It is mainly the latter requirement that rule out projects that need funding from CDM. Also, a project can qualify for CDM funding only if no other private investment has been sought and secured. The CDM EB will not approve an application if the applicant is unable to produce a valid revenue/profit model for evaluation by the CDM EB. Therefore, it is interesting to study the real value of wind power projects under CDM mechanism, not only for the purpose of CDM verification, but also for the financing of the project.

In fact, the revenue of a CDM wind power project comes from two parts: income of electricity and earning from Certified Emission Reductions (CERs). The uncertainty of carbon price makes the evaluation of wind power projects more difficult. Low net present value (NPV) means little reward for investors. However, if the strategic value and options value could be considered also, the real value would be different from traditional NPV.

Traditionally, investment decisions are evaluated by means of the discounted cash flow method (DCF) in which the NPV of an investment is often used. However, DCF often tends to underestimate the value of high technology projects which may actually be viable, mainly because of the conservatively high risk rate assumed at the beginning of the investment. Moreover, DCF is not an adequate methodology as the situation requiring strategic flexibility, where investment decisions can, at some cost, be deferred to some proper future date. Another drawback of DCF is that it cannot deal with the possible varying cost of GHG emission credits.

In reality, corporations have the option to defer investment to some future date. One tool that can prove beneficial in this type of investment environment is the use of real options. This approach treats options at different stages as part of its overall decision making process. A real options model is developed in this paper to evaluate the investment decisions on wind power projects under the CDM mechanism. The model determines the optimal time to invest wind power project using real options. Stochastic programming is employed to evaluate the real options embedded in the wind power project investment.

9.2 Literature Review

9.2.1 Environmental Investment Methods

As organisations are becoming increasingly environmentally conscious, the related investment decisions have become an important consideration for management. Some studies have discussed how environmental investments could benefit organisations (Nehrt 1996; Porter and van der Linde 1995; Bonifant et al. 1995). Nevertheless, many studies seem to investigate the issues in an empirical or conceptual way, and do not incorporate any quantitative analysis. On the other hand, some quantitative techniques have been proposed, such as stochastic dynamic optimisation (Birge and Rosa 1996), mixed integer programming (Mondschein and Schilkrut 1997), activity based costing (Presley and Sarkis 1994), and data envelopment analysis (Sarkis 1999). Although these models are advanced and mathematically complex, the most popular technique used by organisations still is the DCF method, which is essentially a cost-benefit analysis based on the time value of money. The DCF method, which is mainly based on the evaluation NPV, is simple and practical. However, DCF largely has ignored the option to defer an investment. It thus seems that the dynamic option value embedded in the options approach, which can be very useful in analysing some investments, has not been adequately explored in assessing the true value of a technology project.

9.2.2 Real Options Analysis

The fundamental hypothesis of the traditional DCF method is that future cash flows are static and certain, and management does not need to rectify an investment strategy in face of changing circumstances (Myers 1977). Nevertheless, this is inconsistent with the real-life situations. In practice, corporations often face many uncertainties and risks, and the management has to deal address such uncertainties proactively. This means that the issues of operating flexibility time strategy have to be considered (Donaldson et al. 1983).

Other than DCF, real options analysis can be used to deal with investment options and managerial flexibility. The real options method has its roots in financial options, and it is the application and development of financial options in the field of real assets investment. It is generally agreed that the pioneering work in real options was due to Myers (1977). The work suggested that, although corporation investments do not possess of forms like contract as financial options do, investments under a situation of high uncertainty still have characteristics which are similar to financial options.

Therefore, the options pricing method can be used to evaluate the investments. Subsequently, Myers and Turnbull (1977) suggested a 'Growth Options' for corporation investment opportunity. Kester (1984) further developed Myers' research, and argued that even a project with an unfavourable NPV could also have investment value if the manager had the flexibility to defer investment until a later date.

After three decades of development, the theory of real options has become an important branch and a popular research topic. By examining the different managerial flexibility embedded in real options were able to divide real options into seven categories: Option to Defer, Option to Alter Operating Scale, Option to Abandon, Option to Switch, and so on. Other types of options have also been proposed and studied by researchers (O'Brien et al. 2003; Sing 2002).

The real options theory has been applied to investment problems in many different fields including biotechnology, natural resources, research and development, securities evaluation, corporation strategy, technology and so on (Miller and Park 2002). It has also been applied to a gas company in Britain, leading to the conclusion that certain projects are not economically feasible unless they are permitted to have a faster price rise (Sarkis and Tamarkin 2005). Qin and Chu (2011) developed a real options model to determine the optimal time to invest in Carbon Capture and Storage (CCS) project in China, and analysed the behaviour of China green technology business. It took the emission credits cost into consideration and verified the real options analysis by evaluating environmental related investments.

9.2.3 Stochastic Programming

Stochastic programming is a popular modelling framework for decision making problems under uncertainty in a variety of disciplines. Applications can be found in fields such as portfolio optimisation (Cariño et al. 1998; Cariño and Ziemba 1998) and power generation (Dentcheva 1998). Benefited from the well developed optimisation techniques in mathematical programming, stochastic programming is insensitive to the stochastic processes and constraints, and thus can easily be applied to complex decision making problems including valuating compound real options with path dependency. de Neufville (2004) employed stochastic mixed integer programming to manage path dependency and interdependency of compound real options embedded in a water resources planning problem.

In this paper, stochastic programming is chosen for solving the wind power investment problem for the reason that it can easily model the complexity of the portfolio of the real options embedded regardless of the stochastic processes of uncertain factors.

9.3 Real Options Model

A license to invest in a wind power plant is a real option, which means that the investor has the right, but not the obligation, to exercise the payment of investment to obtain the revenue from the project. Facing the uncertain future and the irreversibility of decisions, the investor would value the opportunity to wait and get more information about future conditions. The objective of this real options model is to obtain an optimal timing of a wind power investment decision problem under carbon price uncertainty.

9.3.1 The Deterministic Model

Different from the traditional NPV method, the real options analysis considers not only whether to invest, but also when to invest. The opportunity to invest in a wind power plant could be taken as an option, whose value is given by the following equation:

$$ROV = max(NPV_o) - NPV_s \tag{9.1}$$

where NPV_s is the static NPV of the wind power project investment without considering any management flexibility, i.e., investment is made at stage t = 1. NPV_o is the investment with timing options, i.e., the investor could delay the investment to the optimal time. Let T be the numbers of the planning periods, normally it is around 20 years as the franchise periods of wind power project in China is 25 years, and it takes several years to construct the power plant. The decision variable is denoted as X^t, where X^t is a 0–1 variable. If the investor exercises the investment at stage t, $X^t = 1$. Otherwise $X^t = 0$. $t \in \{1, \ldots, T\}$.

$$X^t = \begin{cases} 1, & \textit{to invest} \\ 0, & \textit{not to invest} \end{cases} \quad t \in \{1, \ldots, T\}$$

Under the CDM mechanism, the revenues due to the investment in wind power come from two sources. The first is derived from the income of the electricity generated and sold (RE). RE is deterministic because the feed-in tariff in China is determined in the bidding. The other revenue is made due to the income of CERs (RC), which is uncertain because the carbon price varies from time to time. The revenue of investment R (per kWh) in wind power is the sum of these two parts: R = RE + RC. In the proposed real options model, we will focus on the income of CERs.

If the wind power plant produces E^t (tonne) CERs per unit electricity output every year, and all the CERs are tradable in the carbon trading market. Then, the income from CERs sales is $A^t * E^t$. Denote by I^t the initial investment, and the construction will take λ years, Q^t as the annual generating capacity (kWh) of the wind power plant, C^t as the unit cost of generating output, NPV_o can be expressed as follow:

$$NPV_o = \sum_{t=1}^{T} X^t \left(\frac{-1^t}{\left(1+\gamma_f\right)^{t-1}} + Q^t \sum_{K=t+\lambda}^{T} \frac{p^t + A^t * E^t - c^t}{(1+\gamma)^{k-1}} \right) \tag{9.2}$$

where

I^t	Initial investment
Q^t	Annual generating capacity
C^t	Unit cost of generating output
E^t	Annual CERs emission
λ	Construction period
γ	Discount rate
γ_f	Risk-free rate.

To obtain the real options value, we need to maximise the NPV_o. The decision problem can be described as:

$$max\ NPV_o \tag{9.3a}$$

s.t.

$$\sum_{t=1}^{T} X^t = 1, \quad \forall t \in \{1, \ldots, T\} \tag{9.3b}$$

$$X^t = 0\ or\ 1, \quad \forall t \in \{1, \ldots, T\} \tag{9.3c}$$

9.3.2 The Stochastic Model

The revenue of investment R (per kWh) in wind power is uncertain because of the uncertainty of the revenue from CERs (RC), which can change considerably depending on factors such as environment policy legislation, cost of alternative fuels, product market demand and so on. Assume the price of CERs A^t shifts stochastically over time represented by the geometric Brownian motions:

$$dA^t = \mu A^t dt + \sigma A^t dW_t \tag{9.4}$$

where

A^t	Price of CERs at the end of time period t
W_t	The standard Brownian motions process
μ	Carbon price drift
σ	Carbon price volatility.

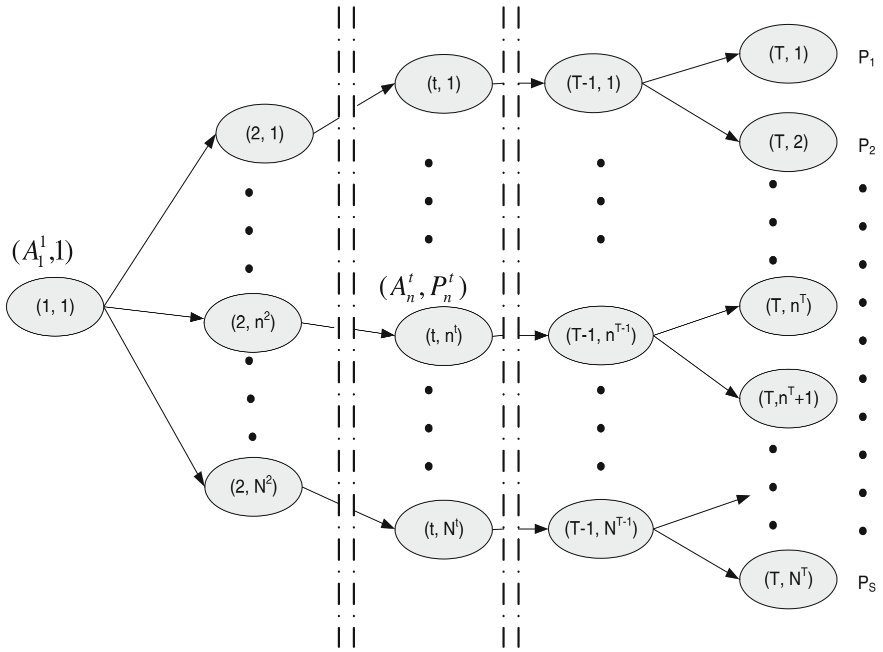

Fig. 9.1 Scenario tree

The stochastic process is assumed to be exogenous and independent of the decision variables in the deterministic model. In addition, the process is considered to follow some discrete distributions. A scenario tree is used to represent this type of discrete stochastic process.

Figure 9.1 shows a scenario tree representing the evolution paths of the stochastic variable A^t. The nodes in the tree are the states of A^t. A decision is made at each node so as to choose an option to exercise. Over the planning horizon, each particular scenario is reflected by the path from the root node to the particular ending node. At stage t, nodes are indexed as (t, n), the number of nodes is N^t, where $\in \{t, \ldots, T\}$ and $n \in \{t, \ldots, N^t\}$. Carbon price on node (t, n) is expressed as P_n^t, and the unconditional probability is expressed as P_n^t. Thus, a scenario can be expressed as the vector of $[1, n^2, \ldots, n^t, \ldots n^T]$, with probability ΠP_n^T. Some of the variables and parameters used in the deterministic model should be modified as follows:

$$X_n^t = \begin{cases} 1, & \textit{to exercise} \\ 0, & \textit{not to exercise} \end{cases} \quad t \in \{1, \ldots, T\},\ n \in \{1, \ldots, N^T\}$$

A_n^t The price of CERs at the end of time period t node n, $t \in \{1, \ldots, T\}$, $n \in \{1, \ldots, N^t\}$

P_n^T Unconditional probability of stochastic event A_n^t, $t \in \{1, \ldots, T\}$, $n \in \{1, \ldots, N^t\}$

Based on the notations above, NPV_o can be modified as follows:

$$NPV_o = \sum_{t=1}^{T} P_n^t X_n^t \left(\frac{-I^t}{\left(1+\gamma_f\right)^{t-1}} + Q^t \sum_{k=t+\lambda}^{T} \frac{p^t + A_n^t * E^t - c^t}{(1+\gamma)^{k-1}} \right) \quad (9.5)$$

and the decision problem can be expressed as:

$$max\ NPV_o \quad (9.6a)$$

s.t.

$$\sum_{t=1}^{T} X_n^t = 1, \quad \forall t \in \{1,\ldots,T\},\ n \in \{1,\ldots,N^t\} \quad (9.6b)$$

$$X_n^t = 0\ or\ 1, \quad \forall t \in \{1,\ldots,T\},\ n \in \{1,\ldots,N^t\} \quad (9.6c)$$

9.3.3 Scenario Generation

Given the assumption that the prices of CERs A_n^t shift stochastically over time represented by the geometric Brownian motions, which is expressed in Eq. (9.4), the sample paths of A_n^t can be obtained. Figure 9.2 shows the result of 50 sample paths with parameter values in Table 9.1.

In general, continuous distributions cannot be incorporated directly in stochastic programs because of the infinite number of scenarios that need to be examined. For this reason, discrete distributions are generally used to approximate the continuous distribution of stochastic parameters. The quality of scenario tree, which consists of such discretized distributions, is vital to the accuracy of the final solutions.

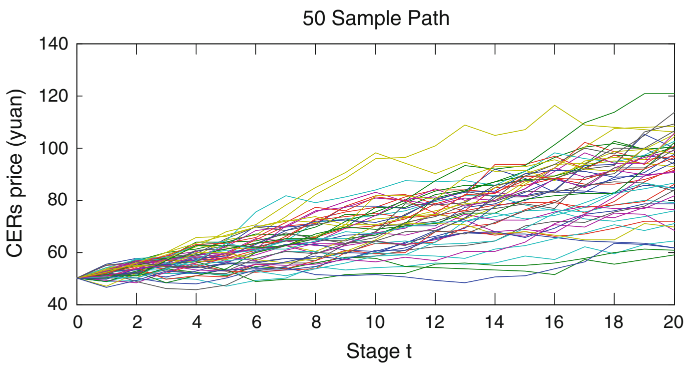

Fig. 9.2 Sample paths of CERs price

Table 9.1 Value of parameters

Notation	Parameter	Unit	Value	Data source
I^t	Initial investment	Yuan	2141129600	Wind Power station In Huitengshile Inner Mongolia
Q^t	Annual generating capacity	kWh	5919000	
C^t	Unit cost	Yuan/kWh	0.1976	
λ	Construction length	Year	2	
T	Operation period	Year	20	
E^t	Annual CERs	T	51429.6	
A_1^1	Price of CERs	Yuan	50	Estimated
μ	Carbon price drift		0.6	
σ	Carbon price volatility		0.18	
γ	Discount rate		0.15	
γ_f	Risk free rate		0.05	

Various methods have been proposed to generate scenario tree. These can be classified into external sampling and internal sampling methods. External sampling methods consist of optimal discretization sampling, conditional sampling, moment-matching, and path-based sampling. Internal sampling is actually a stochastic program solving algorithm with scenarios to be sampled during the solution procedure. Commonly used internal sampling methods are stochastic decomposition, stochastic quasi-gradient, EVPI-based sequential important sampling (Chu et al. 2005).

Equation (9.4) describes the price of CERs A_n^t as a known stochastic process. For the sake of simplicity, path-based sampling is applied to generate the scenario tree, and Latin Hypercube Sampling (LHS) is employed in this study to discretize A_n^t.

9.4 Case Study

In order to investigate the application of stochastic programming in the evaluation of real options, a case study is carried out. Data are collected from a wind power station in Huitengshile Inner Mongolia China, which began its construction in 2005 and went into operation in 2008 (Zhu 2011). The data is shown in Table 9.1.

We sampled 500 scenarios by LHS. The NPV_0^* is found to be 4.278 million Yuan at year 11, whereas the static NPV is 2.045 million Yuan. The difference between them is the value of real options embedded in the wind power project investment. If the strategic value and options value are not considered, the real value would be underestimated. However, the result also shows that investor tends to delay the exercise of wind power investment until the price of CERs increases to certain level.

9.5 Conclusion

Stochastic programming is a powerful technique for solving decision making problems under uncertainty. In this study, a real options model is developed to evaluate the investment decisions on wind power projects under the CDM. A scenario tree, generated by path-based sampling method and LHS discretization, is constructed to approximate the original stochastic program.

This study has considered only the option to delay in the investment of wind power projects. However, there are other important types of options to consider during the operation of wind power projects, especially under the CDM and China's franchise clause for power station operation. The proposed model can be extended to incorporate abandon options. In addition, multi-players can also be considered to study the optimal bidding price of electricity.

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Chapter 10
Action Recognition Based on Hierarchical Model

Yang-yang Wang, Yang Liu and Jin Xu

Abstract The feature representation of human actions is one of the important factors which influence the recognition accuracy of actions. Usually the recognition accuracy is higher, when the feature simultaneously includes both appearance and motion information. However the dimensions of the feature space is high, and this leads to high computational cost. To overcome this problem, we propose a hierarchical model for action recognition. In the first hierarchy, we adopt box features to divide the actions into two classes, according to whether or not legs are all almost stayed in a static place. In the second hierarchy, we construct different structure of motion feature descriptors to represent different kinds of actions, and use nearest neighbor classifier to obtain the final classification results. Experiments on the Weizmann dataset demonstrate the effectiveness of the proposed method.

Keywords Action recognition · Box feature · Hierarchical model · Motion feature

10.1 Introduction

Human action recognition is widely applied in the fields of surveillance, image and video retrieval and so on. Recently many researches have been done for the recognition, however, it still is a challenging problem due to diverse variations of human body motions, for example, occlusion, scale, individual appearance and individual motion fashion. To achieve good recognition performance, a good representation with rich appearance and motion information is of vital. Usually if a feature includes not only still appearance but also dynamic motion information, the

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E. Qi et al. (eds.), *The 19th International Conference on Industrial Engineering and Engineering Management*, DOI: 10.1007/978-3-642-38391-5_10,

feature dimension is high, and it is more discriminative to classify the actions. But this leads to high computational costs. To overcome this problem, we propose a hierarchical model for action recognition using multi-features, and show its performance compared to other exist algorithms.

The rest of this paper is organized as follows. Section 10.2 describes related work. Section 10.3 elaborates the details of our model. Section 10.4 reports the experiment results. Conclusion is given in Sect. 10.5.

10.2 Related Work

Many works have been proposed for action recognition, and some reviews (Moeslund et al. 2006; Poppe 2010; Ji and Liu 2010) have provided a detailed description of the action recognition framework. Here, we only focus on the action recognition that has related to our work.

Features based on shape or appearance is traditional representation in videos analysis. This kind of representation is usually related to global properties of human. First human is separated from the background, which is called box. And then all kinds of descriptors based on silhouette or edges are described. Deng et al. (2010) compute the silhouettes of the human body, and extracts points with equal interval along the silhouette. Through constructing the 3D DAISY descriptor of each point, the space–time shape of an action is obtained. Bobick and Davis (2001) also make use of the silhouette, but they employ motion energy images (MEI) and motion history image (MHI) to describe the actions. Ji and Liu (2009) present contour shaper feature to describe multi-view silhouette images. In Nater et al. (2010) a signed distance transform is applied to the box with fixed size. In Weinland and Boyer (2008) silhouette templates are used to match. But the recognition rate may be reflected by the accurate degree of the localization of the box, and the effect of background subtraction.

Another popular feature representation is about motion information. Messing et al. (2009) use the velocity histories of tracked key points to recognize the actions. Laptev et al. (2008) first use HOF descriptor to represent local motion information. Recently the combination of shape and motion features has received more attention. Lin et al. (2009) construct a shape-motion descriptor, and model a shape-motion prototype tree using hierarchical k-means clustering. Klaser et al. (2008) make use of HOG3D descriptor to combine motion and shape information simultaneously. Although these descriptors include more rich information, and the recognition accuracy is improved, the dimensions of the descriptors are bigger than those of the descriptors with single shape or motion information. A trade-off between computation complexity and accuracy should be considered. Therefore, we propose a hierarchical model, in the first stage, a coarse classification is made according to box features, and then different descriptors are designed to different class, this can reduce the dim of the feature vectors.

10.3 Proposed Method

There are five main steps to our approach: first, preprocessing video to achieve the human box; second, extracting global box features; third, preliminary dividing the actions into two different classes based on box features; forth, computing respective motion features for the actions which belong to different classes; and fifth, recognizing actions using nearest neighbor classifier and voting algorithm. In the following, we describe each step in turn.

10.3.1 Preprocess

We start from a video of k frames which are described in a RGB space. For feature extraction and recognition, we use background subtraction and filtering to segment the foreground object, which is the box of a person in each frame of an action sequence. In our paper, the motion direction of the same action is all aligned to the same direction, e.g. for the action 'running', the direction is appointed from left to right, Fig. 10.1b, c. Furthermore, the resulting silhouettes are converted to a binary representation. Examples of the box are illustrated in Fig. 10.1, and the representation of the boxes of a video S is

$$S = \{B_1, B_2, \ldots\ldots, B_k\}. \tag{10.1}$$

10.3.2 Coarse Classification Based on Box Feature

For each box B_i ($i = 1,\ldots, k$), a three-dimensional box feature vector is computed, i.e. $F_{bi} = [cx_i, cy_i, r_i]$, here cx_i, cy_i, r_i denote the coordinates of the center, aspect ratio of the box. According to the variance of coordinates and aspect ratio in an image sequences, we can easily divided the simple actions into two classes. Class 1 includes the actions which the motions mainly focus on the leg movements, such as jogging, running, walking, skipping and so on. And the actions which legs are all almost stayed in a static place are all belong to the Class 2, such as bending, waving.

10.3.3 Local Weighted-Motion Feature

Having classified the actions into two classes, we can construct different weighted-motion feature according to their particular characteristic.

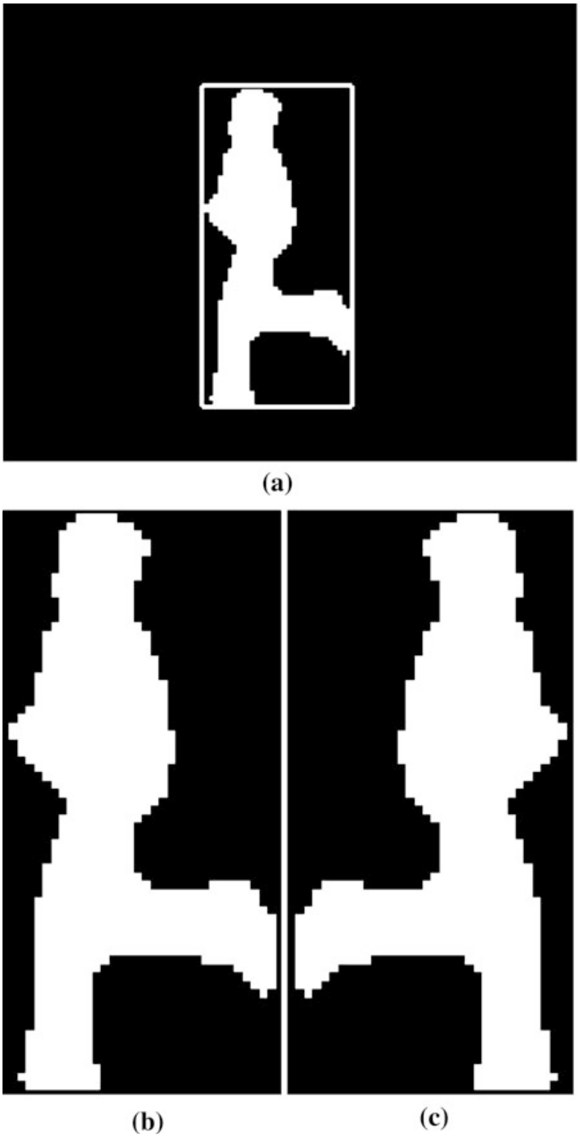

Fig. 10.1 Example of the box: **a** a frame after background subtraction, **b** extracting the box, **c** aligned the motion direction of the box

(1) *Box normalization*. The size and the position of the box in each frame is different, after getting the box feature F_{bi}, we normalized the boxes to equal size (80 × 80 in our case) while maintaining aspect ratio.
(2) *The division of subregions*. When a person is in a state of motion in a video sequence, his body is continually varying in time series. For the actions which belong to Class 1, the movements of its upper limb and lower limb are more important. Whereas for the actions in Class 2, e.g. running, the variances in subregions of legs are more important. In order to exactly describe the

Fig. 10.2 The division of subregions for Class 1

variation, the different division of subregions is adopted to different action classes. First, for all kinds of actions, each normalized box is divided into *n* square subregions. And then for Class 1, on the basis of the division mentioned above, for the first and last row of the box, we use a further division, as shown in Fig. 10.2. And for Class 2, for the second and third row of the box, each subregion is divided into 4 square grids, as shown in Fig. 10.3.

(3) *Weighted-motion feature representation*. Optical flow can be made to describe the human motion. We calculate optical flow using Horn and Schunck algorithm (Horn and Schunck 1981). To each pixel in each subregion, the velocity of optical flow V (x, y, V_x, V_y) is computed, where (x, y) represents the image location of V, and (V_x, V_y) are the x and y components of the velocity V. Besides, for reducing the influences of noise dynamic backgrounds, we use a Gauss filter to smooth the subregions before calculating optical flow. According to the (V_x, V_y), the magnitude and orientation of the V is computed

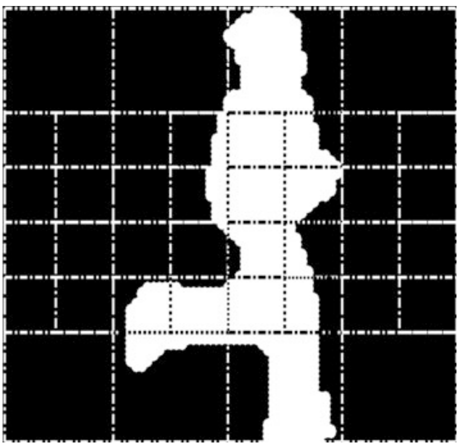

Fig. 10.3 The division of subregions for Class 2

$$M(V_x, V_y) = |(V_x, V_y)|, \quad (10.2)$$

$$O(V_x, V_y) = \arctan(V_y/V_x). \quad (10.3)$$

$O(V_x, V_y)$ is divided into eight equal sectors in polar coordinates, and the $M(V_x, V_y)$ can be regarded as the weights. The weighted-motion histogram's x-axis reflects the eight orientations. The histogram's y-axis shows the contribution within each orientation. And for each subregion we achieve a histogram.

Further, the subregions with grids are more important than others, in order to precisely represent actions, for each grid in a subregion a single motion histogram is computed. Therefore, the number of histogram is $8 + 8 \times 4 = 40$.

10.3.4 Final Classification Based on Weighted-Motion Feature

Having got the features of each frame of an image sequence, we respectively classify two different classes of actions. Although the features of respective class are different, the classifier is the same.

NNC (Nearest Neighbor Classifier) is used to recognize the action categories. For the fth frame of an unknown video Su, we get a distance vector $D_f = [d_1, d_2, \ldots, d_q]$, here d_j ($j = 1, \ldots, q$) denotes the distance between the features of the fth frame in Su and the features of each frame in training set, q denotes the number of all of frames in the training set. The minimum distance in D_f is picked up, and the label of the corresponding training frame is assigned to the fth frame of Su. And finally each frame of Su gets a label; the final action label of Su is determined by voting algorithm.

10.4 Experiments

To evaluate the performance of our algorithm, the popular benchmark dataset—Weizmann dataset is used in action recognition. The Weizmann dataset (Blank et al. 2005) consists of 90 videos of nine actors performing ten different actions. These actions are walking, running, jumping, siding, and bending, one-hand waving, two-hands waving, jacking, jumping in place and skipping. Evaluations were done with a leave-one-out cross-validation.

Our recognition result is shown in Table 10.1 and compared with Lin' method (Lin et al. 2009) and Scovanner's method (Scovanner et al. 2007). In addition, the confusion matrix is shown in Fig. 10.4. The data on the diagonal line present the numbers of the correct identification, and other data in the graph are the numbers of the misclassification. The average recognition rate of our approach is 96.7 %.

Table 10.1 Results using different features on Weizmann dataset

Descriptor	Average precision (%)
Shape-motion tree (Lin et al. 2009)	94.44
3D SIFT (Scovanner et al. 2007)	82.6
Ours	96.7

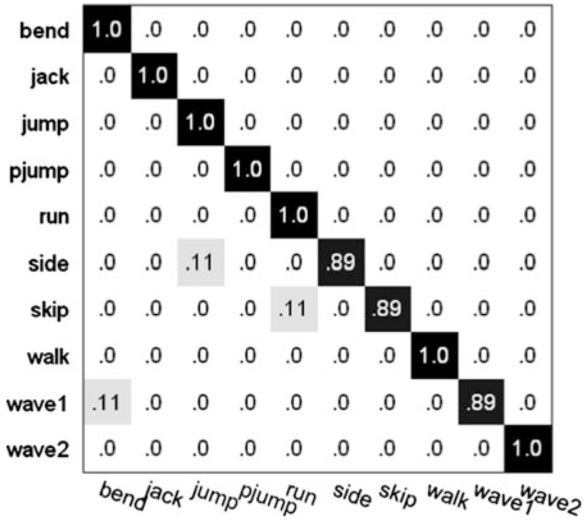

Fig. 10.4 Confusion matrix for Weizmann dataset

Besides we exchange the motion feature structure of the two classes. When the actions in Class 2 use the feature structure of Class 1, as shown in Fig. 10.5, the average accuracy is 93.4 %. When the actions in Class 1 use the feature structure of Class 2, the influence of recognition rate is very small. The results prove that our method is effective.

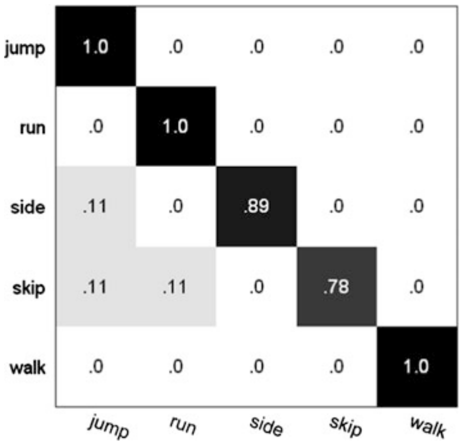

Fig. 10.5 Confusion matrix for Class 2. The form of the feature representation is used Class 1's

10.5 Conclusion

We have presented a novel hierarchical feature representation. First, the actions are divided into two classes based on the box feature. And then for the different classes of actions, the different motion feature structure is designed. This method is clearly useful for action recognition. However background segmentation and the alignment of boxes are required in the method. One future research direction would be to improve the robustness of feature descriptors in scenes where boxes can not be obtained reliably.

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Chapter 11
Adaptive Ant Colony Algorithm Researching in Cloud Computing Routing Resource Scheduling

Zhi-gao Chen

Abstract Cloud computing has been regarded as one of the most important planning projects in the future, the technique will be beneficial to thousands enterprises in our country. The advantages of Cloud service depend on efficient, fast running network conditions. At present, under the condition of limited bandwidth in our country, studying fast and efficient routing mechanism is necessary, according to which Scheduling resource with the maximum capacity of a network node. Therefore, in this paper, the parameters of network capacity was increased as the threshold in each node to route adaptively, the shortest path can be found quickly on the traditional ant algorithm, and also the network capacity of nodes on the path can be adjusted accordingly. As the experimental result shown, the congestion of data on the critical path can effectively avoid by this method.

Keywords Ant colony algorithm · Cloud computing · Pheromone

11.1 Introduction

Cloud computing is a distributed processing, parallel processing and grid computing, that is stored in the PC, mobile phones and other devices on the wealth of information and processor resources are concentrated together collaborative work, great the expansion of IT capacity, a calculation method to provide services to external customers (Asterisk 2010) (XUE Jing 2010). In 2011, cloud computing has been treated as the key project in the twelfth five-year plan by our government, the importance and significance have no question count (Proceedings of the ninth international symposium on distributed computing and applications to business,

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E. Qi et al. (eds.), *The 19th International Conference on Industrial Engineering and Engineering Management*, DOI: 10.1007/978-3-642-38391-5_11,

engineering and science 2010). At present, our country is in the growth stage of cloud computing (Proceedings of 2010 third international symposium on knowledge acquisition and modeling (KAM 2010) 2010) (HAN Bing 2010), over the next 10 years, many IT enterprise and the small and medium-sized enterprises will share hundreds of billions of dollars of "cloud computing cake" in the future of our country (Nezamabadi-pour et al. 2006).

While there are some disadvantages in the cloud computing industry of our country. Cloud computing needs to run in high-speed network to exert its advantages (Satyanarayanan 2001), although China has been used widely the broadband technology, but net is still less than other countries. Cloud computing needs to run in high-speed network to play its advantages, Broadband technology has been applied in our country widely, but the speed of the network is still lower than other countries. It is the premise of cloud computing construction in china that Operation cloud services needs a set of efficient and secure routing mechanism on Cloud Computing to achieve efficient resource scheduling and storage, on the basis of limited bandwidth; on the other hand, along with the expansion of cloud computing network and increase of cloud services, higher requirements are put forward to our existing network bandwidth and the resource scheduling, therefore, the research and application of the cloud computation efficient routing mechanism can improve the efficiency of routing and scheduling speed resources, as a result the cloud service will run more efficiently in the existing network infrastructure and improving fully on the return rate of investment on cloud computing infrastructure, Reference and basis of China's construction of cloud services platform is provided better, the significant on the progress of our society and the pulling and development of national industry is greatly.

11.2 Cloud Computing Infrastructure and Ant Algorithm

11.2.1 Introduced Cloud Computing Environment

At present, cloud computing infrastructure technology is mainly the Google non open source system of GFS and hadoop technology for GFS open source implementation of the HDFS (Fetterly et al. 2010). Hadoop is a reliable, efficient, scalable software framework, and can handle large amounts of distribution data. It can make use of cluster technology processing PB data in the cheap personal computer with parallel manner, and can be used freely because of its own JAVA language framework (Asterisk 2010). The core part of Hadoop HDFS and Map Reduce use Master/slave structure, the Hadoop system is unified into the two layer structure. A HDFS cluster consists of a Name Node and a plurality of Data Node. Name Node is the main server, responsible for the management of the file system name space and client access to files, Data node is the slave server, which distributed on each physical node in a cluster usually, responsible for memory management on their physical nodes. In the internal node, files are usually divided into one or more blocks of data the blocks of data stored in a set of Data Node (IP Multimedia Subsystem (IMS) 2009). Name Node execution operation about the file system name space, such as open, closed, the rename operation, and also decided to map data block from Name Node to Data Node. Data Node is responsible for processing of read and write requests of customers, also performs a data block in accordance with the Name Node instruction.

11.2.2 Ant Algorithm

The ant algorithm (Ant Colony Algorithm) is proposed by the Italian scholar Marco Dorigo in 1992, a parallel and efficient evolutionary algorithm (Guo et al. 2010). The algorithm is a probabilistic technique for the simulation of ant foraging process in nature which is formed to find the optimal path in the graph, the core idea is: ants will left a "pheromone" chemical substances in the path searching for food (Hayden 2009), these "pheromone" can provide heuristic information where selected on walking routes, for the follow-up ants to find food as the constant updating of pheromone, optimal path can be found from the nest to the food in a relatively short period of time. The algorithm has the advantages of high parallel, convergence speed, and has Gained some satisfactory experimental results, in the traveling salesman problem, routing and scheduling problems, but the standard ant algorithm is easy to fall into local optimal solution. Considering the cloud computing environment is large in scale, and the quality of service requirements, to achieve efficient resource scheduling, the shortest path should be found in algorithm and also meet the bandwidth requirements of which cloud services supplied in the path each node can offer. The proposed adaptive ant algorithm, is based on running a cloud service according to our country current limited bandwidth, by setting the appropriate threshold about minimum network capacity to adaptively adjust searching for the shortest path, can both quickly discover the resource such as the routing, but also to improve the convergence of the algorithm, and the QOS.

11.2.3 Adaptive Ant Algorithm

To achieve efficient and fast scheduling of cloud services, in a real environment must fulfill two conditions: (1) the data transmission path must be the shortest path to reduce the data transmission distance; (2) the shortest path through each node must have enough bandwidth to run cloud services, it will be congestion in some nodes. The ant algorithm selects the shortest path by the rapid convergence condition (1) easy to implement. Search the shortest path, all cloud services are run from the path, is bound to be caused by data traffic increased sharply on the shortest path. At present, limited the basis of bandwidth in our country that can be provided by the between of each node network the maximum capacity of is has been spotty. Once all the business on the shortest path on the transmission, will make some smaller capacity network node to enter the congestion in advance. If you cannot adjust in a timely manner will make a follow-up business to continue to transfer from the shortest path, leading to congestion and data retransmission exacerbate transmission of cloud services is very unfavorable. The establishment of a multi-road by the table for the same source knot point to the target knot point. Search idea is that the network capacity threshold set automatically when preferred shortest path congestion routing, get a new "sub-optimal" shortest path. And so on, so as to achieve the normal operation of the entire network in the state of optimal network capacity. Therefore construct adaptive ant algorithm steps are: solving the source node to destination node point shortest path process, consider the capacity constraints and flow changes on the network each path in real time, i.e., solving the shortest path to the source node to destination node sections capacity minus the minimum link capacity. When the data was transferred on the shortest path close to the minimum link capacity, the bottle neck sections of congestion, the other nodes in which sections of the available network capacity bottleneck link capacity minus the capacity of the original node, rather than the capacity of the shortest path remains unchanged.

11.3 Model Designing for Adaptive Ant Algorithm

Firstly, each node in the cloud environment was treated as the point in the map abstractly. A certain node was set as the start point, will was searched by the ant as the "food" finally, namely to complete the routing process.

11.3.1 Improvement of Algorithm

Firstly, each node in the cloud environment is abstracted as a connected graph point to determine a node as a starting point, the final node of the visit as "food" by the ants to search. Routing process was completed when the ants had found the target in the traditional ant algorithm, the filmon was reserved in line which the ants searched, the algorithm has been modified in this paper that the filmon was reserved on each node traversed by the ants. The τi represents the amount of information, H represents the network capacity values the node can carry, Threshold is set to di, if di > H, hosted by the node network traffic has exceeded the network capacity, this means that the congestion would be coming on the node, then the new business transmission can not be longer allowed in the path. The choice of the new path must be started in order to bypass the sections in upcoming congestion, a new sub-optimal path would be created.

With the establishment and the end of the network session, the amount of information on each node would change when each cycle completed, the Fireman on each node Adjusted as (11.1, 11.2):

$$\tau_i(t+1) = \rho\tau_i(t) + \Delta\tau_i \tag{11.1}$$

$$\Delta\tau_i = \sum_{k=1}^{m\times n} \Delta\tau_i^{\mathrm{k}} \tag{11.2}$$

Among them, the k-th ant in the cycle stays in the pixels on the filmon.

11.3.2 Experiment

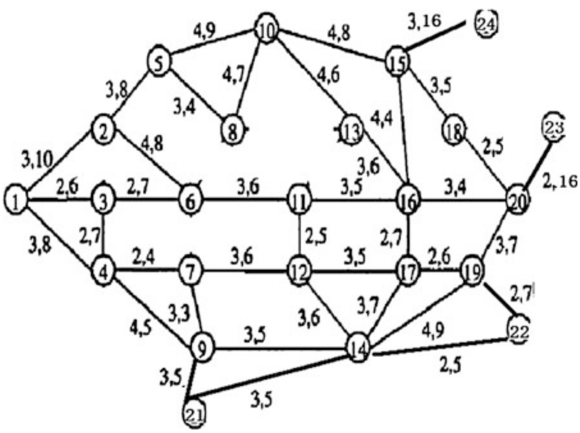
Figure 11.1 is a simulation example of a network of choice in this article, a total of 24 nodes in the graph, the connection on behalf of the node between the node path, the connection of a group of figures, respectively, the distance between the node and the maximum network capacity, it is assumed from the source node 1 to node 23, and the source node to node 24, two paths through the data routing experiment.

Step1: designed to be adaptive ant algorithm to find the shortest path to node 1 → 23;here to take $\alpha = 1$, $\beta = 2$, $\rho = 0.8$, Q = 1000, the initial value τmin = 60. Get 1 → 23 of the shortest path is ①: 1 → 3 → 6 → 11 → 16 → 20 → 23, 15 flow (minimum segment capacity) is 4;

Step2: the capacity of each segment of the shortest path 1 minus the smallest segment of the shortest path capacity, the results of 16 → 20 segment of the capacity is 0, the segment identified as the bottleneck segment, the segment most prone to congestion;

Step3: According to the capacity change and the connection matrix changes to look for the source node and destination node 23 the shortest path available to the

Fig. 11.1 Node topology



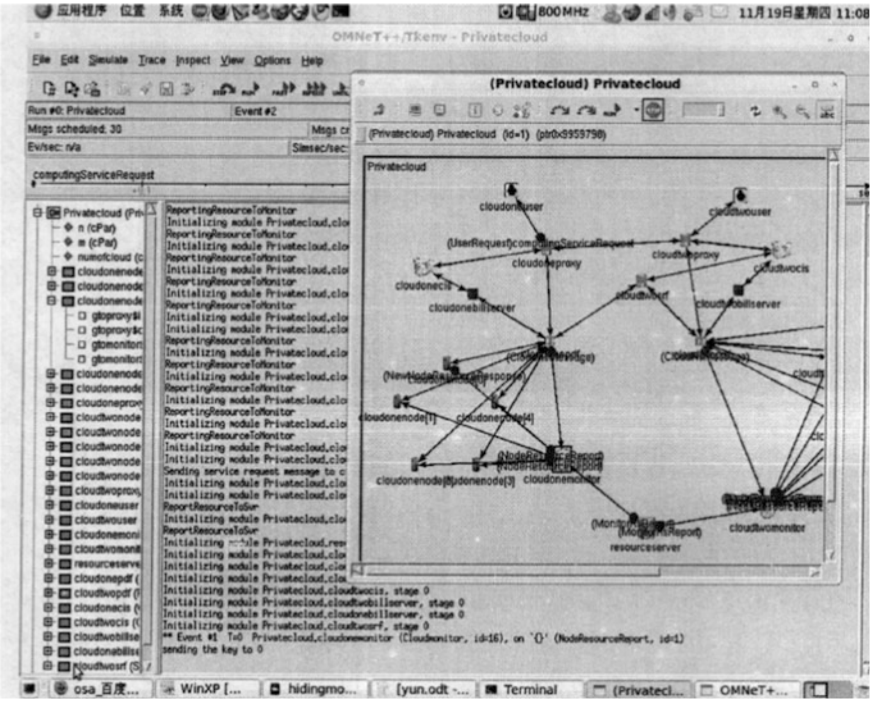


Fig. 11.2 Cloud node topology

new shortest path ②: 1 → 4 → 7 → 12 → 17 → 19 → 20 → 23, 18 flow rate, and similarly the capacity of each segment of the shortest path ② subtract the smallest segment of the shortest path capacity, the result of the capacity of the 4 → 7 segment 0, that segment is identified as unavailable, repeat the same steps to find the shortest path ③ change Network: 1 → 4 → 9 → 14 → 19 → 20 → 23, length 19, flow rate of 3; ④: 1 → 2 → 5 → 10 → 15 → 18 → 20 → 23, length 21, flow rate of 5;

Step4: could not find a feasible route of the destination node of a source node → (or less than the number of shortest path to the default limit), the source node or destination node will become an isolated point, out of the end of the loop; (Fig. 11.2)

Step5: will find the shortest path sequence as the source node 1 → purpose node 23 optional routing tables, the same method can be found in the 9 → 15 optional routing tables. As the experiment shows, the adaptive ant algorithm constructed in this paper had got the data listed in Table 11.1. As the experimental results, dynamic optimal routings from node 1 → 23 and 9 → 24, there are four paths of Optimal routing from node 1 → 23, and four paths of Optimal routing from 9 → 24 as the same. According to the provisions of the preferential routing priority, in order to achieve a dynamic optimal routing because of the network congestion or partial failure.

Table 11.1 Dynamic optimal routing

	Source → target order selected path	Shortest path	Flow
1 → 23	1 → 23 1 1 → 3→6 → 11 → 16 → 20 → 23 2	15	4
	1 → 4→7 → 12 → 17 → 19 → 20 → 23	18	4
	3 1 → 4→9 → 14 → 19 → 20 → 23	19	3
	4 1 → 2→5 → 10 → 18 → 20 → 23	21	5
9 → 24	9 → 24 1 9 → 14 → 17 → 16 → 15 → 24	15	4
	2 9 → 14 → 19 → 20 → 18 → 15 → 24	18	1
	3 9 → 7→6 → 8→10 → 15 → 24	19	3
	4 9 → 4→3 → 2→5 → 10 → 15 → 24	21	5

11.4 Discussion

In this paper, the adaptive ant algorithm can effectively avoid congestion in network on the shortest paths, and select the shortest paths automatic by setting the minimum network capacity threshold for each of the segments in the shortest path in hadoop cloud platform, provided a choice of an adaptive routing scheme in a cloud environment.

The experiments about the algorithm are carried out in hadoop cloud platform, not by simulator, the practicality and adaptability is better. A good self-healing method was provided for some sections on the shortest path when some sections were failed, for author/s of more than two affiliations: to change the default, adjust the template as follows.

The minimum network capacity as the only one factor which was considered in this method when the paths were selected adaptively on each segment, this is certainly not enough in the real cloud environment, therefore, the algorithm needs the further improvement if been applied in the cloud environment.

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Chapter 12
An Empirical Analysis on Guangdong Industrial Energy Intensity Based on Panel Data

Xin-dong Hao

Abstract Energy is of vital importance to the modern industrial economy. Based on the panel data of 36 industrial sectors in Guangdong, this paper analyzes the relationship between energy intensity and industrial added value by means of gray relational analysis. The results show that the energy intensities of industrial sectors are quite inconsistent with their industrial added values. Guangdong should attach great importance to the development of "win–win" industrial sectors which increasing industrial output while reducing energy intensity.

Keywords Energy intensity · Grey relational analysis · Industrial added value · Panel data

12.1 Introduction

China is facing severe challenges from energy supply and environment protection due to its heavy dependence on energy. Up to now, Guangdong has made great progress in industrialization, and its industrial output value has ranked first in China for many years, and even some of its manufactured goods play a prominent role on world scene. Industrialization needs large amounts of energy, Guangdong's total energy consumption was 152.367 million tones of standard coal in 2011, and Guangdong try to reduce its per unit energy consumption by 18 % in the 12th 5-Year Plan (2011–2015).

Over the years, Guangdong's industrial growth rely heavily on high input and high energy consumption, its industrial energy consumption accounts for about 70 % of the total consumption. At present, Guangdong is facing serious challenges

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E. Qi et al. (eds.), *The 19th International Conference on Industrial Engineering and Engineering Management*, DOI: 10.1007/978-3-642-38391-5_12,

of resources and environmental, and the energy problem is hindering Guangdong's economic growth and industrialization. The energy intensities of industrial sectors play a dominant role in total energy consumption; many studies have focused on this problem. A brief literature review as follows.

Sinton and Levine (1994) studied China's industrial energy intensity of 1980–1990 and found that the reasons for the decline of overall industrial energy intensity were primarily the improvement of energy efficiency. Garbaccio et al. (1999) tried to construct an index system on energy intensity and they pointed to that technological changes being one of main reasons for the decline of energy intensity. Karen et al. (2004) analyzed the panel data of 1997–1999 on large and medium-sized industrial enterprises in China, and found that the decline of energy intensity mainly due to the reduction of coal consumption in industrial sector, technology development, industrial restructuring.

Lun and Ouyang (2005) analyzed the relationship of Guangdong's economic and energy consumption, and they argued that there was a significant positive correlation between them. He and Zhang (2005) insisted that the increasing of China GDP energy intensity was mainly due to the fast increase of energy consumption in industry, particularly in heavy and chemical industrial sectors. Fisher-Vanden et al. (2006) studied China's energy intensity based on sample data which coming from a large number of industrial enterprises and they found that the change of production structure was one of the major factors for the decline of energy intensity. Hu and Wang (2006) conducted a comprehensive analysis on the factors of affecting China regional energy efficiency, and they insisted that the main influencing factors include energy structure, industrial structure, technology and so on.

Shi and Dong (2007) insisted that the differences of energy efficiency in China were due to the factors such as economic development level, industrial structure, energy consumption structure, maketization degree. Yu (2007) thought that the decrease of Guangdong's energy intensity was mainly due to the increase of energy utility efficiency in the second industry. The rising of energy utility efficiency in the key sectors of industry had led to the fall of the whole energy intensity. Ma and David (2008) analyzed the data of energy intensity between 1980 and 2003 in China and they pointed out that the technological progress was extremely important for knock-down industrial energy intensity. Zha et al. (2009) nalyzed the energy consumption of 36 China industrial sub-sectors from 1993 to 2003. The results showed that the industrial structure played a important role in China's energy intensity.

Zhu (2010) studied the general characteristics of energy consumption based on the data of Guangdong, and he designed an energy demand path of low-carbon development for Guangdong. Cai (2010) insisted that the energy problems had seriously affected the development of Guangdong's industry and he suggested that the reduce of energy intensity would be a direct ways of accelerating the development of Guangdong industrialization. Fu and Zhang (2011) analyzed the data of 36 Guangdong industrial sectors from 2001 to 2010, the results showed that the structural effect and technical effect had a positive role on the reduction of energy consumption while the scale effect had a negative role. The development of steel, nonferrous metal, building materials, chemical and other high energy consumption industrial sectors was the main reason for the rapid rise of total energy consumption. Zheng (2011) analyzed the general characteristics of energy consumption and energy efficiency based on the data of industrial sectors in Guangdong, and the result showed that there were many differences in different industrial sectors.

In this paper, we go through the main study results of previous literature so as to explore the relationship between industrial energy intensity and industrial added value in Guangdong basing on gray relational analysis. By this way, we try to find out which Guangdong industrial sectors should be the priority development ones by the perspective of energy intensity and industrial added value. Our goal is to identify the key industrial sectors of "win–win" which increasing industrial output while reducing energy intensity.

12.2 Methodology of Gray Relational Analysis (GRA)

The gray system theory was first proposed in 1982, and it is a system containing both insufficient and sufficient information, called "black" and "white," respectively, is a gray system. A system can be called as a black box if its mathematical equations or internal characteristics that describe its dynamics are completely unknown. On the other hand, a system can be named as a white system if the description of the system is completely known. Similarly, a system that has both known and unknown information is defined as a gray system. The gray system theory deals with a system containing insufficient information, the gray relational analysis can capture the relationship between the main factor and other factors in a system regardless whether this system has adequate information. The gray relational analysis can effectively avoid subjective bias and have better performance than some traditional methods when the study involves economic, environmental and technical indices problems.

In real life, each system can be considered as a gray system because there are always some uncertainties in them. Even a simple price system always contains some gray characteristics because of the various kinds of social and economic factors. These factors are generally random and make it difficult to obtain an accurate model. There are many situations in which the difficulty of incomplete or insufficient information is faced, by gray relational method; we can calculate the gray relational coefficient and the gray relational grade of a gray system, and to find out the system's internal relationships.

A GRA model is a kind of impact measurement model of two series which named reference series and compare series. During the processes of system development, the change trends of two series should be consistent, a higher grade of synchronized change can be considered to have a greater ranking; otherwise, the grade of relation would be smaller. Thus, the analysis method, which takes the ranking of the relation into account, is established upon the degree of similarity or difference of the developmental trends of two series to measure the degree of relation.

12.3 Empirical Analysis

Taking energy intensity (Tons of standard coal/yuan) as reference series, and taking industrial added value as compare series. The energy intensity come from the energy consumption per unit industrial added value, the data involving 36 industrial sectors of Guangdong from 2004 to 2010. The compare series are the industrial added values of above-mentioned 36 industrial sectors. All the data come from Guangdong Statistical Yearbooks (GSY, 2005–2011). By the methodology of GRA, we summary the gray relational degrees (descending order) in Table 12.1, we take also Guangdong energy intensity data(ascending order) into Table 12.1, so as to find out the "win–win" industrial sectors.

The 36 industrial sectors as follows: tobacco manufacturing industry (X_1), oil and gas mining industry (X_2), transportation equipment manufacturing industry (X_3), recycling and disposal of waste industry (X_4), instrumentation and culture, office equipment manufacturing industry (X_5), electrical machinery and equipment manufacturing industry (X_6), pharmaceuticals manufacturing industry (X_7), universal equipment industry (X_8), special equipment manufacturing industry (X_9), garments, shoes and caps manufacturing industry (X_{10}), beverage manufacturing industry

Table 12.1 The sorts of energy intensity and grey relational degree (2004–2010)

Sectors	Energy intensity	Sort	Degree	Sort	Sectors	Energy intensity	Sort	Degree	Sort
X_1	0.061	1	0.893	6	X_{19}	0.858	19	0.896	3
X_2	0.127	2	0.910	2	X_{20}	0.923	20	0.850	18
X_3	0.283	3	0.830	29	X_{21}	0.982	21	0.849	19
X_4	0.379	4	0.727	34	X_{22}	1.063	22	0.878	9
X_5	0.445	5	0.841	25	X_{23}	1.258	23	0.894	5
X_6	0.454	6	0.840	27	X_{24}	1.370	24	0.842	24
X_7	0.623	7	0.895	4	X_{25}	1.386	25	0.833	28
X_8	0.664	8	0.845	22	X_{26}	1.403	26	0.827	30
X_9	0.667	9	0.843	23	X_{27}	1.529	27	0.823	31
X_{10}	0.678	10	0.854	16	X_{28}	1.658	28	0.864	12
X_{11}	0.681	11	0.917	1	X_{29}	1.780	29	0.820	32
X_{12}	0.687	12	0.856	13	X_{30}	1.946	30	0.889	8
X_{13}	0.724	13	0.876	10	X_{31}	2.106	31	0.841	26
X_{14}	0.769	14	0.850	17	X_{32}	2.448	32	0.855	15
X_{15}	0.771	15	0.713	35	X_{33}	3.308	33	0.685	36
X_{16}	0.776	16	0.856	14	X_{34}	4.306	34	0.846	20
X_{17}	0.776	17	0.890	7	X_{35}	5.797	35	0.845	21
X_{18}	0.847	18	0.867	11	X_{36}	6.013	36	0.813	33

(X_{11}), leather, furs, feathers manufacturing industry (X_{12}), food manufacturing industry (X_{13}), handicrafts and other Manufacturing industry (X_{14}), nonferrous metals mining and extraction industry (X_{15}), furniture manufacturing (X_{16}), printing and copying industry (X_{17}), metal products industry (X_{18}), ferrous metals mining and extraction industry (X_{19}), cultural, educational, sporting articles manufacturing industry(X_{20}), chemical raw materials and chemical products manufacturing(X_{21}), agro-food processing industry (X_{22}), nonmetal mineral mining and extraction industry (X_{23}), plastic products industry (X_{24}), nonferrous metals smelting and rolling processing industry (X_{25}), wood, bamboo, timber processing industry (X_{26}), water processing and supplying industry (X_{27}), rubber products industry (X_{28}), chemical fiber industry (X_{29}), textiles industry (X_{30}), electric power, hot power producing and supplying industry (X_{31}), papermaking and paper products industry (X_{32}), gas producing and supplying industry (X_{33}), oil processing, coking and nuclear fuel processing industry (X_{34}), nonmetal mineral products industry (X_{35}), ferrous metals smelting and rolling processing industry (X_{36}).

The Table 12.1 shows that the top fifteen industrial sectors from the perspective of gray relational degree are: beverage manufacturing, oil and gas mining, ferrous mining, medicine manufacturing, non-metallic Mining, printing recording media replication, tobacco manufacturing, textiles, agro-food processing, food manufacturing, fabricated metal products, rubber, leather, fur, feathers and their products, furniture, paper and paper products industries. Obviously, the top fifteen sectors from the perspective of energy intensity are different.

12.4 Conclusion

Energy intensity is the comprehensive reflection of a country or region's economic structure, mode of growth, level of science and technology, management capacity, consumption patterns and so on. This study examines Guangdong's industrial energy consumption during 2004–2010 by the gray analysis method and it gives us a new way of thinking (named "win–win") for breaking through Guangdong's energy bottlenecks.

The gray relational analysis shows that there are complex relationships between Guangdong's industrial energy intensity and industrial added value, i.e. the industrial added value of the sectors can be high while their energy intensities are low.

Comparing the rankings of energy intensity and gray relational degree, we find out the "win–win" industries, i.e. increasing industrial output while lowering energy intensity industries, include tobacco manufacturing industry, oil and gas extraction industry, pharmaceutical manufacturing industry, beverage manufacturing industry, leather, fur, feather products industry, food manufacturing industry, they all should be given priority to development. We should also pay attention to the industrial sectors of transportation equipment manufacturing industry, recycling and disposal of waste industry, electrical machinery and equipment manufacturing, non-ferrous metal mining industry because their gray relational degree are low but their ranks of energy intensity are high. Although such industries cannot play an important role in create industrial added value, but they consume less energy.

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Chapter 13
An Empirical Research on the Ability of Sustainable Development for Coal Resource Exhausted Cities

Bing Zhang

Abstract The sustainable development of coal resource exhausted cities has become an important part of whole social development. This paper constructs the sustainable development indicator system of the coal resource exhausted cities from the four perspectives of the economy, society, resource and environment, we choose 12 coal resource exhausted prefecture-level cities for examples, analyze the level of sustainable development of the coal cities from 2006 to 2011 using principal component analysis method. Finally, it proposes the policy recommendations for sustainable development of coal resource exhausted cities.

Keywords Coal resource exhausted city · Empirical research · The ability of sustainable development

13.1 Introduction

Our country has rich mineral resources, it has nearly one hundred large and medium cities built mainly in mining. Since twenty first century, coal resources are gradually shrinking and depletion, the resource cities standing due to coal have difficult to see its former glory, which have seriously lagging behind in economic development, a structural contradiction of single industry has become increasingly emergent (Xu and Zhang 2000). With the growing exploitation of resources, mining geological conditions become more complex, resource extraction enterprises are gradually aging and these resource-based cities will face the important topic of economic transformation (Wang 2003). In the process of continuous improvement of China's market economy, how to promote resource exhausted

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E. Qi et al. (eds.), *The 19th International Conference on Industrial Engineering and Engineering Management*, DOI: 10.1007/978-3-642-38391-5_13,

cities to achieve comprehensive and sustainable development in economic, social, resources and environment has become an imperative and urgent major strategic task needing to be addressed (Xia and Shen 1998).

13.2 Overview of Coal Resource Exhausted Cities

Resource-based cities are an important urban-type in our country, they generally refer to the cities that rely on the natural resources of mineral resources and forest resources and so on, and these cities have specialized functions in which resource extraction and initial processing as their pillar industries, the similar concept is mining city and industrial city and so on (Zhao 2006). The coal resource exhausted cities are an important part of resource exhausted cities in our country (Wang et al. 2010). We choose 12 prefecture-level cities for examples which are the coal resource exhausted cities in the list issued by our country, including the Zaozhuang city of Shandong Province, the Baishan city of Jilin Province, the Fushun city of Liaoning Province, the Fuxin city of Liaoning Province, the Huaibei city of Anhui Province, the Huangshi city of Hubei Province, the Jiaozuo city of Henan Province, the Liaoyuan city of Jilin Province, the Pingxiang city of Jiangxi Province, the Qitaihe city of Heilongjiang Province, the Shizuishan city of Ningxia Hui Autonomous Region, and the Tongchuan city of Shanxi Province. In recent years, these cities have already begun with economic transformation, the level of economic development is gradually increasing, and the GDP growth rate is slightly higher than the national average. At the same time, these cities also focus on the coordinated development of the society, resources and environment; take various measures to raise the level of sustainable development.

13.3 Build Index System of Sustainable Development for Coal Resource Exhausted Cities

The evaluation system of sustainable development for coal resource exhausted cities should reflect the development status and trend of four systems within the economy-society-resource-environment complex system, and also reflect the coordination state of the four systems. In addition to considering the basic ideas and general principles of sustainable development, it should also reflect the characteristics of the coal resource exhausted cities. This paper presents a model of sustainable development indicator systems for coal resource exhausted cities.

$$CRCSD = f(K_1, K_2, K_3, K_4, S, T)$$

In the model, *CRCSD* is the ability of sustainable development for coal resource exhausted cities, K_1 is the economy system, K_2 is the society system, K_3 is the resource system, K_4 is the environment system, S is the space variables, it refers to the different cities, T is the time variables, it refers to the different development stages.

Each subsystem is further represented by a number of indicators.

$$K_i = f(K_{i1}, K_{i2}, \cdots, K_{in}) \quad i = 1, 2, 3, 4$$

Specifically, the index system should highlight the following features. First, it should reflect the quality and scale of economic development for coal resource exhausted cities. Second, it should reflect the operating conditions of the social system; the key is to make a clear assessment of eliminating poverty and improving the quality of life and so on. Third, it should have a great importance to the extent of development and utilization of the main resources and the richness of the existing resources. Four, it should reflect the environment, especially the capacity of natural environment and the ability of regional sustainable development (Li 2005; Li and Lu 2008; Pang and Wang 2012).

According to the function need to be reflected by the above model and index system, combined with the own characteristics and goals of sustainable development for the particular system of coal resource exhausted cities, we establish a index system for sustainable development and select 28 representative indicators as shown in Table 13.1 (Li 2005; Li and Lu 2008; Pang and Wang 2012; Akinbami and Fadare 1997; Marsh 1987).

Table 13.1 The index system of sustainable development for coal resource exhausted cities

Economic indicators	Social indicators
GDP per capita	Annual average wage of workers
Coal resources industry added value accounts for GDP	Disposable income per urban population
The tertiary industry added value accounts for GDP	Employment rate of urban population
Financial revenue accounts for GDP	The poverty rate
The growth rate of investment in fixed assets	The proportion of people in and above college
Investment in environmental protection accounts for GDP	The labor force average years of schooling
The actual utilization of foreign capital	Insurance rates for social insurance
Total amount of import and export	Living area per capita

Resource indicators	Environment indicators
Existing reserves of coal resource	Wastewater treatment rate
The useful life of coal resource	Waste gas treatment rate
The utilization rate of coal resource	Dustfall concentration
Per capita share of coal resource	The comprehensive utilization of solid and waste
The consumption of coal resource	Green area per capita in urban
Available arable land per capita	Forest coverage rate
Available water resource per capita	

13.4 Empirical Study on the Sustainable Development of Coal Resource Exhausted Cities

According to the above index system of sustainable development for coal resource exhausted cities, we select some key indicators to measure its capacity for sustainable development. According to the Statistical Yearbook of the coal resource cities from 2006 to 2011, we select the following variables and data as shown in Table 13.2 (Statistical yearbook of the various coal resource-exhausted cities from 2006). Then use principal component analysis method to comprehensive measure the level of sustainable development in these years of coal resource exhausted cities. Data is processed by the software of EXCEL and SPSS (Gao and Dong 2007).

In Table 13.2, X_1 is GDP per capita (yuan), X_2 is the tertiary industry accounts for GDP (percentage), X_3 is investment in environmental protection accounts for GDP (percentage), X_4 is annual average wage of workers (yuan), X_5 is employment rate of urban population (percentage), X_6 is the proportion of people in and above college (percentage), X_7 is living area per capita (square meters), X_8 is per capita share of coal resource (ton), X_9 is wastewater treatment rate (percentage), X_{10} is green area per capita in urban (square meters) (Table 13.3).

The correlation coefficient matrix of each variable can be seen, the correlation coefficient is larger among each variable, they also have a strong correlation. It can use principal component analysis method to comprehensive reflect the level of sustainable development through the relatively small number of variable synthetic indicators.

Table 13.2 The variable data

Years	X_1	X_2	X_3	X_4	X_5
2006	15055	0.3392	0.0071	15473	0.9499
2007	18254	0.3305	0.0078	19096	0.9543
2008	22923	0.3147	0.0101	22361	0.9579
2009	26103	0.3195	0.0106	25026	0.9600
2010	30860	0.3032	0.0126	29391	0.9629
2011	36499	0.3138	0.0167	33301	0.9635
Year	**X_6**	**X_7**	**X_8**	**X_9**	**X_{10}**
2006	0.0624	24.91	275	0.8678	8.93
2007	0.0656	26.35	260	0.8101	9.56
2008	0.0692	27.41	244	0.8613	10.08
2009	0.0724	28.67	231	0.8593	10.99
2010	0.0772	29.53	220	0.8658	12.23
2011	0.0801	30.53	206	0.9034	12.73

Explanation: the 10 indicators are the simple average of the 12 selected coal resource exhausted cities

Table 13.3 The correlation coefficient matrix of each variable

	X_1	X_2	X_3	X_4	X_5
X_1	1.000				
X_2	−0.823	1.000			
X_3	0.981	−0.735	1.000		
X_4	0.998	−0.840	0.972	1.000	
X_5	0.958	−0.923	0.893	0.969	1.000
X_6	0.995	−0.857	0.960	0.998	0.974
X_7	0.987	−0.858	0.941	0.991	0.987
X_8	−0.992	0.858	−0.953	−0.994	−0.984
X_9	0.664	−0.389	0.739	0.621	0.493
X_{10}	0.988	−0.837	0.951	0.992	0.958
	X_6	X_7	X_8	X_9	X_{10}
X_1					
X_2					
X_3					
X_4					
X_5					
X_6	1.000				
X_7	0.992	1.000			
X_8	−0.994	−0.999	1.000		
X_9	0.622	0.566	−0.602	1.000	
X_{10}	0.996	0.982	−0.982	0.616	1.000

Table 13.4 Total variance explained

Component	Initial eigenvalues		
	Total	% of variance	Cumulative %
1	8.984	89.837	89.837
2	0.740	7.401	97.238
3	0.215	2.154	99.391
4	0.032	0.316	99.707
5	0.029	0.293	100.000
6	2.84E − 016	2.84E − 015	100.000
7	1.27E − 016	1.27E − 015	100.000
8	−1.6E − 016	−1.60E − 015	100.000
9	−2.6E − 016	−2.59E − 015	100.000
10	−4.0E − 016	−4.01E − 015	100.000
Component	Extraction sums of squared loadings		
	Total	% of variance	Cumulative %
1	8.984	89.837	89.837
2	0.740	7.401	97.238

Fig. 13.1 Scree plot

From the results of principal component analysis in Table 13.4 and Scree plot in Fig. 13.1 can be seen, the contribution rate of the first principal component is 89.837 %, the contribution rate of the second principal component is 7.401 %, the cumulative contribution rate of the first two components is 97.238 %. Therefore, it can extract the first two principal components to measure the ability of the sustainable development for coal resource exhausted cities.

From Table 13.4, the first two principal components eigenvalues respectively are $\lambda_1 = 8.984$, $\lambda_2 = 0.740$.

The initial solution of the factor loading matrix is extracted by principal component analysis method is shown in Table 13.5.

For each column values in Table 13.5 respectively divided by the $\sqrt{\lambda_1}$, $\sqrt{\lambda_2}$, it can get the unit eigenvectors corresponding with each eigenvalue e_1, e_2.

Table 13.5 Component matrix

	Component	
	1	2
X_1	0.996	0.041
X_2	−0.865	0.335
X_3	0.966	0.188
X_4	0.996	−0.016
X_5	0.974	−0.207
X_6	0.998	−0.028
X_7	0.990	−0.092
X_8	−0.995	0.053
X_9	0.651	0.732
X_{10}	0.989	−0.020

$$e_1 = \frac{1}{\sqrt{8.984}} \begin{pmatrix} 0.996 \\ -0.865 \\ 0.966 \\ 0.996 \\ 0.974 \\ 0.998 \\ 0.990 \\ -0.995 \\ 0.651 \\ 0.989 \end{pmatrix} = \begin{pmatrix} 0.332 \\ -0.289 \\ 0.322 \\ 0.332 \\ 0.325 \\ 0.333 \\ 0.330 \\ -0.332 \\ 0.217 \\ 0.330 \end{pmatrix}$$

So the expression of the first principal component can be drawn as follows.

$$\begin{aligned} F_1 = {} & 0.332X_1 - 0.289X_2 + 0.322X_3 + 0.332X_4 \\ & + 0.325X_5 + 0.333X_6 + 0.330X_7 - 0.332X_8 \\ & + 0.217X_9 + 0.330X_{10} \end{aligned}$$

$$e_2 = \frac{1}{\sqrt{0.740}} \begin{pmatrix} 0.041 \\ 0.335 \\ 0.188 \\ -0.016 \\ -0.207 \\ -0.028 \\ -0.092 \\ 0.053 \\ 0.732 \\ -0.020 \end{pmatrix} = \begin{pmatrix} 0.048 \\ 0.389 \\ 0.219 \\ -0.019 \\ -0.241 \\ -0.033 \\ -0.107 \\ 0.062 \\ 0.851 \\ -0.023 \end{pmatrix}$$

So the expression of the second principal component can be drawn as follows.

$$\begin{aligned} F_2 = {} & 0.048X_1 + 0.389X_2 + 0.219X_3 - 0.019X_4 \\ & - 0.241X_5 - 0.033X_6 - 0.107X_7 + 0.062X_8 \\ & + 0.851X_9 - 0.023X_{10} \end{aligned}$$

According to the values and characteristics of each principal component, it can calculate the integrated value of the ability of sustainable development from 2006 to 2011 for coal resource exhausted cities, as shown in Table 13.6.

$$\begin{aligned} F &= \left(\lambda_1 / \sum \lambda\right) F_1 + \left(\lambda_2 / \sum \lambda\right) F_2 \\ &= 0.8984F_1 + 0.074F_2 \end{aligned}$$

Table 13.6 The ability of sustainable development for coal resource exhausted cities

Years	The first principal component F_1	The first principal component F_2	Integrated value F
2006	10064.44	444.49	9074.79
2007	12337.07	528.41	11122.73
2008	14979.10	689.14	13508.22
2009	16926.58	790.20	15265.32
2010	19962.27	934.94	18003.29
2011	23140.46	1129.99	20873.01

Explanation: the numerical size of F value has no practical significance, different indicators system will have different values, it only has the reference value

It can be seen by the values of the ability of sustainable development for coal resource exhausted cities as shown in Table 13.6, in recent years, the overall ability of sustainable development of China's coal resource exhausted cities is gradually increasing, but relative to the growth rate of GDP per capita at the same period, the growth rate of the ability of sustainable development is relatively slower. On the one hand, it thanks to the stable and orderly development of overall macroeconomic in our country, on the other hand, it also benefits from the strong support of the development of coal resource exhausted cities in the national policy (Wang and Geng 2012; Campbell and Roberts 2003; Randall and Ironside 1996).

13.5 Policy Recommendations

According to the index system and empirical analysis, it can take the following measures to achieve sustainable development for coal resource exhausted cities. Use industry adjustment assistance policies to broaden the financing channels to increase the capital investment. Select the appropriate pillar industries to raise the employment rate. Improve the population quality. Strengthen the building of scientific and technological contingent. Control pollution, enhance environmental protection. Industry structure and regional development needs are adapting in coal cities.

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Chapter 14
An Extensive Innovation Procedure to Quality Function Deployment for Product Design

Chang-tzuoh Wu, Jyh-rong Chou and Chang-shiann Wu

Abstract In this research, a systematic design method based on quality function deployment and extension method has been developed. The major procedure of QFD is to identify the customers' needs for the product and then convert into appropriate technical measures to fulfill the needs based on the company's competitive priorities. The priorities of product characteristics can be obtained by translating important technical measures. According to their characteristics, the prior engineering parameters will be identified and selected as the key requirements to redesign. This article will focus on the integration of QFD and extension method. With the help of "matter-element theory and extension method", customer requirements (CRs) can be transferred into product design attributes more comprehensively and deeply. An innovative design case, bicycle, successfully demonstrates that the proposed design process is feasible and efficient.

Keywords Extension method · Innovative design · Matter-element · QFD

14.1 Introduction

A successful new product development should meet various customer demands. Hence, analyzing customer requirements (the voice of customers) and responding

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E. Qi et al. (eds.), *The 19th International Conference on Industrial Engineering and Engineering Management*, DOI: 10.1007/978-3-642-38391-5_14,

to their needs has now become an important and inevitable task for a company's product development team. (Liu 2009).

Quality Function Deployment (QFD) is an important quality control theory proposed by the Japanese quality control masters Yoji Akao and Shigeru Mizuno. It was Akao who first realized the value of this approach in 1969 and wanted to utilize its power during the product design stage so that the product design characteristics could be converted into precise quality control points in the manufacturing quality control chart (Hill 1994); Sullivan (1986a, b) indicated that Quality function deployment (QFD) provides a means of translating customer requirements into the appropriate technical requirements for each stage of product development.

In recent years, the correlative researches of application of QFD have been developed rapidly and widely. As for the methodology, Eco-QFD, QFD integrated with Kano Model and QFD integrated with FMEA have been proposed and applied well.

Ernzer (2003) indicated that methodical support is necessary which integrates environmental and market issues in a product. He proposed an integrated approach called EI2QFD, which reduces the effort of carrying out an Eco-QFD. Additionally, Ernzer proposed an effective and efficient application of eco-QFD. Kuo (2005) introduced a fuzzy theoretic modeling approach to the Eco-QFD. The Eco design product development problem was formulated as a fuzzy multi-objective model based on the QFD planning. Chen (2009) proposed fuzzy nonlinear programming models based on Kano's concept to determine the fulfillment levels of PCs with the aim of achieving the determined contribution levels of DRs in phase 1 for customer satisfaction. Besides, the failure modes and effects analysis (FMEA) are incorporated into QFD.

Elif Kılıç (2009) indicated that in real world applications, the values of DRs are often discrete instead of continuous. A new QFD optimization approach combining MILP model and Kano model is suggested to acquire the optimized solution from a limited number of alternative DRs, the values of which can be discrete. Cecilia (2010) proposed a tool which utilized a combination of the Quality Function Deployment (QFD)—Kano model to evaluate service quality. Relevant information may be obtained about issues that should be improved in order to increase customer satisfaction by listening to the voice of the customer (VOC).

Most of the associated researches provide valuable and valid methods to enhance the effect of QFD. Though these studies applied successfully the proposed methods to solve design problems, they focused on local perspective view only. This article will concentrate on the creativity way of thinking "matter-element theory and extension method", with the help of this method to assist to translate customer requirements (CRs) into engineering characteristics (ECs) more deeply and widely.

14.2 Innovative Design Method

14.2.1 Quality Function Deployment

QFD, introduced by, Akao 1972 was designed to improve quality in product development. It has been a successful tool in assisting product designers systematically incorporate customer requirements (CRs) into product and process development (Akao 1990). Specifically, QFD systematically brings customer's needs to the level of detailed operations. The American Supplier Institute's (ASI's) Four-Phase approach was selected as the framework of this research. As shown in Fig. 14.1, the Four-Phase approach consists of product planning, part deployment, process planning, and production planning phases.

QFD is a structured design tool, and is defined as: "A consumers' needs oriented tool which establishes the relationship between customer attributes and design parameters to be quantified through the House of Quality (House of Quality), and integrated customers' cognition, finding key design factors in the product to determine the direction of product development and market positioning." HOQ indicates the relationship between customer requirements (what to do) and engineering characteristics (how to do it). It is the engine that drives the entire QFD process. In essence, the product planning phase translates qualitative customer requirements into measurable engineering characteristics, and identifies important engineering characteristics. The part deployment phase translates the output of the product planning into critical part characteristics and explores the relationship between engineering characteristics and part characteristics. The process planning phase establishes the relationship between part characteristics and manufacturing operations related to a part. Critical process parameters are identified and deployed in operation instructions. The production planning phase translates the manufacturing operations into production standards or work instructions, such as the number of parts to be checked, type of tools to be used, the inspection method to be performed, etc. (Liu 2009).

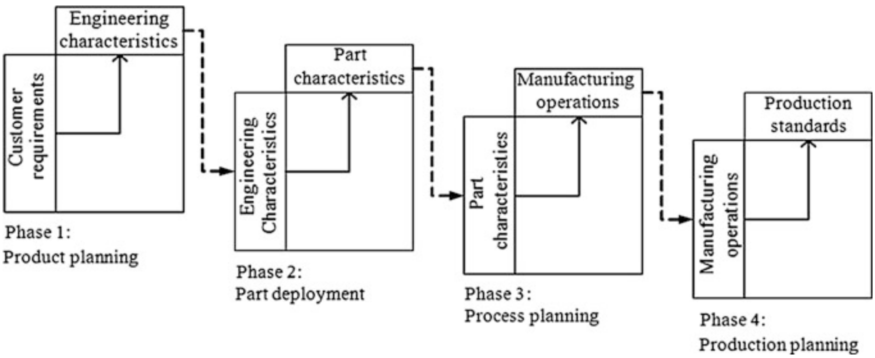

Fig. 14.1 Four-phase approach of QFD

The first phase of QFD, usually called house of quality (HOQ), is of fundamental and strategic importance in the QFD system, since it is in this phase that the customer needs for the product are identified and then, incorporating the producing company's competitive priorities, converted into appropriate technical measures to fulfill the needs. (Chen and Wu 2005) The goal of product planning phase is to translate customer requirements (CRs) into engineering characteristics (ECs) and prioritize their importance. Therefore, the CRs must be acquired from market surveys or customer questionnaires. The acquired information can be used to calculate the relative importance of CRs, calculate the final importance of CRs, and identify the Ecs, so that the final importance of ECs will be calculated and the relationship matrix also be established.

14.2.2 Matter-Element Analysis and Extension Method

In 1983, Cai developed a powerful tool, Matter-element and extension method, to systematically analyze concrete or intangible products. Extension theory is a course to study the extensibility, extent rules, performing procedure of matter and try to employ to resolve contradictive problems. Extension theory and method are the new science. Their application to the research on conceptual design of the products and innovative design is a new field. The extension method can help people resolve problems separately by decomposing and recombining the problems to search for the feasible solutions.

A matter-element can be combined with the other matter-elements to form a new one, or be decomposed into a few new matter-elements; new matter-elements contain qualities that former matter-elements do not have. The extension of matter-element provides another way of resolving contradiction. Matter-element can be used to describe every matter in real world. We use an ordered triad.

$$R(N, c, v) \tag{14.1}$$

The basic element for describing the matter N is called matter-element, where N represents the matter; c the characteristic name; v is N measure about c. Thus, $v = c(N)$

The extensibility of matter-element is the basis of dealing with incompatible problem. It includes divergence, expansibility, conjugate inside the matters and relativity of matter-element. Divergence is to study the possible routes of outward extension. It includes the same matter of matter-element, the same characteristics of matter-element, the measure of matter-element, the same matter and characteristics of matter-element, the same characteristics and measure of matter-element, the same matter and measure of matter-element. Extensibility studies plausibility, integration and separability of matter-element.

Replacement, decomposition, addition/deletion and expansion/contraction are four basic methods for transformation of matter-element and to be conducive to

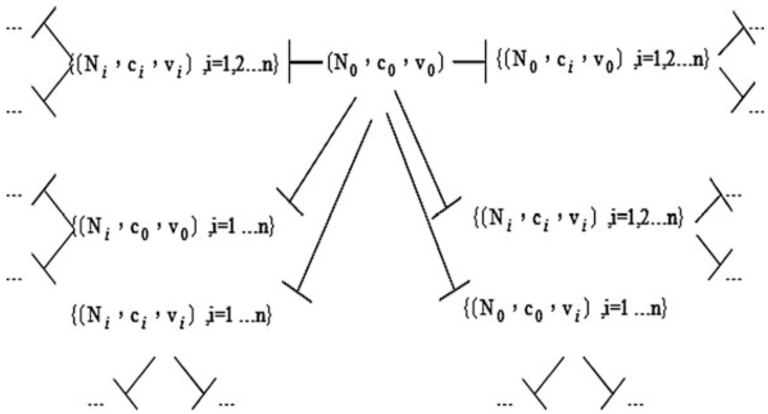

Fig. 14.2 General model of extending tree

exchanging or to synthesizing different matter-element. As shown in Fig. 14.2, general model of extending tree constructed by matter-element symbols expresses the divergence in simple way.

Study of the internal structure of matter is contributive to solve contradictive problems by using any element of matters. Systems theory, a description of structures of matters, is a science to study matters from system components and internal-external relationships. Through the analysis of a large number of matters, we found that, the properties of substance, dynamic and opposition can also be the research topics of the structure of matters in addition to systemic. A matter consists of the tangible part and intangible part of substance, both of which should also be considered. As for the dynamic properties, matter has the significant part and potential part. Such as the development of the disease, it generally includes the incubation period and the exacerbation period.

The structure of matter can be described more completely and the nature of variation of the development of matters can also be revealed more deeply while we explore the matter from the point of view of systemic, substance, dynamic and opposition. Therefore, we proposed corresponding four pairs of opposing concepts such as real/imaginary, soft/hard, potential/significant and positive/negative to describe the composition of matters called conjugate of matters.

14.3 Extensible QFD

Customer needs-orientation is the principal spirit of QFD. The conversion between functional quality and engineering design parameters is the important creativity thinking course for the fulfillment of the customer needs-oriented innovative design.

The major procedure of QFD is to identify the customers' needs for the product and then convert into appropriate technical measures to fulfill the needs based on the company's competitive priorities. The priorities of product characteristics can be obtained by translating important technical measures. According to their characteristics, the prior engineering parameters will be identified and selected as the key requirements to redesign. Throughout the procedure, the creativity activities with matter-element theory and extension method can be imported or expanded mainly in two parts,

(1) The course of translating customers' needs into product design attributes (technical measures).
(2) The course of identifying corresponding product defect or the parameters needed to be improved.

The use of extensibility of matter-element and extension method for the translation of product design attributes and engineering properties can provide effective assistance for the designer to conceive new products comprehensively and deeply. In this research, we will discuss the procedure for improving design attributes by the aids of extensibility of matter-element and extension method.

Matter-element and matter-element with multi-characteristics are defined as follows,matter-element

$$R = (N(t), c, v(t)) \tag{14.2}$$

matter-element with multi-characteristics

$$R(t) = \begin{bmatrix} N(t) & c_1 & v_1(t) \\ & c_2 & v_2(t) \\ & \vdots & \vdots \\ & c_n & v_n(t) \end{bmatrix} = (N(t), C, V(t)) \tag{14.3}$$

Based on the divergence of matter-element, matter-element $R_0(N_0, c_0, v_0)$ can be diverged from one or two of N_0, c_0, v_0 to synthesize different matter-elements, and build an extending tree. Extending tree is a method for matter to extend outwards to provide multi-orientated, organizational and structural considerations, as operating in Fig. 14.2. An event is the interaction of matters and described as event-element. Basic elements for describing an event-element are constructed by verb (d), name of verb characteristic (b) and u, the corresponding measure about (b). Event-element

$$\mathrm{I}(t) = (\mathrm{d}(t), \mathrm{b}, \mathrm{u}(t)) \tag{14.4}$$

Multi-dimensional event-element

$$\mathrm{I}(t) = (\mathrm{d}(t), \mathrm{B}, \mathrm{U}(t)) \tag{14.5}$$

Relationship-element is form by relationship name s(t), characteristics $a_1, a_2, \cdots, a_n$ and corresponding measure values $w_1(t), w_2(t), \ldots, w_n(t)$:

$$Q(t) = \begin{bmatrix} S(t) & a_1 & w_1(t) \\ & a_2 & w_2(t) \\ & \vdots & \vdots \\ & a_n & w_n(t) \end{bmatrix} = (S(t), A, W(t)) \tag{14.6}$$

While solving design problems based on Su-field model, diversity and creativity, the advantages of "extenics" method, will be imported by implementing the extensibility of matter-element, event-element and relationship-element. Thus, the solution will not be limited to standard solutions but be inspired.

14.3.1 Procedure for Improving Product Design Attributes

Throughout the procedure of QFD, the extensibility of matter-element and extension method can be introduced into the course of improving product design attributes (technical measures) based on product defects found from customers' voice. Below are the steps of creative activities for matter-element theory and extension method to be imported or expanded.

Step 1: express the existing products N into an n-dimensional matter-element

Step 2: Obtain the products' functional defects or the shortcomings lead to customer dissatisfaction by the customer voice (complain). Define the sub-matter-elements R_i $(i = 1 \sim m)$ corresponding to functional defects and rearrange as

$$R = \begin{bmatrix} & c_1^{(1)} & v_1^{(1)} \\ N & c_2^{(1)} & v_2^{(1)} \\ & \vdots & \vdots \\ & c_m^{(1)} & v_m^{(1)} \\ & \vdots & \vdots \\ & c_n^{(1)} & v_n^{(1)} \end{bmatrix} \tag{14.7}$$

Step 3: Transformation on the defects sub-matter-elements R_i $(i = 1,2,\ldots,m)$. Treat the replacement, addition/deletion, expansion/contraction transformation to the iso-matter-element but the addition/deletion, expansion/contraction transformation to the distinct matter-element. That is, either separately or integrated transform sub-matter-elements for each shortcoming R_i $(i = 1,2,\ldots,m)$

$$T_i R_i = R_i^* (i = 1, 2, \ldots, m) \tag{14.8}$$

After performing the matter element transformation, a new n-dimensional matter-element R^* which contained the revised sub-matter-elements will be occurred. The revised sub-matter-elements obtained by transforming the matter-element with shortcomings to a better one. Corresponding to the elements of R, a sequence of new products will occur.

14.4 Illustrative Design Case

In this research, design case "Bicycle", the most favorite exercise equipment and transport is adapt to explain and verify feasibility of the proposed innovative procedure. The proposed approach, QFD integrated with extension method, has been used to investigate the users' needs and relative functional requirements. In the creative course, we make use of the extension method to improve product design attributes and to determine the associated engineering design parameters. The creative solution programs based on customers' voice will thus be achieved.

14.4.1 Cooperated with Extenics

Two parts are in this stage of research. First, obtain the needs of bicycle by interviewing the elderly and translate to product design attributes, and then in the second part, the questionnaire checks for the elderly to pick the important requirements.

In this study, survey candidates are the cycling sport amateurs, and the cyclists are included to avoid some problems are ignored. Gathering respondents' views, users' requirements are sorted out as Table 14.1.

Use extending tree method to assist the establishment of HOQ. First, we build the transformation model by extending tree: A matter refers to multi-characteristics; a characteristic is also mapped by matters. Thus, "one matter with multi-characteristics", "one characteristic maps to multi-matters", "one value maps to multi-matters", "one matter, one value versus multi-characteristics", "one matter, one characteristic versus multi-values" are the extending propositions of matter-element to resolve contradiction.

Table 14.1 Requirements of bicycle for the sport amateures

Portability operating experience	Sturdy and durable
Overall riding comfortable	Additional functions
Cost/price	Attractive appearance
Flexibility to adjust	

$$R_1 = \begin{bmatrix} \text{Overall riding comfortable} & \text{comfortable grip} \\ \cdot & \text{anti-shock} \\ \cdot & \text{comfortable saddle} \\ \cdot & \text{ventilatory saddle} \end{bmatrix}$$

$$R_2 = \begin{bmatrix} \text{Portability operating experience} & \text{Light weight} \\ \cdot & \text{Breaking effort} \\ \cdot & \text{Operatederailleur smoothly} \\ \cdot & \text{Chain - link come off the ratchet and slip gears} \end{bmatrix}$$

$$R_3 = \begin{bmatrix} \text{Flexible adjustment} & \text{Easy to adjust seat post} \\ & \text{Quick detach} \end{bmatrix}$$

…etc.

We can translate product functional requirements into product design attributes as shown in Table 14.2.

We derive and confirm the "hypostatic characteristics" from "functional characteristics" and then the corresponding "certain characteristics" will also be derived and confirmed. Then, we use the corresponding four pairs' concepts such as replacement, addition/deletion, expansion/contraction transformation to the iso-matter-element but the addition/deletion, expansion/contraction transformation to

Table 14.2 Product design attributes

Level 1	Level 2	Level 3
Basic function	Specifications	Simplify parts
		Parts design for assembly
		Weight
		Size
	Mechanism	Driving mechanism
		Breaking mechanism
		Derailleur mechanism
	Safety	Material of frame
		Maintenance
		Breaking performance
		Structural strength
Ergonomic	Comfort	Heat dissipation of saddle
		Suspension performance
		Body dimensions
	Handling	Derailleur maneuverability
		Flexible adjustment
		Brake system

the distinct matter-element to describe the composition of matters and assist the transformation and extension of matter-elements.

Take the design attribute, driving mechanism, for example. One of the Customers' complaints is that a traditional bicycle uses a chain for transferring the pedal actuated driving force from the pedal crankshaft to the rear wheel. After using period of time, the chain-link is prone to come off the ratchet and slip gears. In addition, the long skirt also has the risk of being sullied or rolled into chain link. The extension of relationship-element of driving mechanism

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

We consider making the "rigid transmission device" play the major role of bicycle devices and then, design problem becomes "How to transform the flexible device into a rigid device?" This leads to new design problems based on the new concept. Repeat matter-element extending program. Transform the flexible device into a new general model by the divergence tree. Therefore, restart the extending processes by taking a new matter "rigid transmission device" and a new characteristic "contact type" to set up matter-element, event-element, and relationship-element and extending tree. Many ideas will be obtained. Therefore, a new device, bevel gear set, can meet the demand. We may consider using "bevel gear set" to replace "chain". We propose changing the transmission type. Bevel gear mechanism will be the new design concept we proposed.

14.5 Conclusions

This study proposes an innovative design and problem-solving process, based on quality function deployment method with the assistance of extension of matter-element.

In this research, we assess possibility and advantages to combine quality function deployment with the extension of matter-elements. The procedures for improving product design attributes and engineering design parameters transformation are also proposed. Furthermore, an innovative design case, bicycle, successfully demonstrates that the proposed design process is feasible and efficient.

Acknowledgments This work is supported by the National Science Council, Taiwan, and No. NSC 95-2221-E-017-006-

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Chapter 15
Analysis on Grey Relation of Labor Export Mechanism's Influence Factors in Poverty-Stricken Areas

Shan-ping Wang and Yi Zhou

Abstract Aiming at how to improve the labor export at the new period of poverty alleviation work of China, this paper first analyzed the influence factors of labor export mechanism in our country's poverty-stricken areas theoretically, then selected the related influence indexes, chose the poverty alleviation counties as the research object and used the Grey Correlation Analysis, empirically analyzed each index's influence size and order, so as to provide basis of related policy for further improving the poverty alleviation mechanism of labor export.

Keywords Grey correlation analysis · Labor export · Poverty alleviation

15.1 Introduction

From the "The Seven-year Priority Poverty Reduction Program", "Outline for Poverty Reduction and Development of China's Rural Areas (2001–2010)", to the issue of the new round of national poverty alleviation tasks and implement of "Outline for Development-oriented Poverty Reduction for China's Rural Areas (2011–2020)", all what can see is the government's spirit of encouraging poverty-

The research is supported by the New Century Training Program Foundation for the Talents of the Ministry of Education (NET06-0703) and by National Social Science Foundation (08BJY025).

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E. Qi et al. (eds.), *The 19th International Conference on Industrial Engineering and Engineering Management*, DOI: 10.1007/978-3-642-38391-5_15,

stricken areas to export their labor force, so as to help the poor people get employment in non-agricultural field and then increase their income to finally overcome poverty. However a poverty policy wants to get implementation and achieve the expected effects, it needs to meet the basic conditions: the poor people have the opportunity and ability to benefit from it. But the influence factors of labor export in poverty-stricken areas are various, just depending on poverty alleviation strategy or poverty relief funds are not enough to make them realize the goal successfully and get self-development in the constraint condition. In this case, the poverty relief investment's performance to the mechanism is very low, budget constraints and the requirements of improving efficiency are also not allow the funds' increasingly growth. Policy's limitation highlights the urgency of changing the focus of poverty strategy. What must be realized is the labor export is not a simple process of transferring the poverty-stricken areas' labor force to others; it needs to have a comprehensive understanding of each affecting factor, and then choose corresponding policy tools. Only in this way, in a new period of poverty alleviation and development, the export of labor can be more specific, and its effects can also be more enduring.

Based on this, this paper collect 2002–2010s related data, and using the Grey Correlation Analysis method (GCA) to study the influence factors of poverty-stricken areas' labor export mechanism, calculating the correlation degree and sorting, so as to seek for the major factors of this mechanism and make accurate evaluation.

15.2 Related Literatures Review

Labor export is a poverty alleviation mechanism that points to provide short-term vocational training to improve laborers' skills from poverty-stricken areas, after the training, the labor transfer to town or other developed regions to seek for higher income employment opportunities, so as to improve the family's income level. Existing studies have confirmed, carrying out the export of labor is one of the main effective poverty alleviation way. Through the flow of labor force, this mechanism can make reasonable use of labor resources, and it is an important channel of developing the rural human capital. Furthermore, China's rural labor flow's impact on the farmers' income increase, labor force optimal allocation and regional harmonious development is also of great significance. Based on the active effects from rural labor transfer, the study of the poverty-stricken areas' labor export accords to the similar research paradigm. Among these studies, the motive, barriers of the labor are embodied in the following aspects.

A. Institutional variables, especially the development strategy and the household registration system's impact. Cai (2001) research on institutional influence to rural laborers' decision-making shows that, the traditional development strategy and household registration system limit potential transfer, and institute reform has eased the restrictions. But the slow process of reform, make labor flow free is still filled with obstacles and would be a long-term standing problem. In this case, the explanation of expected income and human capital for labor transferring is not sufficient. Li (2003) regards the institutional factors have great influence on the China's rural labor transfer. Improvement of the household registration system will promote smooth migrant of the peasant-worker. Li (2007) establishes rural labor force transformation model which includes institutional factors, and comes to the similar conclusions.

B. Economic factors' impacts on the rural labor force transformation. In Chen and Hu labor transfer analysis framework, the town's informal employment department is introduced to explain labor transfer's causes and obstacles, observe the theory and practice, and study the transfer strategy and path of China's rural surplus labor, thus forming the widely accepted "Triangle Economic Theory". Du (1997) observes the China's rural laborers' transfer behavior from the perspective of income or resources, finds that the low income of farming and shortage of agricultural resource are the main reasons of rural labor force's shifting. Bai and Gan's (2005) paper investigates the Jiangxi rural labor force transformation's dynamics and obstacles by establishing the dynamic game model, and finds that the primary reason of rural labor transfer is economic income factors.

C. Discuss physical factors (include age, gender, health etc.) and mental factors (include education degree and non-agricultural working experience), and other demographic characteristics that effect the rural laborers' transfer decision-making. The results of Li (1999) study show that, the household's education is proportional to the possibility of labor flow, the higher the household's education degree is, the more likely to make the decision of family migration. Zhao considers the influence of formal education on labor transfer decision-making is very small, as to the labor force's shift from agriculture to non-agricultural areas, the influence is significant. Cheng and Shi's research confirms this conclusion.

In addition, as to the labor from the poverty-stricken areas, they are not only influenced by these three common factors as the national rural labors are, but also facing another important influence factor—the government's poverty alleviation activities to labor export mechanism. As Wang (2004) study shows that, if the poverty relief funds of training skills be combined with the labor export, it can put a more significant effect on the farmers of the poverty-stricken areas and can be more easily accepted. And he points out that the government should be given more autonomy and flexibility in choosing specific projects, so that the projects can take more farmers' needs into consideration. Through analyzing the changes of China's rural poverty properties, Du thinks the poor community which has more migration probability, the government should provide them the basic resources for migration to ensure them can make full use of the outside employment opportunities to improve their own welfare. Li (2007) tries to investigate the way of poverty alleviation, finally come to the conclusion that the existing method can't adapt to

China's the complexity of rural poverty problems and diversity of peasant households' demands, it decreases the accuracy of poverty relief funds. Fang (2007), based on the theory of ability poverty, points out that the effective poverty alleviation strategy should develop and enhance the poverty population's risk coping ability.

Reviewing the literatures above, we can see the poverty-stricken areas' influence factors of labor export mechanism, should be considered from the aspects of institute, economic, self-own and poverty alleviation activities, in order to examine whether the existing poverty alleviation way correspond to the factors or not. As to the research methods about the mechanism, most existing ones deduce the factors theoretically, but lack of the accurate result of the factors' contribution degree or ranking, and empirical evidence is mostly from regression analysis and time series analysis. However, if using the same empirical method to study the problems of poverty-stricken areas' labor export, the problem lies in, the lack of data. Considering the history of our country's poor monitoring is still short, so the available sample data is very poor. But the sample requirement of regression analysis and time series analysis are at least 30, or the accuracy of analysis cannot be guaranteed. In addition, the adjustment of the poverty line, the economic condition' variation and other external factors, make the sample cannot meet the requirements of distribution conditions of traditional quantitative analysis. So it is necessary to adopt new analysis method in exploring poverty-stricken areas' labor export mechanism.

15.3 Grey Correlation Analysis of the National Poverty Alleviation Counties's Labor Export

As a subsystem of the society, poverty-stricken areas' poverty problem is caused by social, economic, nature, history, etc. Combining the analysis above, we can see that the influence factors related with it is complex, and these factors constitute a network of relationships, of which there are many feedback loop. It is because of the relationship between the influence factors are not clear, so the labor export mechanism has gray system's characteristics. In this case, adopting the traditional regression analysis is difficult to achieve the expected effect, but the Grey Correlation Analysis method can compensate for it. The method has no strict requirement for samples and distribution, and is very convenient; it generally won't appear to be the situation that the quantitative result does not accord with the qualitative analysis. And the method can find out the advantage and disadvantage factors, or the leading and potential factors for the development of the system, and judge them. So this paper uses the Grey Correlation Analysis method to empirically analyze the influence factors' size and order of the mechanism.

15.3.1 Model Specification

This paper's research object is to study the influence factors' impact on poverty-stricken areas' labor export. The Grey Correlation Analysis is based on grey correlation degree to analyze the relationship of lord behavior factor and the relevant behavior factors in the grey system, and then judge the main factors and secondary factors for the development of the system according to similar degree of the curves' geometry. The closer the curves are, the greater correlation between the corresponding sequences is Deng (1993). If the grey correlation degree between influence factors and the Labor export index is deeper, then the factor's impact on this mechanism is greater. Thus provide policy guiding direction to promote smoother labor export in the new period of poverty alleviation work.

The basic steps of the grey relation analysis are:

Firstly, confirm the reference sequence that reflects system lord behavior characteristics and the comparison sequences that influent the system behavior.

Set system behavior sequence and comparison sequences:

$$Y = \left\{ y_i \middle| \begin{array}{c} i \in N, N = 0, 1, 2, \ldots,,\ m \geqq 2, y_i = (y_i(1), y_i(2), \ldots, y_i(n)), \\ y_i(k) \in y_i, k \in K, K = (1, 2, \ldots, n),\ n \geqq 3 \end{array} \right\}$$

Among them: $y_0(k)$, $(k = 1, 2, \ldots, n)$ is the reference sequence; $y_i(k)$, $(i = 1, 2, \ldots, m,\ k = 1, 2, \ldots, n)$ are the comparison sequences.

Secondly, the reference sequence y_0 and comparison sequences y_i are converted into proper dimensionless indexes in order to uniform dimension, making the factors comparable. This paper uses the equalization method to eliminate the dimension:

$$\overline{y_0} = \frac{1}{n}\sum_{k=1}^{n} y_0'(k),\ y_0' = \frac{y_0(k)}{\overline{y_0}} \qquad \overline{y_i} = \frac{1}{n}\sum_{k=1}^{n} y_i'(k),\ y_i' = \frac{y_i(k)}{\overline{y_i}}$$

$(k = 1,2, \ldots, n,\ i = 1,2,\ldots,m)$

Thirdly, calculate the correlation coefficients $\xi_{0i}(k)$ of the reference sequence and the comparison sequences to assess the correlation between them:

$$\xi_{0i}(k) = \frac{\max_i \max_k |y_0(k) - y_i(k)| + \zeta \max_i \max_k |y_0(k) - y_i(k)|}{|y_0(k) - y_i(k)| + \zeta \max_i \max_k |y_0(k) - y_i(k)|}$$

Among them, ζ, is the distinguish coefficient, its value range is (0, 1), this paper take $\zeta = 0.5$.

Fourthly, calculate the grey correlation degree γ_{0i}. Due to the correlation coefficients are correlation degrees at different times, so we need to prevent from data too much to compare. It is necessary to average the correlation coefficients. The formula of grey correlation degree is:

$$\gamma_{0i} = \frac{1}{n}\sum_{k=1}^{n} \zeta_i(k)\ (k = 1,2,\ldots,n, \quad i = 1,2,\ldots,m)$$

Fifthly, sort the grey correlation degree. The correlation's sequence between factors is mainly used by the grey correlation degree to describe. Sorting the $\gamma_{0i,}$ can reflect comparison sequences' impact on reference sequence.

15.3.2 Index Selection and Processing

Through the review of existing literatures, it can be seen that labor export is restricted by many factors, but considering the analysis method's feasibility, this paper, on the basis of existing researches, using the Grey Correlation Analysis method and combining with the "Chinese rural poverty monitoring reports", "China Statistical Yearbook" and "Chinese labor statistics yearbook", mainly from the aspects of institute, economic, self-own and poverty alleviation activities to empirically analyze influence factors of poverty-stricken areas' labor export.

Since 2002, the State Council determined the 592 national poverty alleviation work counties (i.e. counties) again according to "631 index method". So considering the continuity of the statistical data, this paper selects the time series data of 2002–2010 years for the model analysis.

Y_0 is set to represent the counties' number of export labor who obtains the employment outside the counties for more than a month. According to the analysis above, the influence factors are classified into 4 kinds:

- Institutional factor (y_1). This paper uses Chen (1999), Jin's (2001) researches for reference and selects the following indexes: the private sector employment rate (y_{11}), namely the non-state sector employment's proportion of total town employment; The urbanization rate (y_{12}), that is, the proportion of the urban population in total population, to measure the impacts of the institutional factors including economic component change and the household registration system change on the counties' labor export respectively. In addition, institutional changes' consequence is the proportion of market distributes labor resources gets bigger. Generally speaking, high degree of marketization of the country, the proportion of government allocating labor resources is usually low. So this paper adopts the proportion of GDP distributed by the market to approximate reflect the Proportion of Market Allocate Resources index (y_{13}), its measurement formula is: (GDP–national finance income)/GDP (national finance income without debt revenue).
- Economic factor (y_2). Because the income gap between urban and rural areas (y_{21}) reflect the attraction for the rural labor transfer, the proportion of the secondary and tertiary industry in GDP (y_{22}) reflects the modern industrial and service sectors' output, and for the rural surplus labor's transfer, the secondary

and tertiary industry provide them with the huge absorb space, it is an important way for rural labor to get non-agriculture employment; registered urban unemployment rate (y_{23}) represents the supply and demand situation of the urban labor market. So we take these three as the economic factor indexes to review.

- Self-own factor (y_3), The rural human capital stock is the comprehensive reflection of the rural labor force's culture quality, so using the Rural Human Capital Stock (y_{31}) to measure the overall Labor's culture quality of the counties, its computation formula is:

$$y_{31} = \sum_{1}^{4} Q_i h_i$$

n represents the workforce of the county, Q_i is the proportion of rural labor force with different education degree in total labor force, h_i is the Education conversion coefficients.[1] Considering the data's accessibility, we classify the rural labor's education degree into four kinds, namely, illiterate or semiliterate, elementary school, junior high school, high school and above.

Due to the First Industry Productivity (y_{32}), namely the ration of county's first industry output value with number of the first industry employees, and Rural Industrialization Rate (y_{33}), namely the proportion of the counties' non-agricultural labor force in the total labor, the two indexes represent the labor's transfer ability from the first industry in the counties, so we choose them to represent self-own factor indexes.

- Poverty alleviation factor (y_4). As for the poverty alleviation factors, this paper investigates from the following three aspects: poverty relief funds (y_{41}), namely the amount of poverty relief funds each year; the coverage of Poverty alleviation projects (y_{42}), namely that the proportion of poor village that participate in the in poverty alleviation projects; Farmers' participation (y_{43}) in poverty alleviation activity, using the proportion of farmers who have been funded by the poverty alleviation projects to measure.

15.3.3 Empirical Analysis

This paper use the GTMS3.0 software to process the initial data above, then get the Grey Correlation Degree (GCD) of each single influence index, the result is as Table 15.1 shows.

[1] For the education conversion coefficient, this paper refer Li's method, assume that illiterate or semiliterate is 1, the primary school is 1.1, junior high school is 1.2, high school and high school above is 1.5.

Table 15.1 Grey correlation degree of the counties' labor export influence indexes (2002–2010)

	Labor export number		
	Influence indexes	GCD/single	GCD/mean
Institutional factor (y1)	Y11	0.7129(6)	0.7025(2)
	Y12	0.7393(4)	
	Y13	0.6552(12)	
Economic factor (y2)	Y21	0.6888(7)	0.6830(4)
	Y22	0.6813(9)	
	Y23	0.6788(10)	
Self-own factor(y3)	Y31	0.6769(11)	0.6957(3)
	Y32	0.6828(8)	
	Y33	0.7274(5)	
Poverty alleviation factor (y4)	Y41	0.7805(3)	0.8139(1)
	Y42	0.8273(2)	
	Y43	0.8340(1)	

According to the Grey Correlation Analysis results, we can see that impacts of the influence factors on the counties' labor export are all relatively obvious, the sequence is: $y_{43} > y_{42} > y_{41} > y_{12} > y_{33} > y_{11} > y_{21} > y_{32} > y_{22} > y_{23} > y_{31} > y_{13}$. The result shows grey correlation degree of the poverty alleviation factor is the biggest, an average of 0.8139, the institutional factor takes the second place, the economic factors' is the minimum; As to the single factor, the coverage of poverty alleviation projects and farmers' participation in poverty alleviation activity are of great influence, the grey correlation degree of them are both above 0.8, while the influence of the Proportion of Market Allocate Resources, rural human capital stock and the town unemployment rate town influence are relatively small, are 0.6552, 0.6788, 0.6788 respectively. Therefore, we can see:

(1) The poverty relief activities (0.8139) is the most important factor for the counties' smooth labor export, especially the labors' participation in poverty alleviation activity (0.8273) and projects' coverage (0.8340). It shows that the poverty relief projects and related funds to this mechanism are closely correlated. This can be explained from the existing problems of present poverty alleviation mode and labor export mechanism.

In the poor counties which with few outworkers, poor information and surplus labor forces, the peasant lack adequate capital to pay for the initial cost of transferring, and the majority of them, the transfer is originated from spontaneous. In this case, only with the government's involvement, organize and guide the labor a proper way to transfer, associated with training them corresponding public knowledge and skills and improving their participation in these activities, then provide them appropriate initial funds, such as education and training funds or interest loans, will the ability of labor forces to win non-agriculture employment get effectively improved, and so will the resistance of the transfer channel decrease. In addition, considering our country's present poverty alleviation mode, it just aims at the poor county, not the real poor people. After the key counties have been determined, resources will be given. But these resources are mainly used in infrastructure projects, so that it cannot have wide coverage and the labor force cannot benefit from it directly. Therefore, if the pointing accuracy of individual increases, and making project cover more people, the poverty relief resources will be more accurately and timelier transmit to the poor labor force, and make the labor export mechanism more effective.

(2) The institutional factor (0.7025) is still one of the dominate factors that affect the counties' labor transfer. The institutional factor, including urbanization rate (0.7393) and private sector employment rate (0.7129), raise the threshold of labor export. The grey relation analysis result also concomitants with the present situation of our country's rural labor transfer. because of discriminations from the census register system and other related institutional factors, the cost of labor export increases invisibly, making the labor force pay more transaction cost to get a non-agricultural job; On the other hand, the discriminations also make the labor forces face the situation that trading places are not fixed and there are no contracts, they can only seek job in the subprime market, hardly get a long-term stable employment in the town, result in most of the labor forces wander between towns and poor areas helplessly.

(3) In the self-own factor (0.6957) and economic factor (0.683), the counties' proportion of non-agricultural production value (0.7274) and the income gap between towns and countries (0.6888), are also important to the labor export mechanism. This shows that the development of the counties' non-agricultural industries, the adjustment of economic structure, change of economic growth, and actively promoting agricultural industrialization and the third industry in the counties, will release labor force. As to the income gap between urban and rural, it also can promote the transfer to some extent. What worth noting is, the rural human capital which has been widely recognized as one of the key factors that affect rural labor flow, however, in this study, its grey relational grade only gets 0.6769, ranking No. 11. The reason for this situation may lie in the education pattern in poor counties, it almost copy the city' mode, just pay attention to the ordinary education, but ignore the importance of vocational skills, result in one's education does not fit him for a certain job and low effectiveness of the education investment. So the deficiency and dislocation of poor areas' human capital make the gray relational grade between rural human capital stock and labor export is small.

15.4 Conclusion and Suggestions

This paper has empirically researched the influence factors' impact on the counties' labor export base on the Grey Correlation Analysis method, the result shows that the government's poverty relief activities have positive impacts on the counties' labor export; these positive impacts come into effect mainly through improving labor's participation of poverty relief programs, programs' coverage and increasing the investment. This means that, increasing poverty alleviation investment is necessary but not enough, it is more important to improve the poverty alleviation projects' pertinence and coverage, so that more poor labor force can benefit from the activities, therefore changing their families' economic conditions through labor export. In addition, the empirical result also shows that, for poverty-stricken areas' labor force, whether they can smoothly export or not, still related with the institutional and economical factors, such as the household registration system, economic composition, the income gap and human capital stock, etc.

In conclusion, it is the national macro institutional arrangements, policies and regulations, and economic changes that have a profound influence on the poverty-stricken areas' labor export. The influence may be direct and clear, or indirect and potential. Under these constraints, if the poor labor forces want to change their social economic status through labor export, the government must leave spaces and opportunities for them to realize it, or promote this change as s driving force of the outside world. And these measures should by no means just by increasing the poverty alleviation funds (though its importance is obvious), but should be combined with improvement of poverty relief programs' coverage and pertinence; institution reform, especially the household registration system; improvement of the income gap between urban and rural; human capital investment mode reform of the poor areas. All in all, only the macro system reform, policy adjustment and micro poverty activities combined together, implementing more comprehensive poverty alleviation policies, will China's poor labor forces indeed benefit from this labor export mechanism in the new period and eventually get out of poverty.

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Chapter 16
Analysis on Trend of Research and Development Intensity in China

Bin Huang and Lu-cheng Huang

Abstract Research and development (R&D) investment is an important index to measure the R&D activity scale and evaluate the innovation ability. Based on review of the theory of R&D intensity from scholars at home and abroad, the paper analyzes R&D intensity trend in China. GM (1, 1) model is used to simulate and predict future trend of China R&D intensity.

Keywords China · GM (1, 1) model · Gray predication · R&D intensity

16.1 Introduction

Research and development (R&D) intensity is defined as the ratio between R&D expenditures and GDP (OECD 2011a). R&D intensity is used as an indicator of an economy's relative degree of investment in generating new knowledge. Several countries have adopted "targets" for this indicator to help focus policy decisions and public funding (OECD 2011b). The government intends to have R&D intensity reach 2.2 % by 2015 according to the Twelfth Five-Year Plan for National Economic and Social Development of the People's Republic of China (English section of the central document translation department 2011).

16.2 Research on R&D Intensity at Home and Abroad

The Human Development Report shows that R&D intensity has strong positive correlation with logarithmic per capita GDP, and R&D intensity of high-income

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E. Qi et al. (eds.), *The 19th International Conference on Industrial Engineering and Engineering Management*, DOI: 10.1007/978-3-642-38391-5_16,

countries is much higher than that of low-income countries (United Nations Development Program 2001).

The research induces that approximate "S" curve of R&D intensity, pointing out that 1.0 and 2.5 % are two points of inflection in the curve of R&D intensity (Zeng and Tan 2003).

The study finds that the pattern of science and technology (S&T) take-off is characterized by an abrupt increase from 1 to 2 % in the R&D intensity (Gao and Jefferson 2007).

According to the UNESCO's research, the variation in R&D has intimate relationship with economic development stage. In general, the variation in R&D intensity is not more than 1.5 % during the initial stage of industrialization; the variation in R&D intensity is about 1.5–2.5 % during the middle stage of industrialization; the variation in R&D intensity is generally greater than 2.0 % during the advanced stage of industrialization.

In the initial stage of industrialization, the growth of variation in R&D intensity is from fast to slow; in the middle stage of industrialization, the variation in R&D intensity grows rapidly at first, but later it grows more slowly; in the advanced stage of industrialization, the variation in R&D intensity tends towards stability (Deng and Ai 2004).

Generally, the country with its variation in R&D intensity below 1.0 % is lack of innovation ability; the country with its variation in R&D intensity between 1.0 and 2.0 % makes a difference; the R&D intensity of innovative country is above 2 % (Zhang 2001).

The trend of R&D intensity is showed in Fig. 16.1.

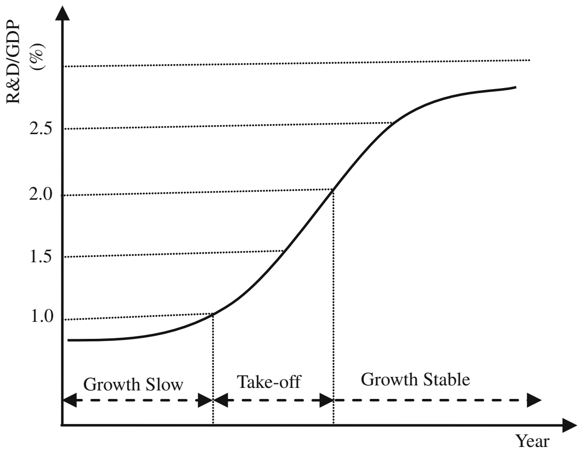

Fig. 16.1 The trend of R&D intensity

16.3 The Trend of R&D Intensity in China

16.3.1 Trend of R&D Intensity

Over the past thirty-four years, China's economy has moved from being largely closed to becoming a mayor global player. Gross expenditure on R&D (GERD) increased consistently from 0.61 % in 1987 to 1.76 % of GDP in 2010. The government requires above 2.5 % R&D intensity by 2020 according to the Medium and long-term Science and Technology Strategic Plan (2006–2020) in china (The Communist Party of China and State Council 2006). China's R&D intensity was low between 1987 (0.61 %) and 1998 (0.65 %). R&D intensity fell from a peak of 0.74 in 1992 to 0.57 % in 1995 or 1996. R&D intensity increased only marginally between 1997 and 1998 from 0.64 to 0.65 % but increased rapidly, particularly after 1998, at 1.07 % of GDP by 2002. China has started to step into the stage of scientific and technological take-off since 2002. The China's R&D intensity trend from 1987 to 2010 is showed in Fig. 16.2.

16.3.2 Reflection of R&D Intensity Trend

China's R&D intensity is still low. Taken as a whole, China is still in the primary stage of socialism and remains a developing country. China is in the grouping of upper-middle-income countries, in the middle stage of industrialization, and its innovation ability places twenty-ninth in the word according to Global Innovation Index (GII) 2011.

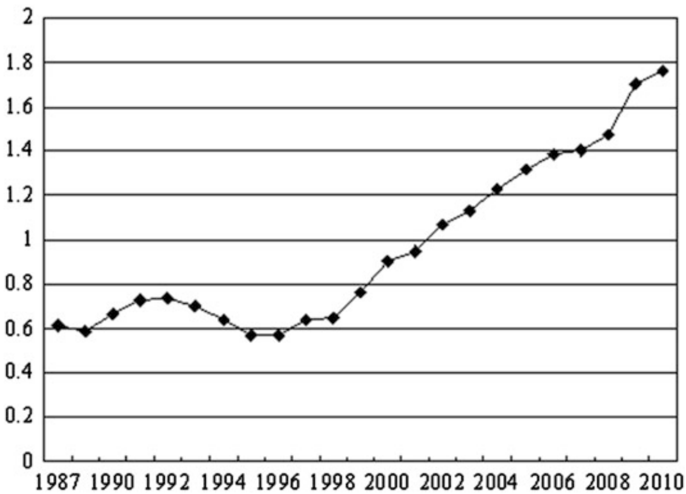

Fig. 16.2 The China's R&D intensity trend from 1987 to 2010, *Source* Statistics of science and technology of China, http://www.sts.org.cn/index.asp

16.4 Gray Prediction of R&D Intensity in China

16.4.1 Gray Prediction

Gray Prediction Theory, based on the Gray System Theory, established by Chinese Scholar Professor Deng Julong in 1982 (Di 2002), is a new method to solve the problems that are lack of data and information. GM (1, 1) model construct gray prediction model to predict the characteristic quantity of a given amount of time, or the time to reach a certain characteristic quantity by a number of equal interval observed numbers which reflect the characteristics of the predictable object, such as production, sales, population, interest rates, etc. (Deng 1982; Liu and Lin 2006; Deng 1989). In theory, GM (1, 1) model is a continuous function of time, stretching from the initial value to the future at any time (Deng 1995).

The basic procedure for grey prediction is as follows (Deng 2005):

Step 1: Determine the raw series $x^{(0)}$, class ratio series $\sigma^{(0)}$

The raw series $x^{(0)}$ for modeling are given as follows:

$$x^{(0)} = \left\{x^{(0)}(1), x^{(0)}(2), \ldots, x^{(0)}(n)\right\} \tag{16.1}$$

where n is equal or greater than 4.

Let $\sigma^{(0)}(k)$ be class ratio of $x^{(0)}$ at point k,

$$\sigma^{(0)}(k) = x^{(0)}(k-1)/x^{(0)}(k) \tag{16.2}$$

Step 2: Determine the semi-finished series $x^{(1)}$, $z^{(1)}$

$x^{(1)}$ is valued as follows:

$x^{(1)} = AGOx^{(0)}$, where AGO means Accumulated Generating Operation.

$x^{(1)}(1) = x^{(0)}(1)$, where k is equal 1;

$$x^{(1)}(k) = x^{(0)}(k-1) + x^{(0)}(k) \tag{16.3}$$

where k is greater than 1.

$z^{(1)}$ is valued as follows:

$z^{(1)} = MEANx^{(1)}$, where $MEAN$ means the average of adjoining number of $x^{(1)}$.

$$x^{(1)}(k) = (x^{(1)}(k) + x^{(1)}(k-1))/2 \tag{16.4}$$

where k is greater than 1.

Step 3: Determine the semi-parameters C, D, E, F

$$\begin{aligned} E &= \sum (z^{(1)}(k) \times x^{(0)}(k)),\ F = \sum (z^{(1)}(k) \times z^{(1)}(k)) \\ C &= \sum z^{(1)}(k),\ D = \sum x^{(0)}(k) \end{aligned} \tag{16.5}$$

where k is greater than 1, and less than n.

Step 4: Determine the developing coefficient a and grey input b as follows:

$$a = (C \times D - (n-1) \times F)/((n-1) \times F - C \times C) \tag{16.6}$$

$$b = (D \times F - C \times E)/((n-1) \times F - C \times C) \tag{16.7}$$

Step 5: Determine the Grey differential equation of GM (1, 1) and the white response of GM (1, 1) as follows:

$$x^{(0)}(k) + a \times z^{(1)}(k) = b \tag{16.8}$$

then we can get the white response of GM (1, 1):

$$x'^{(0)}(k+1) = \left(x'^{(0)}(1) - b/a\right)e^{-ab} + b/a \tag{16.9}$$

Step 6: Checking residual errors $\sigma^{(i)}(k)$ as follows: recuperating value:

$$x^{(0)}(k+1) = x^{(1)}(k+1) - x^{(1)}(k) \tag{16.10}$$

residual errors:

$$\delta^{(1)}(k) = \left[\left(x^{(1)}(k) - x'^{(1)}(k)\right)/(x^{(1)}(k)\right] \times 100\,\% \tag{16.11}$$

$k = 0,1,2,\ldots$ where $x^{(1)}(k)$ is the actual value, $x'^{(1)}(k)$ is the modeled value.

Step 7: Check GM (1, 1) model accuracy

According to literatures (Liu et al. 2004), if $\delta^{(1)}(k)$ value is equal or less than 0.01, the model is level 1, if $\delta^{(1)}(k)$ value is between 0.01 and 0.05, the model is level 2, if $\delta^{(1)}(k)$ value is between 0.05 and 0.10, the model is level 3, if $\delta^{(1)}(k)$ value between 0.10 and 0.20, the model is level 4.

16.4.2 China's R&D Intensity Gray Prediction

According to recent R&D intensity data in China, take data on R&D intensity in China over the past 6 years as original sequence:

$$x^{(0)} = (1.32,\ 1.39,\ 1.40,\ 1.47,\ 1.70,\ 1.76),$$

let $x^{(0)}_{n-1}$ as $x^{(0)}$ subsequence, also is

$$x^{(0)}_{n-1} = (x^{(0)}_{(n-i)}, x^{(0)}_{(n-i+1)}, \ldots, x^{(0)}_{(n)})$$

where n is equal six. Then make models for these sub-semi-groups sequence, respectively, constantly adjusted to these sequences' interval boundary value, repeatedly modeling, thus obtained GM (1, 1) models with different interval boundary value of the project, also is

Table 16.1 Forecast data on China's R&D intensity

Years	R&D intensity
2011	1.89
2012	2.02
2013	2.16
2014	2.31
2015	2.48
2016	2.65

$$x'^{(0)}(k+1) = \left(x'^{(0)}(1) - b/a\right)e^{-ab} + b/a.$$

In the end, make residual inspection of GM (1, 1) model with different interval boundary value, then selected residual qualified model for level or close precision level as the R&D intensity GM (1, 1) model.

Forecast data on China's R&D intensity in the next 5 years is showed in Table 16.1.

16.5 Conclusion

The upward trend of R&D intensity in China is generally in agreement with the rule of R&D intensity trend. It has entered the second stage Science and Technology (S&T) take-off which is a crucial period. However the level of R&D intensity in China is still low. But, this study documents that China has begun a similar S&T take-off, and the increased ratio of R&D intensity is consistent with that of GDP. So R&D intensity in China will be able to realize the steady and quick growth based on the goal of building of innovation-oriented country. Meanwhile, R&D intensity in China will have reached 2.5 % before 2016.

Acknowledgments The project is supported by the National Natural Science Foundation of China (70639002).

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Chapter 17
Application of IE Method in Modern Agro-Ecological Park Planning

Li Yue

Abstract The present paper deals with the comprehensive planning of a new modern agro-ecological park established by a company. Learning from the practices of IE method used in the manufacturing and service industries and considering the characteristics of modern agriculture, we offers some references to the planning of fungi configuration, functional zone, processing zone and layout of the park to maximize the overall benefits of the construction of a modern agro-ecological park.

Keywords IE method · Modern agriculture · Plan · SLP

17.1 Introduction

The IE method has been widely used in the manufacturing and service industries such as automobile, steel, machinery, home appliance, construction materials, and information. Japan is the first country to apply IE method in agriculture and this application is still at its initial stage (Guo 2003; Qi et al. 1999; Yi and Guo 2007).

One company (hereinafter referred to as A company) will establish a modern agro-ecological park covering 90 mu, which will incorporate fungi cultivation, personnel training, eco-tourism, entertainment and dining and conference and leisure. Combining the characteristics of modern agriculture and the practices of IE method used in manufacturing and service industries, this article considers solutions to the problems in the planning of a modern agro-ecological park with a view to maximizing corporate and social benefits (Shi 2002; Shin 2001; Wu et al. 2008).

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E. Qi et al. (eds.), *The 19th International Conference on Industrial Engineering and Engineering Management*, DOI: 10.1007/978-3-642-38391-5_17,

17.2 Research Guideline and Methodology

The construction of modern agro-ecological park shares much in common with that of modern manufacturing company. This paper employs the IE method in the research of agro-ecological park planning in the following areas: location and layout of the park, organizational structure planning, supply chain planning, capacity planning, industrial chain planning, human resource planning, human factors environmental planning and standardized production (Lu and Wang 2004; Wang 2009).

The research guideline and procedures in this article are shown in Fig. 17.1: (1) using Fuzzy Comprehensive Evaluation method to choose the most suitable fungi species for cultivation., (2) using SWOT analysis and Historical Analogy Analysis method to predict the capacity of each functional zone and make personnel and equipment planning according to the market demand., (3) in accordance with the results of capacity planning, employing the knowledge of Operations Research, building a model with the optimal area as its target and using Lindo to find the optimal solutions to the area of each functional zone., (4) and on the above basis, using SLP method to make a plan for the layout of the processing zone and the park (Jiang 2001).

17.3 The Species of Edible Fungi Planning

Through the market research and the analysis of cultivation techniques, there are six selected species of edible fungi to be cultivated: *Morchella conica*, *Lentinus edodes*, *Ganoderma lucidum*, *Coprinus comatus*, *Pleurotus ostreatus*, *Flammulina*

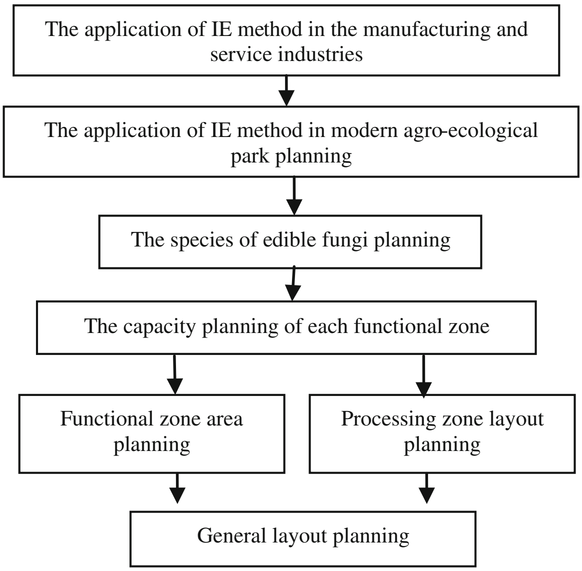


Fig. 17.1 Research guideline

Table 17.1 The evaluation of the species of fungi

Evaluation indicators	Weights
1. Return on investment	0.25
2. Difficulty of cultivation technique	0.15
3. Sales channels	0.20
4. Competition environment	0.22
5. Managerial expertise	0.10
6. Market response capability	0.08

Morchella conica   Lentinus edodes   Ganoderma lucidum

Fig. 17.2 Edible fungi

velutipes, but only three of them can be cultivated due to the actual demand of A company. Therefore, use fuzzy comprehensive evaluation method to make evaluations of the selected species. The evaluation indicators and their associated weights are shown in Table 17.1 (Pan 2003).

According to the Table 17.1, the selected six species are graded, ranking from high to low, and *Morchella conica*, *Ganoderma lucidum*, *Lentinus edodes* are the final selections. See Fig. 17.2 (Hang 2003; Zhang 2002).

17.4 Capacity Prediction and Planning of Each Functional Zone

The agro-ecological park can be divided into 6 zones with some relevantly distinctive functions: (1) Dining and Training Zone; (2) *Morchella conica* Cultivation Zone; (3) *Ganoderma lucidum* Cultivation Zone; (4) *Lentinus edodes* Cultivation Zone; (5) Breeding and Sightseeing Zone; (6) Processing Zone (Ding 2004).

We analyze the geographic conditions and human environment of the park as the first step, then start from the market analysis and make capacity predictions of each zone using the historical analogy method and SWOT analysis according to the various features of each functional zone, and finally make personnel, equipment and construction planning for each zone in conformity with the results of capacity predictions.

17.4.1 Capacity Planning for Catering and Training Zone

Dining and training zone is a major functional zone featuring farmer training, instructing, dining (mainly for fresh edible fungi), eco-tourism, specialty shops, DIY zone and leisure and entertainment. It is predicted that the annual number of visitors will be 27,000–33,000 and about 1,000 edible fungi cultivators will receive professional training annually.

17.4.2 Capacity Planning for Edible Fungi Cultivation Zone

The market demand for *Morchella conica* mainly comes from the visitors who are coming here for relax and leisure. In accordance with the capacity planning for dinning and training zone, it is projected that the annual demand of *Morchella conica* will reach 5,900–7,300 kg.

Ganoderma lucidum has been proven to have medicinal properties, and its market demand has been increasing year after year. There are two sales channels for *Ganoderma lucidum*: (1) fresh *Ganoderma lucidum* consumed in restaurants; (2) *Ganoderma lucidum* spore powder, dried *Ganoderma lucidum* and powdered *Ganoderma lucidum* sold to herbal medicine dealers. Based on the market analysis, competitor analysis and SWOT analysis, it is forecasted that the annual demand of *Ganoderma lucidum* will stand at 149,000–165,000 kg.

Skiitake is rich in vitamin, iron and potassium, treating loss of appetite and relieving languor. Through the current market analysis and the sales data analysis, it is calculated that the annual demand of *Lentinus edodes* will be 455,000–572,000 kg in terms of the historical analogy method.

17.4.3 Capacity Planning for Breeding and Sightseeing Zone

Breeding and sightseeing zone takes breeding and earthless cultivation as its core, mainly breeding for *Morchella conica* cultivation zone, *Ganoderma lucidum* cultivation zone and *Lentinus edodes* cultivation zone. Thereupon, the capacity of breeding zone can be determined to some extent by that of the three cultivation zones. The capacity planning is as follows: *Morchella conica* 118–146 bottles, *Ganoderma lucidum* 2980–3300 bottles, *Lentinus edodes* 9100–11440 bottles.

Table 17.2 Annual capacity planning of processing zone (ten thousands kg/year)

Species of edible fungi	Name	Total
Lentinus edodes	Powdered *Lentinus edodes*	319
	Dried *Lentinus edodes*	410
	Preserved *Lentinus edodes*	182
Ganoderma lucidum	Powdered *Ganoderma lucidum*	74
	Dried *Ganoderma lucidum*	124
	Preserved *Ganoderma lucidum*	50

17.4.4 Layout Planning for Processing Zone

The main function of this zone is processing *Ganoderma lucidum* and shiitake. Given the development goals of A company, the capacity planning of processing zone is shown in Table 17.2.

17.5 Optimized Layout of Processing Zone

The processing zone layout has much in common with plant layout, so SLP method can be applied.

According to the processing techniques of *Ganoderma lucidum* and *Lentinus edodes*, this zone can be divided into 10 operating units: 1 raw material base, 2 cleaning zone, 3 drying room, 4 sun drying zone, 5 sterilization room, 6 cooling room, 7 pulverizing room, 8 low-temperature packaging room, 9 packaging and quality monitoring workshop, 10 processing products zone.

First, analyze the processing procedures of the edible fungi and logistics amount and then establish logistics relationship shown in Fig. 17.3.

Analyze non-logistics relationship in processing zone and establish non-logistics relationship shown in Fig. 17.4.

Then, combine the two above relationships and establish integrated relationship shown in Fig. 17.5.

Finally, according to the integrated relationship between various operating units, draw their area diagram (Figs. 17.6 and 17.7).

Take the characteristics of edible fungi processing, relevant regulations and restraints into account and then determine the overall layout of the processing zone shown in Fig. 17.8 (Chen et al. 2008; Dong 2005).

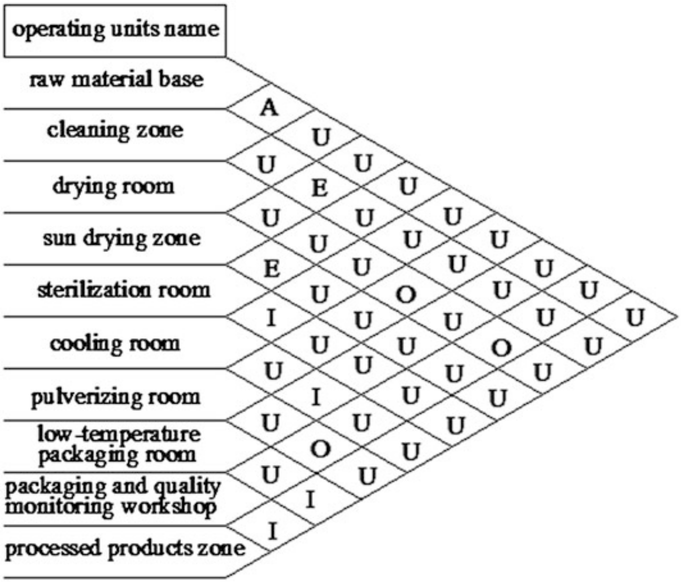


Fig. 17.3 Logistics relationship diagram

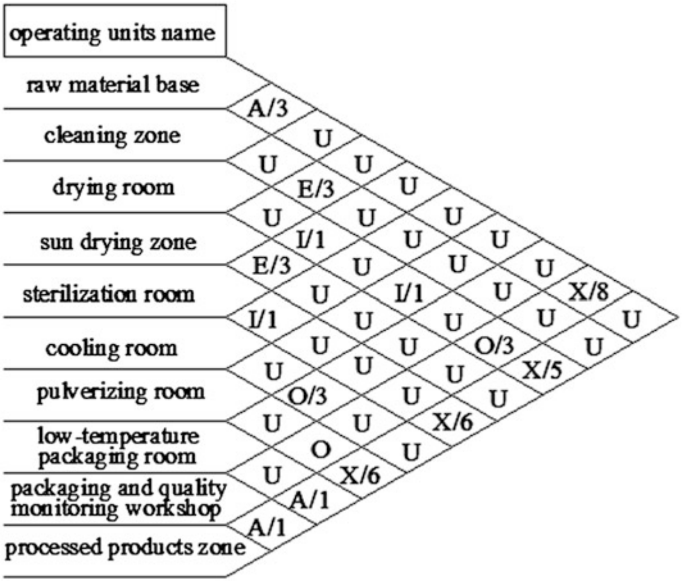


Fig. 17.4 Non-logistics relationship diagram

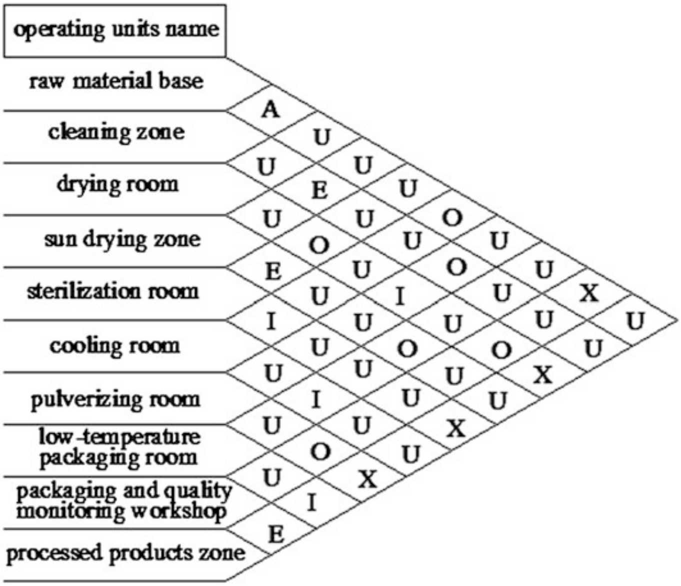
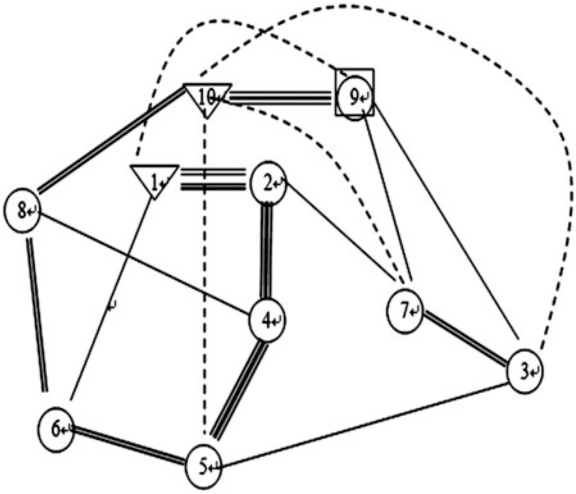


Fig. 17.5 Integrated relationship diagram

Fig. 17.6 The location-related map of operating units



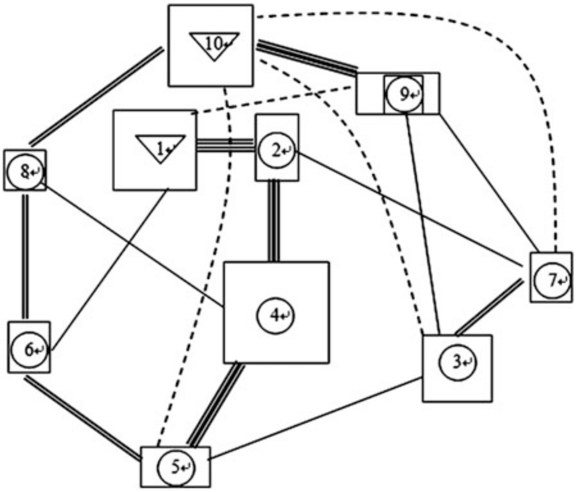


Fig. 17.7 The area-related map of operating units

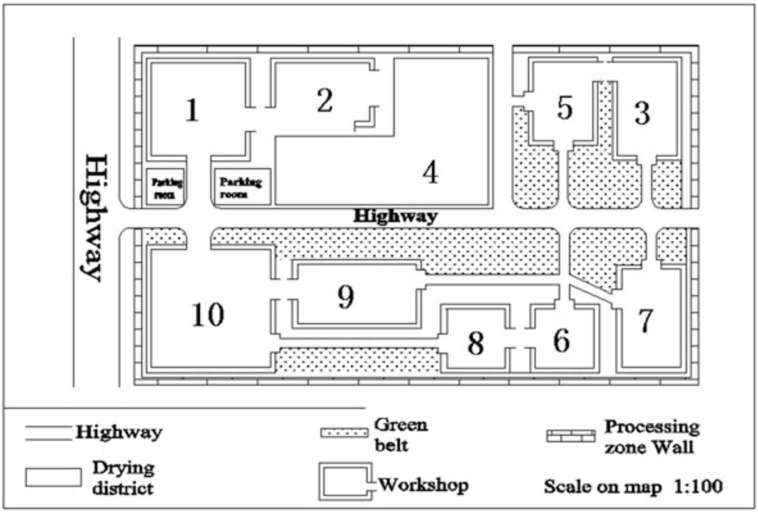


Fig. 17.8 Overall layout of processing zone

17.6 Optimized Layout of the Park

17.6.1 Preliminary Area of Each Functional Zone

The capacity per unit of each functional zone divided by its overall annual demand equals the initial area of each zone shown in Table 17.3.

Table 17.3 The initial area of each zone

Name		*Morchella conica* cultivation zone	*Ganoderma lucidum* cultivation zone	*Lentinus edodes* cultivation zone	Processing zone	Breeding and sightseeing zone	Catering and training zone
Area requirement	Maximum	1.1	20	44	10	10.8	11
Unit (acre of land)	Minimum	0.91	18	35	10	8.6	9

Table 17.4 The interest coefficient of yield acre of land in each functional zone

Name	*Morchella conica* cultivation zone	*Ganoderma lucidum* cultivation zone	*Lentinus edodes* cultivation zone	Catering and training zone
Interest coefficient	13.4	11.1	7.6	6.5

17.6.2 Formula for the Calculation of Optimal Area of Each Functional Zone

The interest coefficient of each functional zone is shown in Table 17.4.

Set the values of added areas of *Morchella conica* cultivation zone, *Ganoderma lucidum* cultivation zone, *Lentinus edodes* cultivation zone, breeding zone and catering and training zone as X_1, X_2, X_3, X_4, X_5 respectively, and make use of the knowledge of operations research to build mathematical model with the maximum benefits of the agro-ecological park as the target.

17.6.2.1 Objective Function

$$\text{MAX } Z = 13.4X_1 + 11.1X_2 + 7.6X_3 + 6.5X_5 \tag{17.1}$$

Constraints:
S.T.

$$X_1 + X_2 + X_3 + X_4 + X_5 \le 71 \tag{17.2}$$

$$0.12X_1 + 0.09X_2 + 0.2X_3 = X_4 \tag{17.3}$$

$$0.1X_5 + 1 = X_1 \tag{17.4}$$

$$0.9 \le X_1 \le 1.1 \tag{17.5}$$

$$18 \le X_2 \le 20 \tag{17.6}$$

$$35 \le X_3 \le 44 \tag{17.7}$$

$$0 \le X_5 \le 2 \tag{17.8}$$

Use Lindo to find the optimal solutions and calculate the results: $X_1 = 1,\ X_2 = 3,\ X_3 = 40,\ X_5 = 0,\ X_4 = 0.12X_1 + 0.09X_2 + 0.2X_3 = 10.$ Thus the optimal area of each functional zone is shown in Table 17.5.

Table 17.5 The optimal area of each functional zone (mu)

Name	*Morchella conica* cultivation zone	Lingzhi mushroom cultivation zone	Shiitake cultivation zone	Processing zone	Breeding and sightseeing zone	Catering and training zone
Optimal area	1	20	40	10	10	9

Table 17.6 Comprehensive relationship between each functional zone

Name	Processing Zone	Catering and Training Zone	Breeding and Sightseeing Zone	Morchella Conica Cultivation Zone	Ganoderma lucidum Cultivation zone	Lentinus edodes Cultivation Zone
Processing Zone		XX	XX	X	E	A
Catering and Training Zone	XX		A	I	E	O
Breeding and Sightseeing Zone	XX	A		I	I	I
Morchella Conica Cultivation Zone	X	I	I		E	E
Ganoderma lucidum Cultivation zone	E	E	I	E		E
Lentinus edodes Cultivation Zone	A	O	I	E	E	
Close degree	2	8	8	9	14	13
Ranking	6	5	4	3	1	2

17.6.3 Analysis on Comprehensive Relationship Between Each Functional Zone

The higher ranking the close degree is, the closer to the center of the general layout the operating unit should be and vice versa.

According to Table 17.6, the rankings are as follows: 1 *Ganoderma lucidum* cultivation zone; 2 *Lentinus edodes* cultivation zone; 3 *Morchella Conica* Cultivation Zone; 4 breeding and sightseeing zone; 5 catering and training zone; 6 processing zone. The location-related map of each functional zone and the general layout of the park are shown in Figs. 17.9 and 17.10.

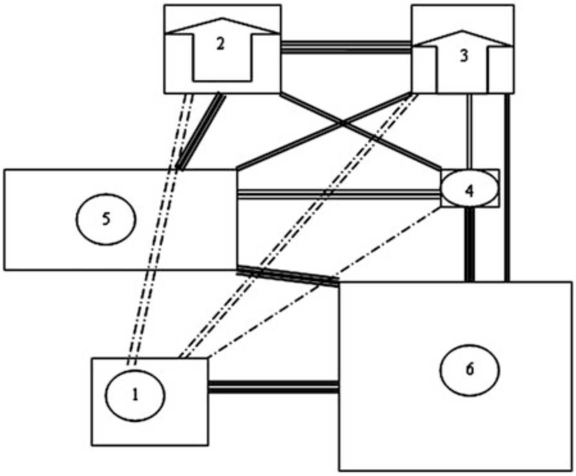


Fig. 17.9 The location and area-related map of each functional zone

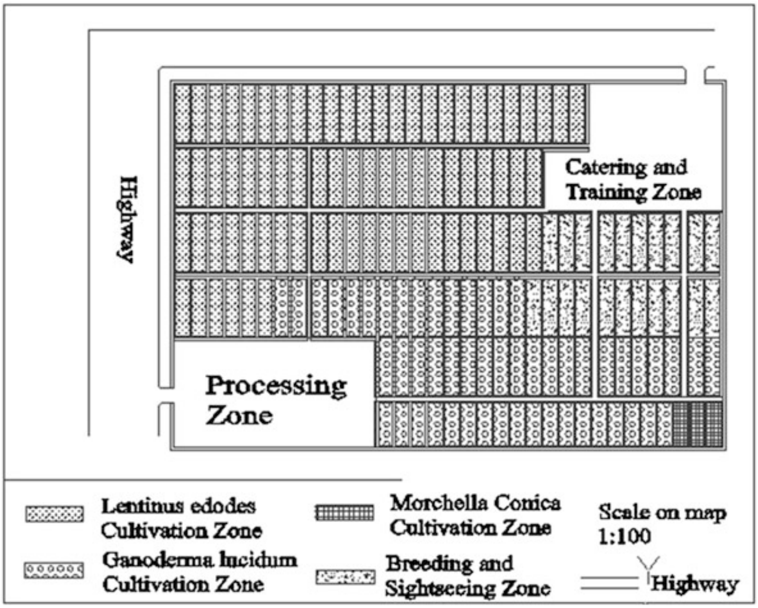


Fig. 17.10 The general layout of the agro-ecological park

17.7 Conclusion

This paper examines a new way about modern agricultural park planning theoretically and practically. We draw references from the practices of IE method used in the manufacturing and service industries and make full use of IE knowledge, making planning for capacity, fungi configuration, park layout and other aspects so as to maximize the overall benefits of the agro-ecological park.

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Chapter 18
Application of Improved Grey Prediction Model for Chinese Petroleum Consumption

Ying Ma and Meng Sun

Abstract An improved Grey-based settlement predictor is promoted. Adopt Grey prediction as a forecasting means because of its fast calculation with a few of data inputs needed. However, our preliminary study shows that the general Grey model, GM (1,1) is inadequate to handle settlement prediction as its only adapt to the data with exponential law. In this paper, the prediction is improved significantly by adopting equal dimensionality information fill model aim at enhancing the prediction accuracy. The prediction is made on Chinese petroleum consumption in future.

Keywords Grey system theory · Improved GM (1,1) · Petroleum consumption · Prediction

18.1 Introduction

Energy is the life blood of the economy, relations with the development of the national economy and improving the People's living conditions. Energy consumption is forecast to the stable and rapid economic development, to speed up the healthy development of the energy industry, and conducive to the formulation of a sound energy planning, so energy consumption accurate forecasts that is very necessary.

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E. Qi et al. (eds.), *The 19th International Conference on Industrial Engineering and Engineering Management*, DOI: 10.1007/978-3-642-38391-5_18,

China is the world's petroleum Producing and consuming nations. In recent years, along with the rapid economic growth, domestic petroleum consumption increased substantially. How to better predict petroleum consumption, which has become an important sustainable development issues on the national economy. Many researchers developed the settlement prediction methods, 'Three Point Method' (Li et al. 1994), 'Hyperbola Method', 'Grey Theory' (Zhang et al. 1999), 'Neural Network' (Tavenas and Leroueil 1980), 'Asaokao' (Asaoka 1978) etc. Grey theory is one of the most widely used methods. Grey theory, developed originally by Deng (1982), is a truly multidisciplinary and generic theory that deals with systems that are characterized by poor information and/or for which information is lacking. The fields covered by grey theory include systems analysis, data processing, modeling, prediction, decision making and control. Grey forecasting models have been extensively used in many applications (Gao et al. 2003; Liu 2001; Meng et al. 2002; He 2002), and it was improved by many researchers.

18.2 Methodology

18.2.1 GM (1,1) Model

Deng proposed Grey theory to deal with indeterminate and incomplete systems. Unlike conventional stochastic forecasting theory, Grey theory simply needs few sample data inputs to construct a Grey model. Since the poor regularity for the tested settlement data, the AGO technique in Grey forecasting is suitable to reduce the randomization of the raw data efficiently. Generally, the procedure for GM (1,1) forecasting is explained as follows:

Step 1. Denote the original data sequence by

$$\left| X^{(0)} = \left\{ X^{(0)}(1), X^{(0)}(2), \ldots, X^{(0)}(n) \right\} \right| \tag{18.1}$$

where n is the number of data observed.

Step 2. The AGO formation of $x^{(0)}$ is defined as:

$$\left| X^{(1)} = \left\{ X^{(1)}(1), X^{(1)}(2), \ldots, X^{(1)}(n) \right\} \right| \tag{18.2}$$

where

$$X^{(1)}(1) = X^{(0)}(1)$$

$$\text{and } X^{(1)}(k) = \left\{ \sum_{i=1}^{k} X^{(0)}(i), k = 1, 2, 3, \ldots, n \right\} \tag{18.3}$$

The GM (1,1) model can be constructed by establishing a first order differential equation for $X^{(1)}(k)$ as:

$$dx^{(1)}(k)/dk + ax^{(1)}(k) = b \tag{18.4}$$

Therefore, the solution of Eq. 18.4 can be obtained by using the least square method. That is,

$$\hat{X}^{(1)}(k) = \left[X^0(1) - \frac{b}{a}\right] e^{-a(k-1)+} \frac{b}{a} \tag{18.5}$$

where

$$[a \quad b]^T = \left(B^T B\right)^{-1} X_n \tag{18.6}$$

and

$$B = \begin{bmatrix} -Z^{(1)}(2) & 1 \\ -Z^{(1)}(3) & 1 \\ \cdots & \cdots \\ -Z^{(1)}(n) & 1 \end{bmatrix} \tag{18.7}$$

where

$$\begin{aligned} Z^{(1)}(k) &= ax^{(1)}(k) + [1-a]x^{(1)}(k) \\ X_n &= [x^{(0)}(1), x^{(0)}(2), \ldots, x^{(0)}(n)]^T \end{aligned} \tag{18.8}$$

We obtained $\hat{x}^{(1)}$ from Eq. 18.5. Let $\hat{x}^{(0)}$ be the fitted and predicted series,

$$\hat{x}^{(0)} = (x^{(0)}(1), x^{(0)}(2), \ldots, x^{(0)}(n), \ldots \tag{18.9}$$

where $\hat{x}^{(1)}(1) = x^{(0)}(1)$

$$\hat{x}^{(0)}(k) = (1 - e^a)\left[X^{(0)}(1) - \frac{b}{a}\right] e^{-a(k-1)} \tag{18.10}$$

where $\hat{x}^{(0)}(1), \hat{x}^{(0)}(2), \ldots \hat{x}^{(0)}(n)$ are called the GM (1,1) fitted sequence, while $\hat{x}^{(0)}(n+1), \hat{x}^{(0)}(n+2), \ldots$ are called the GM (1,1) forecast values.

18.2.2 Improved GM (1,1) Model

Grey prediction has lot of advantages, such as less data required, regardless of distribution, regardless of trends, convenient operation, short-term forecasts of high precision, easy to test, etc., so it is widely used, and achieves satisfactory results. But there are some limitations. Many scholars encountered a number of problems of low prediction accuracy in the application of GM (1,1) model, and many researchers have proposed methods to improve prediction accuracy. There are mainly two ways to improve the forecasting model, one is to transform the original series, and the other is to transform GM (1,1) itself. GM (1,1) improved methods are generally $\hat{a}$ parameter correction method, the raw data moving average processing, and equal dimension information processing, residual treatment etc., here we took equal dimensionality information fill model.

Generally modeling must be based on the latest data as a reference point. According to the different choice of data, new information model and equal dimension new information model are commonly used in GM (1,1) model. New information model will add the new information into the original series when coming up with new information and modeling after adding the new information (full-line modeling), also known as metabolic models. It's mechanism close to the general theory of forgetting factor modeling ideas.

18.3 Empirical Analysis

In 1993, China became a petroleum importing country. With the rapid development of the national economy, petroleum demand was in the rapid growth, the petroleum supply situation will be even more severe in the future. No matter From the goal of economic development, or the goal of environmental protection, adjusting and improving the energy structure, promoting the diversification of energy use are the only way for China's sustainable energy strategy. Table 18.1 shows China's petroleum consumption in recent years.

The raw data $x^{(0)}(k)$ are tested by Quasi-smooth conditions. Then Test whether $x^{(1)}$ have the quasi-exponential law. Raw data, for example:

$$\rho(k) = \frac{x^{(0)}(k)}{x^{(1)}(k-1)} \tag{18.11}$$

Table 18.1 Petroleum consumption of China

Years	The proportion of total energy consumption (%)				Petroleum (million tons of standard coal)
	Coal	Petroleum	Nature gas	Hydroelectric, nuclear, wind power	
2002	66.3	23.4	2.6	7.7	35520
2003	68.4	22.2	2.6	6.8	38847
2004	68.0	22.3	2.6	7.1	45319
2005	69.1	21.0	2.8	7.1	47414
2006	71.1	19.3	2.9	6.7	49924
2007	71.1	18.8	3.3	6.8	52735
2008	70.3	18.3	3.7	7.7	53334
2009	70.4	17.9	3.9	7.8	54889
2010	68.0	19.0	4.4	8.6	61738
2011	69.7	18.2	4.6	7.4	63278

when $k > 3, \rho(k) < 0.5$, Quasi-smooth conditions are met.

Given

$$\text{Given } \delta^{(1)}(k) = \frac{x^{(1)}(k)}{x^{(1)}(k-1)} \tag{18.12}$$

when $k > 3, \delta^{(1)}(k) \in [1, 1.5]$, then Quasi exponential law are met.

First doing the quasi-smooth test, the results are as follow:

$$\begin{aligned}
&\rho(3) = 0.55, \rho(4) = 0.36 < 0.5, \\
&\rho(5) = 0.28 < 0.5, \rho(6) = 0.24 < 0.5, \\
&\rho(7) = 0.23 < 0.5, \rho(8) = 0.19 < 0.5, \\
&\rho(9) = 0.17 < 0.5, \rho(10) = 0.12 < 0.5
\end{aligned}$$

So when k > 3, the quasi-smooth conditions is met.

Similarly quasi-exponentially test, when k > 3, meet the exponential law.

To illustrate the superiority of improved GM (1,1) model in predicting. For the purpose of fitting the existing data and predicting future demand, we selected petroleum consumption data and using MATLAB software for data processing. The result of relative error of calculated values and actual values are as follows in Table 18.2 by using gray theory method.

Using Gray theory to fit the original data, the model has a higher fitting accuracy. Because of uncertainty of the future factors, using traditional gray theoretical model to predict may cause the results are untrue. Sometimes the higher the reliability of the data closing to the true value and the longer time interval, the data reliability is easier to change. Therefore using equal dimensionality information fill model to predict China's future petroleum consumption will be better, we used MATLAB software predicted the results shown in Table 18.3.

Table 18.2 Chinese petroleum consumption fitting value (million tons of standard coal)

Years	Petroleum	Traditional GM(1,1) model			Error test
		Predicted value	Residual	Relative error (%)	
2002	35520	35520	0	0.00	C = 0.02
2003	38847	39746	−899	−2.31	P = 1
2004	45319	42840	2479	5.47	
2005	47414	46776	638	1.35	
2006	49924	49770	154	0.31	
2007	52735	53645	−910	−1.73	
2008	53334	54987	−1653	−3.10	
2009	54889	56765	−1876	−3.42	
2010	61738	62876	−1138	−1.84	
2011	63278	63786	−508	−0.80	

Table 18.3 The forecast value china's petroleum consumption (million tons of standard coal)

Years	Petroleum	Years	Petroleum	Years	Petroleum
2012	67646	2018	97180	2024	139911
2013	72690	2019	104769	2025	150558
2014	74876	2020	112466	2026	161961
2015	77925	2021	120915	2027	174083
2016	83413	2022	130027	2028	187124
2017	90110	2023	139911	2029	201156

18.4 Conclusion

Through the forecast shows that China's petroleum consumption in the year of 2029 will increase of 13.351 billion tons standard coal compared to the year of 1998. A big shortfall of petroleum demand will lead a tough situation of the petroleum security. In the year of 2029, China will basically realize industrialization and modern agriculture, the rapid growth in demand of petroleum will restrict China's economic growth, if we do not take some practical countermeasures for the security of petroleum.

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Chapter 19
Applying an Integrated SOM Model on Studying Corporate Governance Data

Jen-Ying Shih

Abstract Corporate governance has gradually become an important consideration in investment decisions of stock market and credit evaluation of financial market since several notorious business scandals, such as Enron's inside information trading in the US and executive entrenchment of Rebar conglomerate in Taiwan. However, corporate governance is presented by a large amount of data, which involves the following facets: managerial ownership, external ownership, board size, board composition, financial transparency, executive compensation, etc. To utilize these data, this study applied an integrated self-organizing map (SOM) model, which has been successfully used for visualizing and clustering high-dimension data in several applications, to study corporate governance of Taiwan's semiconductor companies by recognizing implicit patterns of these data. The research results demonstrate that eight types of corporate governance have been identified by the SOM model, and features selected by LabelSOM are used to interpret the eight styles of companies.

Keywords Corporate governance · Data mining · Self-organizing maps · Semiconductor companies

19.1 Introduction

In recent decades, corporate governance has gradually become an important consideration in investment decisions of stock market and credit evaluation of financial market since several notorious business scandals. For example, Enron used false accounting information to cheat stock market investors and the U.S.

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E. Qi et al. (eds.), *The 19th International Conference on Industrial Engineering and Engineering Management*, DOI: 10.1007/978-3-642-38391-5_19,

Securities and Exchange Commission, which made its executives earn an enormous amount of illegal returns by manipulating the false information and inside information in securities market. Similar cases also existed in Taiwan, for instance, Rebar's executives entrenched assets of the Rebar conglomerate and such behavior hurt plenty of its stockholders and financial institutions who lend a lot of money to the Rebar.

With consideration of the above examples, stock market investors prefer to invest in the promising companies with strong corporate governance to minimize the loss resulting from weak corporate governance; credit analysts of credit rating agencies and financial institutions consider corporate governance factors in their credit granting decisions to avoid the risks associated with bad debt (Standard and Poor's 2002; Fitch Ratings 2004; Ashbaugh-Skaifea et al. 2006). The authorities of financial markets, such as the Financial Supervision Commission, R.O.C. (FSC), thus required listed companies to file multifaceted corporate governance data, including ownership structure, information on inside shareholders, institutional shareholdings, board composition, board size, financial transparency, executive compensation, etc., to protect stakeholders of these companies.

However, due to that corporate governance is presented by a massive amount of data, to make a full use of these data, it is important to provide an analytical tool to interpret the data. Therefore, this study applied an integrated self-organizing map (SOM) model to study corporate governance of Taiwan's semiconductor companies by recognizing implicit patterns of these data. The SOM has been successfully used for visualizing and clustering high-dimension data (i.e., in this study, each case company with lots of corporate governance data) in document classification, construction of knowledge maps, market segmentation, financial statement analysis, etc. (e.g., (Back et al. 1998; Eklund et al. 2002; Shih et al. 2008; Shih 2011; Kohonen et al. 2000)).

The remainder of this paper is organized as follows. In Sect. 19.2, we review corporate governance literature to define features (input variables) used in this study. Then the dataset of this study is introduced in Sect. 19.3. Subsequently, Sect. 19.4 describes the methodology applied in this research (i.e., the integrated-SOM model); Section 19.5 presents results and interpretation of such results. Finally, the conclusions are provided in Sect. 19.6.

19.2 Corporate Governance

According to (Luo 2005), business corporations are directed and controlled by their corporate governance system. The system specifies the distribution of rights and responsibilities among different parties who participate in corporate affairs and spell out the rules and procedures for making decisions on these affairs. Corporate governance should assure that all stakeholders receive reliable information about the value of the firm and it motivates corporate managers to maximize firm value instead of pursuing personal goals in managerial decision making. Based on this concept, considerable research investigated the relationship between corporate governance and firm performance (Kim et al. 2004; Cui and Mak 2002; Short and Keasey 1999), as well as the relationship between corporate governance and firm's credit ratings (or firm's cost of debt financing) (Ashbaugh-Skaifea et al. 2006; Sengupta 1998; Bhojraj and Sengupta 2003). Most of the research applied regression models, such as linear regressions (e.g., (Demetz and Lehn 1985)), nonlinear regressions (e.g., (Short and Keasey 1999)), piecewise regressions (e.g., (Morck et al. 1988)), and two stage least square regressions (e.g., (Kapopoulos and Lazaretou 2007)), to investigate how corporate governance impact on firm performance or credit ratings. For example, Jensen and Meckling (1976) found that firm performance was positively affected by managerial ownership and proposed an alignment effect hypothesis for the relationship between managerial ownership (one of corporate governance factors) and firm performance.

However, due to limitation of regression method assumptions, previous research using regression models only investigated the relationships between a few independent variables (i.e., limited corporate governance variables) and dependent variables, which only provide partial evidence on specific observation but not on a whole picture of corporate governance. Instead of using regression models, this study used a clustering methodology based on self-organizing map (SOM) algorithm, to study this important issue. The major characteristic of SOM is that it could map high-dimensional input data into a low-dimensional representation space to facilitate data analysis and data visualization (Shih et al. 2008). This study adopted a different approach relative to previous studies to explore the corporate governance issue and its relationship with firm performance.

According to previous research, the factors that influence on corporate governance cover: (1) managerial ownership or insiders' shareholdings (Short and Keasey 1999), (2) external ownership or shareholder activism, such as institutional shareholdings (Smith 1996), (3) board size (Ashbaugh-Skaifea et al. 2006), (4) board composition (Ashbaugh-Skaifea et al. 2006), (5) financial transparency (Ashbaugh-Skaifea et al. 2006), and (6) compensation system for board directors, supervisors, managers, and employees (Cheng and Firth 2005). Therefore, these factors are all included in the input data used in this study for constructing the corporate governance maps.

19.3 Dataset

Taiwan's semiconductor companies have played important roles in the global semiconductor industry, and they thus have raised huge amounts of capitals from securities markets and financial institutions for business operation. Therefore, this study used the semiconductor companies as a test bed because the stakeholders of these companies are affected seriously by the corporate governance of these companies.

This study gathered data from 53 semiconductor companies that are listed on the Taiwan Stock Exchange (TSE). The data set contains a total of 30 corporate governance variables which are illustrated as follows.

- Managerial ownership or insiders' shareholdings

The factor is observed by the following variables:

1. Percentage of shares held by board directors
2. Percentage of shares held by supervisors
3. Percentage of shares held by managers
4. Percentage of shares held by family
5. Percentage of shares owned by large shareholders whose holdings exceed 10 % of outstanding shares
6. Shares pledged by directors to shares owned by directors
7. Shares pledged by supervisors to shares owned by supervisors

- External shareholdings

The factor is observed by the following variables:

8. Percentage of external shareholdings
9. Percentage of shares held by institutional investors
10. Percentage of shares held by foreign institutional investors
11. Percentage of shares held by domestic government
12. Percentage of shares held by domestic financial institutions
13. Percentage of shares held by foreign financial institutions

- Board size

The factor is observed by the following variables:

14. Number of board directors
15. Number of supervisors

- Board composition

The factor is further decomposed into three dimensions, including family control, independence and division of managerial work, measuring by the following variables.

i. Family control
16. Number of family-controlled board directors
17. Number of family-controlled supervisors
ii. Independence
18. Number of independent board directors
19. Number of independent supervisors
iii. Division of managerial work
20. Number of directors who are also managers in the conglomerate
21. Number of supervisors who are also managers in the conglomerate

22. Whether CEO also serves as the chairman of board

- Compensation system

  The factor is observed by the following variables:

23. Compensation of directors and supervisors (in NT$ million)
24. Average compensation of each director or supervisor
25. Compensation of directors and supervisors to earnings before tax
26. Employee bonus to earnings before tax
27. Employees' cash bonus (in NT$ million)
28. Employees' stock bonus (in NT$ million)

- Financial transparency

29. Frequency of financial forecast
30. Frequency of financial statement revisions

19.4 Methodology

This study mainly used the SOM algorithm to analyze corporate governance patterns of Taiwan's semiconductor companies. Kohonen (1982) proposed the SOM algorithm, a two-layered fully connected artificial neural network, for clustering tasks. The SOM model is widely used for generating topology-preserving maps and for data visualization. The most notable characteristic of the SOM algorithm is that the similarities in input data are mirrored to a very large extent by their geographical vicinity within the representation space. Similar types of input data are assigned to neighboring regions on the map (Shih et al. 2008). The main advantage of the SOM algorithm is that it can map high-dimension data into a lower dimension representation space. The SOM algorithm has been successfully applied in knowledge management (Shih et al. 2008; Schweighofer et al. 2001) and financial statement analysis (Back et al. 1998; Eklund et al. 2002).

In addition, the appropriate map size of SOM is determined by a growing SOM (GSOM) algorithm (Shih et al. 2008) in this study. The interpretation of SOM maps is assisted by LabelSOM (Dittenbach et al. 2002) for analyzing the clustering results.

This integrated SOM model is constructed by the following procedures.

Step 1: Initialize all parameters of the integrated SOM model for model training, including an initial neighborhood range, an initial learning rate of the SOM, an accepted error measure, an initial map size for SOM training process, a growing-stopping criterion (τ_1) for growing SOM, a maximum number of labels and a label threshold for LabelSOM in selecting labels that represent each unit in the output layer.

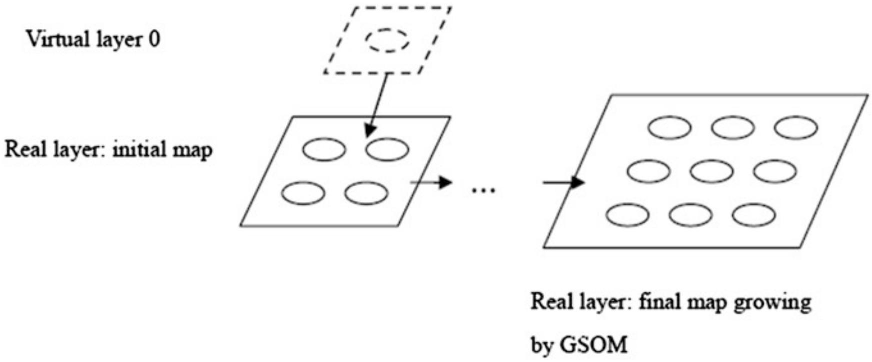

Fig. 19.1 Topology of GSOM

Step 2: Start with a virtual layer 0 (see Fig. 19.1) consisting of only one unit whose weight vector (m_0) is initialized as the average of all the input data. Then calculate the mean quantization error (*mqe*) by the Euclidean distance between the weight vector of the unit and all input vectors. The *mqe* of the unit 0 is calculated as the following equation.

$$mqe_0 = \frac{1}{n} \cdot \sum_{j=1}^{n} \left\| m_0 - x_j \right\|,$$

where x_j denotes the input vector j, $\| \cdot \|$ represents the Euclidean vector norm, and n is the total number of the input vectors.

Step 3: Set the initial map size of the output layer in a topology of, for example, 2×2 units. This topology is determined by the parameter provided in Step 1.

Step 4: Initialize weight vectors of the output layer.

Step 5: Use input vectors to train the initial SOM by the following algorithm (Shih et al. 2008), Fig. 19.2.

Step 6: Evaluate the mapping quality by calculating each unit's *mqe* in this map. The *mqe* of the unit i is calculated as the following equation.

$$mqe_i = \frac{1}{n_{c_i}} \cdot \sum_{x_j \in C_i} \left\| m_i - x_j \right\|,$$

where m_i refers to the weight vector of the unit i, x_j denotes the input vector j mapped to the unit i, C_i denotes the set of all input vectors mapped to the unit i, and n_i is the total number of the input vectors that are mapped to unit i.

A large *mqe* value means that the input vectors are not clustered well by the current map topology. Hence, some new units need to be added on this map to improve the mapping quality (i.e., to decrease the *mqe*). To determine where to add the new units, we have to find the error unit (e) which has the largest value of *mqe*. The e is determined by the following equation.

For each input vector $x(t)$, t represents the time-stamp of the current learning iteration.

For each node in the output layer, calculate the distances between the weight vectors and the input vector: $D_i(t) = \|x(t) - m_i(t)\|$,

where $m_i(t)$ refers to the weight vector of unit i, and

$\|\cdot\|$ represents the Euclidean vector norm.

Determine the winner c: $c(t) : \|x(t) - m_c(t)\| = \min_i \{\|x(t) - m_i(t)\|\}$

Adapt the weight vectors according to the following learning rule:

$m_i(t+1) = m_i(t) + \alpha(t) \cdot h_{ci}(t) \cdot [x(t) - m_i(t)]$,

where $\alpha(t)$ represents a time-varying learning-rate decreasing over time, and

$h_{ci}(t)$ is a time-varying neighborhood function that takes into account the distance between the winner c and unit i $\|r_c - r_i\|$ within the output space.

The most often used function is $h_{ci}(t) = \exp\left(-\frac{\|r_c - r_i\|^2}{2 \cdot \delta(t)^2}\right)$.

Reduce the learning rate and radius of the neighborhood function

Until (Convergence or the maximum number of iterations is achieved)

Fig. 19.2 SOM algorithm adapted from (Shih et al. 2008)

$$e = \arg\max_i \{mqe_i\}.$$

Then, either a new row or column of units is interpolated between the error unit and its most dissimilar neighbor (as shown in Fig. 19.3).

The weight vectors of these new units are initialized as the average of their neighbors. After growing the map, calculate the mean *mqe* of all units (*MQE*) in the current map. A map grows until its *MQE* is reduced to a predefined fraction (the growing-stopping criterion, τ_1) of the mqe_0 in the virtual layer (as shown in Eq. 19.1). The lower the value of the quantization error, the better the map has been trained.

$$MQE < \tau_1 \cdot mqe_0 \tag{19.1}$$

Step 7: After training GSOM, LabelSOM (Dittenbach et al. 2002) is used to select the features that can represent the input vectors mapped to each unit in the final map. The selection mechanism is based on the quantization error vector (q_{i_k}), which is determined by the distance between the weight vector $m_i = (\mu_{i_1}, \mu_{i_2}, \ldots, \mu_{i_n}) \in R^n$ of the unit i and all the input vectors $x_j = (\xi_{j_1}, \xi_{j_2}, \ldots, \xi_{j_n}) \in R^n$ mapped to the unit i (Eq. 19.2). After sorting the all q_{ik} of each unit, according to the parameters set by step 1 (i.e., the maximum number of labels and the label threshold), several features are selected as the labels for representing the unit.

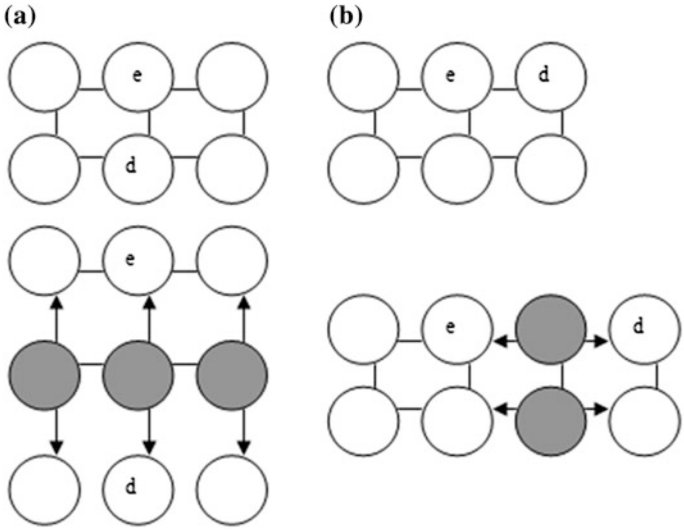

Fig. 19.3 Growing mechanism of GSOM adapted from (Dittenbach et al. 2002)

$$q_{i_k} = \frac{1}{|C_i|}\sqrt{\sum_{x_j \in C_i} (\mu_{i_k} - \xi_{j_k})^2}, \; k = 1, \ldots, n \tag{19.2}$$

where C_i is the set of all input vectors mapped to the unit i in the output layer, μ_{i_k} denotes the kth element of the weight vector of unit i in the output layer, and ξ_{j_k}represents the kth element of the input vector x_j mapped to the unit i in the output layer.

19.5 Results

The training result of the integrated SOM model is shown in Fig. 19.4, which illustrate that eight types of corporate governance of semiconductor companies in Taiwan are identified by this study. Based on the LabelSOM, each unit (cluster) is assigned a set of up to three labels to represent various types of corporate governance. The eight types of corporate governance are described as follows.

1. CEO also serves as the chairman of board (unification of directing). The companies listed on Unit (1, 1)[1] and Unit (2, 1) belong to this style; totally, 15 semiconductor companies are clustered in this style.

[1] We use the notation (x,y) to refer to the unit in row x and column y, starting with (1,1) in the upper left corner.

CEO also serves as the chairman of board UMC 2006 ROA Level L.htm MXIC 2006 ROA Level M.htm SUNPLUS 2006 ROA Level M.htm ELAN 2006 ROA Level M.htm SpringSoft 2006 ROA Level H.htm PAN JIT 2006 ROA Level L.htm ESMT 2006 ROA Level M.htm ITE 2006 ROA Level VH.htm Zongtai 2006 ROA Level VL.htm SIGURD 2006 ROA Level M.htm	Number of directors who are also managers in the conglomerate MOSEL 2006 ROA Level L.htm Realtec 2006 ROA Level M.htm Weltrend 2006 ROA Level M.htm Davicom 2006 ROA Level H.htm Sonix 2006 ROA Level VH.htm Tong Hsing 2006 ROA Level H.htm Sitronix 2006 ROA Level H.htm	Number of board directors Percentage of shares held by institutional investors Percentage of shares held by foreign financial institutions TSMC 2006 ROA Level H.htm
CEO also serves as the chairman of board GTM 2006 ROA Level L.htm Rectron 2006 ROA Level VL.htm OSE 2006 ROA Level NA.htm SDI 2006 ROA Level L.htm LINGSEN 2006 ROA Level L.htm	ASE 2006 ROA Level M.htm Taiwan Mask 2006 ROA Level M.htm winbond 2006 ROA Level VL.htm SIS 2006 ROA Level VL.htm VIA 2006 ROA Level VL.htm Walton Chaintech 2006 ROA Level VL.htm MOSPEC 2006 ROA Level L.htm GREATEK 2006 ROA Level VH.htm KYEC 2006 ROA Level L.htm Transcend 2006 ROA Level H.htm Precision 2006 ROA Level L.htm FARADAY 2006 ROA Level VH.htm ALi 2006 ROA Level M.htm PQI 2006 ROA Level VL.htm PTI 2006 ROA Level H.htm RICHTEK 2006 ROA Level VH.htm	Percentage of shares held by institutional investors Percentage of shares held by foreign institutional investors Percentage of shares held by foreign financial institutions SPIL 2006 ROA Level VH.htm MediaTek 2006 ROA Level VH.htm HOLTEK 2006 ROA Level H.htm
Percentage of shares held by institutional investors Percentage of shares held by family Percentage of shares held by board directors Nanya 2006 ROA Level VL.htm GET 2006 ROA Level H.htm FATC 2006 ROA Level H.htm	Number of supervisors who are also managers in the conglomerate Percentage of shares held by domestic financial institutions PPT 2006 ROA Level L.htm NOVATEK 2006 ROA Level VH.htm IST 2006 ROA Level VL.htm	Percentage of shares held by institutional investors Number of board directors Number of independent board directors KINSUS 2006 ROA Level H.htm GUC 2006 ROA Level VH.htm Isotera 2006 ROA Level VL.htm FST 2006 ROA Level VH.htm Orise 2006 ROA Level M.htm Walton 2006 ROA Level L.htm

Fig. 19.4 Corporate governance maps of the semiconductor companies and its relationships with ROA

2. Managers participate in decision making of the board by serving as board directors. This style is represented by the variable "number of directors who are also managers in the conglomerate". Those companies listed on Unit (1, 2) belong to this style; totally, seven companies are clustered in this style. The major characteristic of this style is that more than two directors also serve as managers in their business conglomerate.
3. Companies with a large board size and a high percentage of shares held by institutional investors, especially foreign financial institutions. Only one company (TSMC) is listed on Unit (1, 3).
4. Companies with a high percentage of shares held by institutional investors, especially foreign institutions. Three companies are listed on Unit (2, 3). Basically, this type of companies is similar to the third type of companies (Unit (1, 3)) except that the third type of companies has a large board. Hence, Unit (2, 3) is near Unit (1, 3).

5. Family-controlled companies with a high percentage of shares held by institutional investors, family, and board directors. Three companies are listed on Unit (3, 1).
6. Companies with supervisor internalization and a high percentage of shares held by domestic financial institutions. Three companies are listed on Unit (3, 2).
7. Companies with a high percentage of shares held by institutional investors, a large board size, and more independent board directors. Six companies are clustered in Unit (3, 3).
8. Others. Those companies not belonging to the above styles are clustered in Unit (2, 2). However, LabelSOM could not provide any label to induce this style because no feature can be determined to explain this cluster.

19.6 Conclusion

This study explored the corporate governance data of 53 semiconductor companies listed on TSE in Taiwan by using the integrated-SOM model with 30 corporate governance features. Eight types of corporate governance have been identified by the model and some associations between the clustering results and features can be represented on the maps. The study results show that the SOM could be a feasible tool for analyzing corporate governance data. It is easy to visualize and interpret the SOM results and provides a very practical approach to compare the corporate governance data of different companies. Future research can extend the data set to the other industries to investigate the feasibility of SOMs for analyzing corporate governance data.

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Chapter 20
Applying Constraint Satisfaction Methods in Four-Bar Linkage Design

Gang Chen

Abstract Product design is a very complicated problem. Effective and efficient computerized methods are hence needed to assist human engineers in original product design and design modifications. Constraint satisfaction problem (CSP) provides the insight of problem solving. Many practical algorithms have been developed along with the exploration of CSP's theoretical foundation. This paper applies the general CSP methods into solving product design problems. A crank-rocker mechanism is used as an example to illustrate the proposed ideas.

Keywords Change propagation · Constraint satisfaction · Graph theory · Product design

20.1 Introduction

Mechanical products are usually composed of several components or parts. For a product to realize its designated functions, these parts must be linked in a specified way. Hence, one of the important issues in product geometric design is finding a proper configuration and linking relations for all parts. This task is usually not easy due to the complexity of most mechanical products.

Constraint satisfaction problem (CSP) provides the theoretical foundation and many practical algorithms for finding solutions to complex constraints among multiple variables.

This paper applies CSP methods in four-bar linkage mechanism design. Firstly, theory and basic methods of CSP are briefly introduced; secondly, the four-bar linkage mechanism design is modeled as a CSP with CSP elements specified.

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E. Qi et al. (eds.), *The 19th International Conference on Industrial Engineering and Engineering Management*, DOI: 10.1007/978-3-642-38391-5_20,

How to apply constraint propagation and searching methods to find a solution for four-bar linkage mechanism is explained. The purpose is to explore automatic and efficient computerized methods for mechanical or mechatronic product design.

20.2 Constraint Satisfaction Problem

A constraint satisfaction problem is consisted of three elements: a set of variables (V), a set of possible values for each variable (its domain, D), and a set of constraints specified among variables (C). Constraints are rules that impose a limitation on the values that a variable, or a combination of variables, may be assigned simultaneously. A solution to a CSP is an assignment of a value to each variable from its domain such that all constraints are satisfied (Dechter 2003).

Figure 20.1 uses an 8-queen problem as an illustration of CSP. The problem is to place eight queens on an 8 × 8 chessboard satisfying the constraint that no two queens will be a threat to each other (Tsang 1996). One way to model an 8-queen problem as a CSP is as follows: each column in the chessboard is treated as a variable, its domain is all rows in the chessboard, and the constraints are that no two queens should be placed on the same row, column or diagonal.

Constraint satisfaction problems can be represented as constraint graphs in which nodes represent variables while arcs represent constraints between two variables (for binary CSPs). Figure 20.2 is a graph representation of the above-mentioned 8-queen problem.

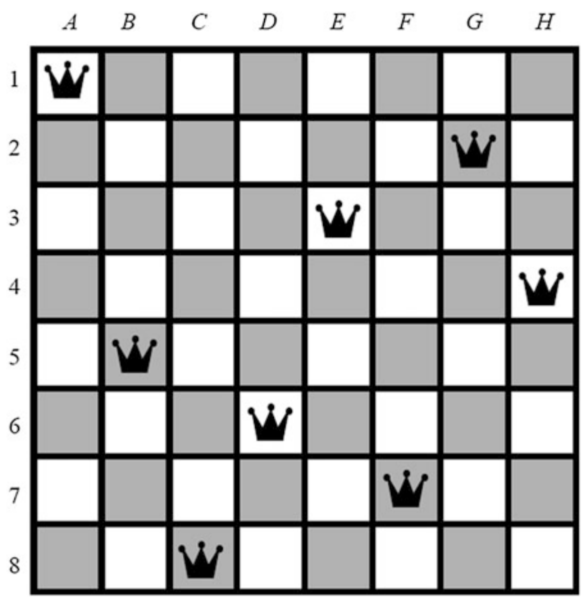


Fig. 20.1 A possible solution to the 8-queen problem (Tsang 1996)

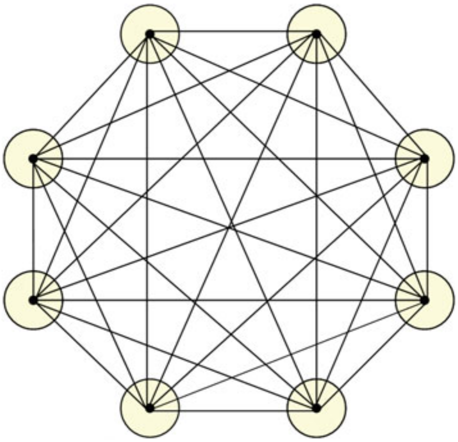


Fig. 20.2 Constraint graph of the 8-queen problem

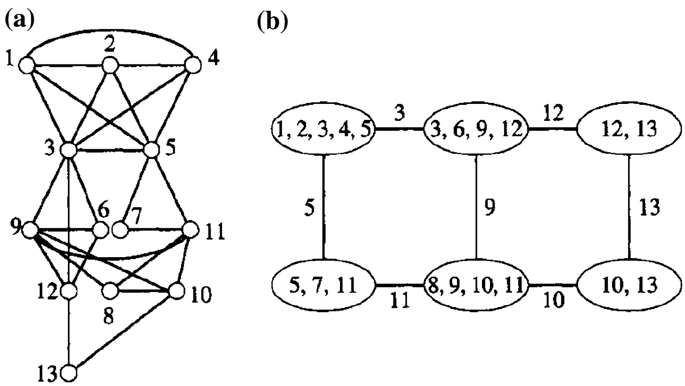


Fig. 20.3 Constraint hypergraph (Dechter 2003)

However, for most practical problems, such as mechanical products design, since most constraints are specified among multiple variables, simple graphs for binary constraints are insufficient. Constraint hypergraph is a more general and suitable representation. Figure 20.3b shows a constraint hypergraph in which each hyperedge (e.g. the circle around variables 1, 2, 3, 4, 5) represents a constraint specified on a set of variables. Arcs between hyperedges represent that two related constraints share one or more variables (labels on arcs).

Two main CSP solving techniques are problem reduction and searching.

(1) *Problem reduction*: Although problem reduction through propagating and processing constraints among related variables can not solve a CSP by itself, however, an original CSP usually can be transformed into an equivalent problem which is easier to be solved.

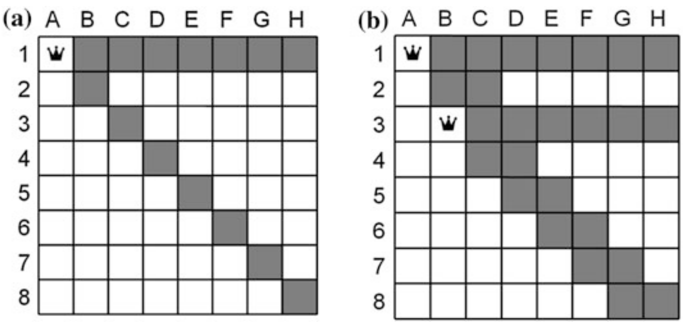


Fig. 20.4 Constraint propagation

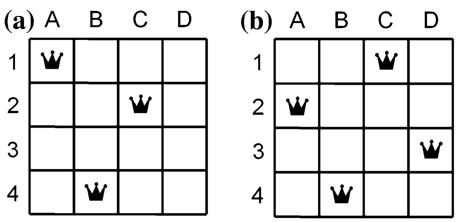
For example, in Fig. 20.4, if the first queen (variable A, which has its value domain as 1–8) is put at cell (1, A), i.e. assigning variable A value 1, then the shaded cells in Fig. 20.4a are excluded from domains of the remaining 7 variables. Figure 20.4b shows further constraint propagation after variable B has been assigned value 3. The problem has become easier to be solved with domain reduction.

(2) *Search*: This might be the most fundamental technique for solving CSPs. Variables are instantiated one by one. With a partial solution, a new variable is selected and instantiated. If it is impossible to find a feasible value after traversing the new variable's domain, then the searching process is backtracked to select a new value for the previous variable. For a CSP with limited domains, the searching process will carry on until either a solution is found or all the combinations of possible values have been tried and have failed (Tsang 1996). Figure 20.5a shows an inconsistent partial instantiation for the first three variables in a 4-queen problem since no value is feasible for variable D. After backtracking, i.e. assigning a new value to variable A, a solution is found as illustrated in Fig. 20.5b.

A lot of improvements have been made to the simple backtracking algorithm, such as forward checking constraints which involve the most variables or heuristic-guided backtracking instead of chronicle backtracking.

Each constraint may have a weight that indicates its importance. Weight setting represents the priority of a constraint during decision-making. Hard constraints (i.e. constraints that must be satisfied) have higher weights than soft constraints,

Fig. 20.5 Instantiation through searching (Dechter 2003)



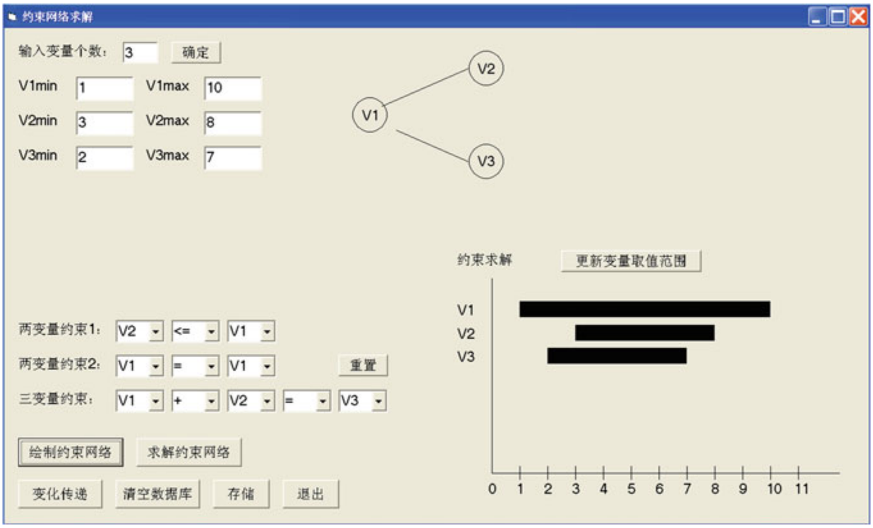


Fig. 20.6 A prototype system for constraint solving

which are negotiable or can be relaxed if necessary. For practical problems in real life, a complete solution which satisfies all constraints is usually impossible. It is more realistic to satisfy as many constraints as possible or the most important constraints (with higher weights).

The application of CSP modeling and solving techniques in mechanical design or manufacturing area is rare except for workshop scheduling problem. It might be due to the following reasons:

(1) Realistic problems in mechanical engineering are usually very complex. For example, variables may have different types and abstraction levels; constraints may involve multiple variables and may be represented as complicated mathematical functions.
(2) Value domains of variables in mechanical engineering are usually unlimited and continuous. Traditional searching techniques must be modified.

Figure 20.6 shows a prototype constraint solving system developed using Visual Basic. Interval computing is used to propagate constraints and prune off value domains. Domain discretization based on the precision requirements can be used to transform a continuous problem into a discrete problem.

20.3 Four-Bar Linkage Mechanism Design

The planar four-bar linkage mechanism (crank-rocker mechanism as illustrated in Fig. 20.7) is used here as an example to illustrate how to apply the general CSP solving techniques to mechanical design problems.

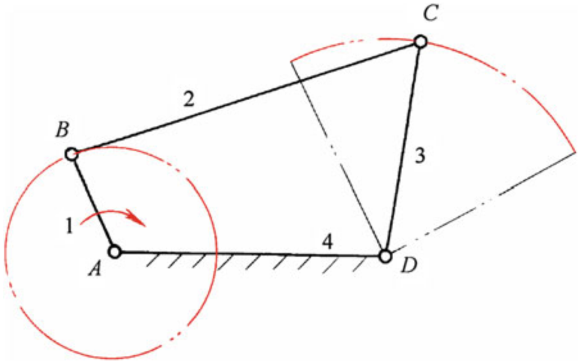


Fig. 20.7 Crank-rocker mechanism (Zhang 2011)

As shown in Fig. 20.7, a planar crank-rocker mechanism has four revolute joints, A, B, C, and D. Link 4 is fixed as the ground link. Link 1 (crank) and link 3 (rocker) are connected to the ground link. Respectively, they are the input and output links of the system.

For a four-bar linkage mechanism to work properly, it must obey several implicitly or explicitly specified rules. For example, let:

$$S = length\ of\ the\ shortest\ link$$
$$L = length\ of\ the\ longest\ link$$
$$P = length\ of\ one\ remaining\ link$$
$$Q = length\ of\ the\ other\ remaining\ link$$
$$Then\ if: \quad S + L \leq P + Q$$

the Grashof condition indicates that at least one link will be capable of making a full revolution with respect to the ground plane (Norton 1999). Hence, for the mechanism shown in Fig. 20.7 to be a crank-rocker mechanism, lengths of four links must follow the Grashof condition. If lengths of four links are modeled as four variables, then the Grashof condition represented a constraint among variables that the crank-rocker mechanism must satisfied.

One method to design a crank-rocker mechanism is using the specified rocker length, rocker oscillating angle, and the travel velocity-ratio coefficient K as input to synthesize crank length, coupler length, and frame length. The design procedure is described as follows (see Fig. 20.8):

(1) Calculating limitation location angle θ

$$\theta = 180^{\circ} \frac{K-1}{K+1} \tag{20.1}$$

(2) Selecting a position for joint D, using rocker length L_3 and rocker oscillating angle ψ to determine two extreme rocker positions C_1 and C_2 (as shown in Fig. 20.8);

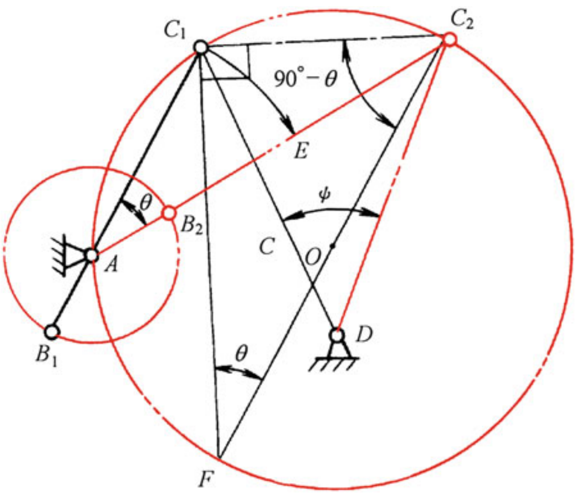


Fig. 20.8 Design procedure of a crank-rocker mechanism (Zhang 2011)

(3) Determining the position of point F as follows: drawing a line C_1F which is perpendicular to line C_1C_2; drawing another line C_2F with the angle $\angle C_1C_2F = 90° - \theta$, θ is the limitation location angle as calculated in step 1;
(4) Making the circumscribed circle of ΔC_1C_2F, another joint A must locate at this circle;
(5) Using the minimum transmission angle γ as the optimization object to finally determine the position of joint A as well as the frame (AD) length L_4;
(6) As shown in Fig. 20.9, the crank length L_1 and the coupler length L_2 can be calculated as follows:

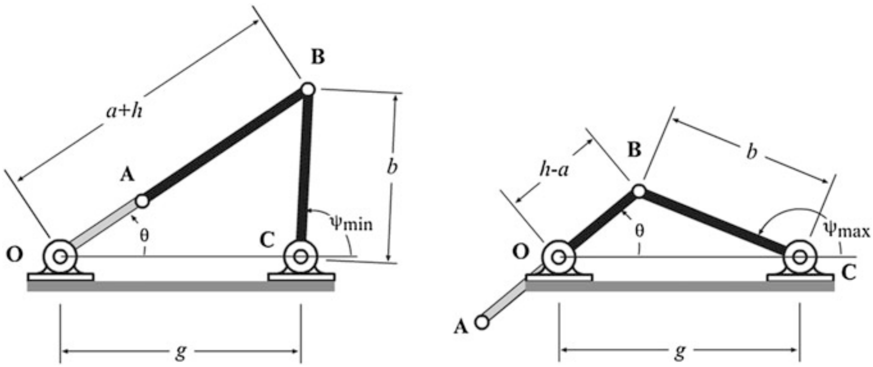


Fig. 20.9 Calculating the crank length and the coupler length (McCarthy and Soh 2010)

$$L_1 = (AC_2 - AC_1)/2 \\ L_2 = (AC_2 + AC_1)/2 \tag{20.2}$$

The above-mentioned design procedure can be modeled as a CSP which has the following variables:

(1) Crank length L_1;
(2) Coupler length L_2;
(3) Rocker length L_3;
(4) Frame length L_4;
(5) Travel velocity-ratio coefficient K;
(6) Rocker oscillating angle ψ;
(7) Transmission angle γ;

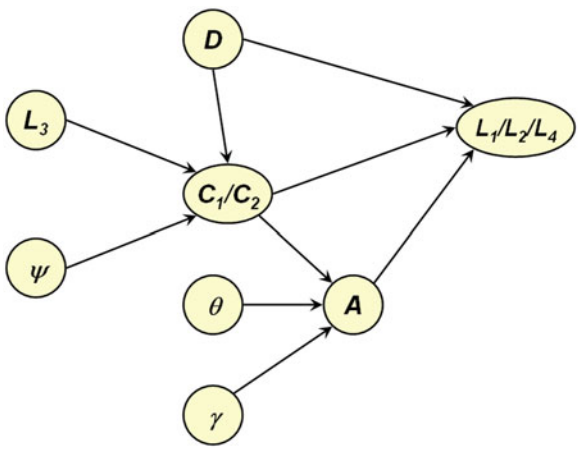
The lower and upper limits for each variable should be specified. The value domain for each variable should be discretized based on the precision requirements. For example, continuous domain (3–8) for rocker length can be transformed into discrete domain (3.0, 3.1,…, 7.9, 8.0).

Some intermediate variables, such as limitation location angleθ, positions of C_1, C_2, F, and A, should also be presented in the constraint graph (see Fig. 20.10).

The Grashof condition, Eqs. (20.1) and (20.2), etc. are modeled as constraints among variables.

The constructed CSP model is shown in Fig. 20.10. Constraint propagation and searching techniques can be used to solve the problem and find a feasible solution.

Fig. 20.10 Constraint graph of crank-rocker mechanism design



20.4 Discussion

A lot of issues need to be addressed before the general CSP methods can be realistically applied into solving mechanical engineering problem (Lottaz et al. 2000; Ribeiro et al. 2008; Ouertani and Gzara 2008; Ermolaeva et al. 2004; Chen et al. 2006; Zhao et al. 2002; Li and Xiao 2004; Jie and Sun 2007; Xu et al. 2002; Li and Xiong 2002). These issues are listed as follows:

(1) Design variables usually have different abstraction levels, how to represent this characteristic using hypergraph;
(2) How to represent complicated mathematical functions as constraints;
(3) How to tackle and manage the complexity of a design problem;
(4) Many disciplines are usually involved in product design, how to represent them in a constraint network;
(5) Product design usually involve several phases in product life cycle, how to model the temporal relations among variables in a constraint graph.

20.5 Conclusion

This paper proposes applying CSP methods to solve mechanical design problems with a crank-rocker mechanism as an example. The purpose is to explore an effective and efficient computerized method for product design. This work is still very primitive. A prototype system is currently under development to illustrate the feasibility of the proposed ideas.

Acknowledgments This research is sponsored by Natural Science Foundation of China (Grant No.51075300), Research Funding from Tianjin University of Science and Technology (Grant No.20090407), and Natural Science Foundation of TianJin (Grant No. 10JCYBJC06800).

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Chapter 21
Appraisal of Estate Enterprise's Social Responsibility Based on ANP and Fuzzy Theory

Chun-hua Wu

Abstract The estate industry is one main pole of China's economy, and it has done great contribution to economy development as well as improving urban and rural appearance. But in recent years, the negative reports about building's quality, false advertising and so on appear frequently. These have done great damage to estate enterprises' social image, so it is necessary to set up one reasonable system and give out proper method to assess estate enterprises' social responsibility. Reasonable appraisal will play an active role in changing estate enterprises' negative image as well as promoting the realization of harmony society. After analyzing the existing problems of estate enterprises, this paper sets up one compressive system and applies ANP and fuzzy theory into the appraisal of estate enterprise's social responsibility. At last a case is shown to identify the appraisal process.

Keywords ANP · Estate enterprise · Fuzzy theory · Social responsibility

21.1 Introduction

Under the big construction and big development background, the estate industry of China has make great development in recent 10 years, becoming one main pole of economy and occupying second place in absorbing labor forces only behind of manufacturing industry (Wu 2011). However, during this process, many problems appears, especially the absence of social responsibility, such as the false advertising, getting abnormal profit by raising house price deliberately, discard of ordinary customer's urgent demand by putting too much resource in developing

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E. Qi et al. (eds.), *The 19th International Conference on Industrial Engineering and Engineering Management*, DOI: 10.1007/978-3-642-38391-5_21,

high-level residential, and so on (Zheng 2008; Zhang and Qin 2007). It is the time to do some thing to improve estate enterprises' social responsibility, not only for customer's benefit but also for estate industry's healthy and sustainable development. But relative research in China just start, till now not much papers can be found, so in order to enrich relative research and do some efforts to improve estate enterprises' social responsibility, this paper sets up one comprehensive index system and gives out one model to appraise estate enterprises' social responsibility, thus providing some useful references to enterprises and relative government department.

21.2 Why Estate Enterprises Should Put Emphasis on Social Responsibility

21.2.1 The Important Way to Improve Social Image

Because the estate industry of our country founded recently, till now is only about 30 years, relative law and regulation is not perfect, so in recent years, in order to get windfall profit, some developers sacrifice profit of stakeholders deliberately (Qu 2007). The negative reports often occur, such as quality problem of house, bidding up price, peasants' pay in arrears and so on (Ceng 2007). This phenomenon not only despairs customer's interest, but also destroys the image of estate industry, thus bringing unfavorable influence to its healthy development. Under such background, the estate enterprise should take some positive action to improve its image, so in the process of profit obtaining, the social responsibility should be put much emphasis. Only by solving the exiting problems felicitously, can estate industry's social image will be improved, and then estate industry's sustainable and harmonious development can be realized.

21.2.2 The Requirement to Keep in Line with International Practices

After entering WTO, how to accelerate the speed to take part in international competition becomes one common problem to domestic enterprises, including estate enterprises. In recently years, after ISO9000 and ISO14000, now the western is advocating SA 8000, which is the first worldwide standard pointed to enterprise's social responsibility (Chen and Chen 2006). Its main purpose is to endow market economy with humanism, so under such background, domestic estate enterprises must treat social responsibility as important component of development, other else, the chance taking apart in international cooperation and competition will be lost.

21.2.3 Requirement to Cultivate Enterprise's Core Competitiveness

The enterprise's core competitiveness is the integrity of technological core competence, organizational core competence and culture core competence. With the upgrading of people's living standard and development of society economy, the enterprise image and brand consciousness are taking a more and more important role in enterprise's core competitiveness. Under such background, the estate enterprises should aware social responsibility has become a significant part of competitive advantage in the competition era of brand, so undertaking social responsibility actively will get public's approbation, thus improving enterprise's competitiveness.

21.3 Construction of Appraisal Index System

Since 1970s, researchers began to study enterprise social responsibility, till now several representative viewpoints have formed. First one is the viewpoint from the economy, famous scholar Milton Friedman is its main advocator. This viewpoint holds that enterprises' only social responsibility is through utilizing resource to obtain or increase profit under certain game rule. The second one is centered social economics, to which Howard R. Bowen is the main representative scholar. It thought increasing profit is not the all of enterprise's responsibility, besides this, protecting and upgrading social welfare were also important component (Yan and Wang 2007). The third one pointed out enterprises should take on 3 aspects social responsibility: realizing the earnings of finance, society and environment. This is the famous "three-dimensional model", put forwarded by Archie B. Carroll. Until early 1990s, more and more scholars and entrepreneurs began to use "corporate citizenship" to describe enterprise's social responsibility (Cui et al. 2011). As a good corporate citizenship, the corporate should be good to all level interest-related parties, such as customer, employee, district, environment, partnership as well as stakeholders.

Based on the viewpoints above, this paper sets up one comprehensive index system from four aspects, including operation and product, employee development, social contribution and relation with nature, see Fig. 21.1.

The first aspect mainly concerns enterprise's operation and product. Estate enterprise is a business organization, so through smooth and healthy operation and then bring acceptable profit to stakeholders well as the employees is important, other else the estate enterprise will lose the most crucial developing power. Meanwhile, enterprises' main task is to provide qualified and acceptable product, this means the house quality is reliable, house type as well as price is acceptable by ordinary customers.

The second aspect concerns employee' development. Employee is the most valuable treasure of enterprise, employee's benefit should get more attention than

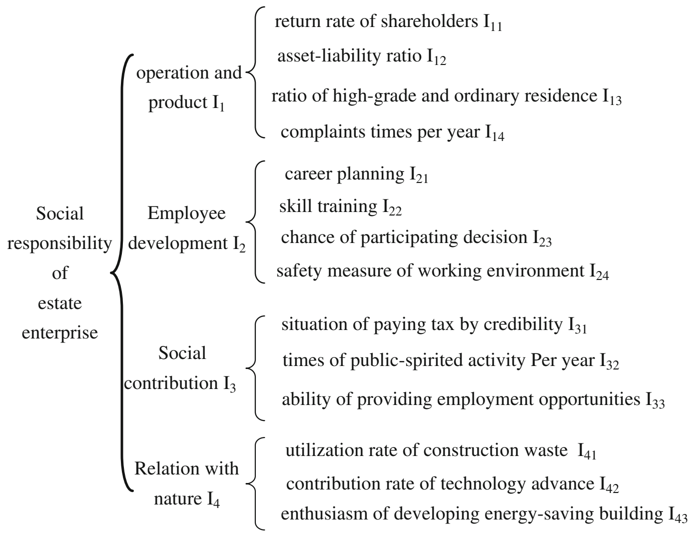

Fig. 21.1 The index system of social responsibility

before, because of this, the SA 8000 put employee's benefit on the most important status. Employee's development not only means salary, but also refers upgrading employee's skill level, improving working environment and so on.

The third aspect concerns estate enterprise's social contribution. Estate enterprise is one component of society, so it should do proper social contribution. This means estate enterprises should obey relative laws, pay tax on time, create employment chance, and be active in social public service.

The fourth aspect mainly concerns estate enterprises' environment protection consciousness. The estate enterprises of China doesn't get rid of extensive growth pattern, so high resource and energy consuming, low level of productivity and low contribution of scientific development are still the main characters of estate enterprises. According to estimation, compared with advanced countries, the estate industry of China consumes 3–5 times resource, while providing merely 1/5–1/6 productivity of these countries. On the same time, in the process of development, some estate enterprises ignore the rule of nature, so the lake is filled and farmland is exploited and so on, leading to ecological environment deterioration (Li 2012).

21.4 Construction of Appraisal Method

Till now the research about estate enterprises' social responsibility mainly stay on qualitative analysis level, such as the sense to improve estate enterprise's social responsibility, the index study as well as the relation of improving social responsibility and its healthy development. Although exiting research has play an active role in improving estate enterprise's social image at some degree, but it is necessary to set up one more comprehensive index system and give out one quantitative model to measure the level of society more objectively, which can provide more information to enterprise and government.

The appraisal method put forward by this paper is as follow (Fig. 21.2).

Phrase1: index value fixation. To measure the value of every index scientifically is first key step of appraisal. As to quantitative index, its value is got directly from its financial statements or statistical data, based on appraisal subject's performance. While to qualitative index, it is difficult to use one objective value, so in order to get more accurate measurement value, this paper will apply unascertained rational number to do this task. Unascertained rational number is put forwarded firstly Guang-Yuan Wang, academician of the Chinese Academy of Engineering. This method can identify all the possibility and as well as experts' reliability, thus avoiding the information distortion or omission. Till now it has been applied in practice widely, such as production decision, data processing, interval analysis and so on.

Phrase2: index weight fixation. The indexes are not of equal importance, so we need to fix every index's weight scientifically. In this paper, the task will be realized by Analytic Network Process (short of ANP), which firstly put forward by American Thomas L. Satty at 1996, It developed from AHP, so they have nearly same decision principle, but their decision structure is different, for ANP network structure is applied while in AHP is hierarchical structure (Sun et al. 2007). ANP model can take into the feedback of different levels' indexes and the inner loop relation of the same level indexes, while traditional AHP only emphasizes the domination of upper layer to lower layer and suppose the indexes under same level is independent, so compared with AHP, ANP is inefficient in tackling complex problem (Zhang et al. 2012a; Guo and Bai 2011). In a word, ANP can make the analysis process more close to practical situation, thus making the analysis result more efficient and more reliable.

Phrase3: social responsibility comprehensive appraisal. On the base of frontal two phrases, in this phrase fuzzy theory will be used to appraise estate enterprises' social responsibility. Because in the appraisal process, there is full of unascertained information, so the fuzzy model is adapted and will make the appraisal

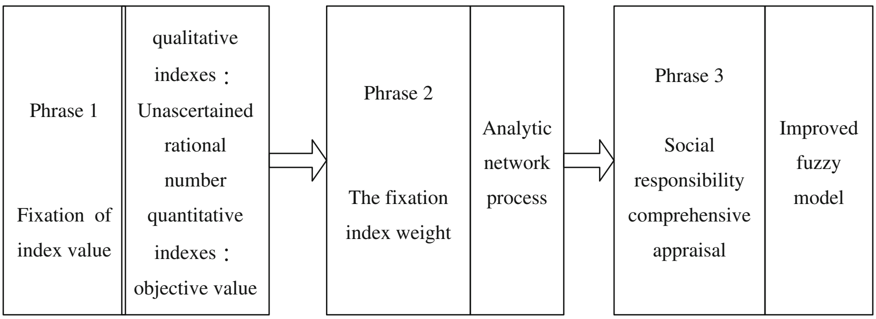

Fig. 21.2 The main appraisal phrases and its method

result more objectively (Ma et al. 2007). But traditional fuzzy model has some deficiency needing to be overcome, such as the max–min in algorithm of fuzzy set, the maximum membership degree recognition criteria to ranked evaluation grade (Liu et al. 2009; Zhang et al. 2012b). So in the application process, some improvement will be done to fuzzy model from the two aspects.

21.5 The Application

In order to show the appraisal process of the model put forward by this paper as well as identify its reasonability, this paper applies it to one estate of An Hui Province.

21.5.1 Fixation of Index Value

To the quantitative index the value is get from this enterprise's financial statements or statistical data of relative government department. While to qualitative indexes, we invite 4 experts to grade from 100 to 0 based on the logic of unascertained rational number. For example, take index I_{13} as an example to show the grading process. Specifically speaking, four experts' grade intervals to this index are (75–80), (70–80), (80–85) and (70–75) respectively, and because experts' experience and knowledge structure is different, so different experts is allocated different credibility, which is 0.3,0.2, 0.3 and 0.4 respectively. Then based on unascertained rational number theory, the credibility function is fixed:

$$f_{13}(x) = \begin{cases} 0.3 & x \in (70, 75) \\ 0.4 & x \in (75, 80) \\ 0.15 & x \in (80, 85) \\ 0 & \text{other} \end{cases}$$

Through computation, the grade of I_{13} 77.5 can be got. By the same way, other quantitative indexes' grade can be got.

Finally, we can get all indexes' value, as shown in Table 21.1.

Table 21.1 Value of indexes

Index	I_{11}	I_{12}	I_{13}	I_{14}	I_{21}	I_{22}	I_{23}
Value	27 %	30 %	77.5	3	78	75	82
Index	I_{24}	I_{31}	I_{32}	I_{33}	I_{41}	I_{42}	I_{43}
Value	72	27 %	30 %	77.5	3	78	75

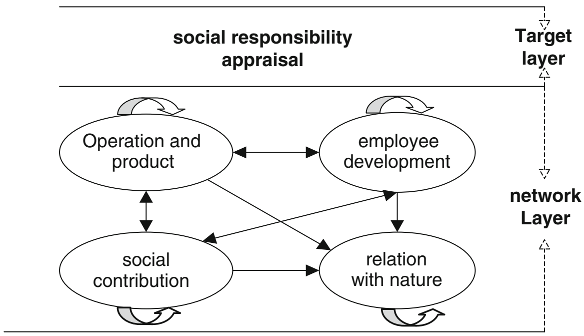

Fig. 21.3 The network of indexes

21.5.2 Weight Fixation

In order to overcome the shortcoming of AHP, this paper turns to ANP, which can make the weights more reasonable and scientific. First the network hierarchy is set up as follow (Fig. 21.3).

Then this paper uses software Super Decision, which is designed specifically to ANP, to realize the computation process. The weight get from the software are shown in Table 21.2.

21.5.3 Comprehensive Appraisal Using Improved Fuzzy Theory

Firstly, based on the experts' advice and industry standard, this paper sets up indexes' rank standard, including quantitative and qualitative indexes, see Table 21.3. Then the membership function of every index can be set up.

Secondly, based on the logic of fuzzy theory (Qu 2007), substituting index's value into corresponding membership function, the membership matrix is got. But in computation process, some change is done to fuzzy theory's max–min algorithm following the way of reference (Ceng 2007).

Finally, the comprehensive appraisal vector V is got,

Table 21.2 Weights fixed by ANP

First level index	I_1				I_2				I_3			I_4		
Duster weights	0.29				0.22				0.26			0.23		
Second level index	I_{11}	I_{12}	I_{13}	I_{14}	I_{21}	I_{22}	I_{23}	I_{24}	I_{31}	I_{32}	I_{33}	I_{41}	I_{42}	I_{43}
Local weights	0.26	0.29	0.21	0.24	0.28	0.22	0.31	0.19	0.35	0.38	0.27	0.34	0.35	0.31

Table 21.3 Rank of indexes

Rank / Index	Low	Relativity	General	Relativity high	High
I_{11} (%)	≤5	5–10	10–20	20–30	≥30
I_{12} (%)	≥80	70–80	50–70	40–50	≤40
I_{14}	≥15	10–15	5–10	5–2	≤2
I_{32}	≤3	3–6	6–9	9–12	≥12
I_{41} (%)	≤20	20–40	40–60	60–80	≥80
I_{42} (%)	≤25	25–40	40–55	55–70	≥70
Qualitative indexes	≤50	50–60	60–70	70–80	≥80

$$V=[0.29 \quad 0.22 \quad 0.26 \quad 0.23]\bullet\begin{bmatrix}0.578 & 0.422 & 0 & 0 & 0\\ 0.478 & 0.465 & 0.057 & 0 & 0\\ 0 & 0.14 & 0.545 & 0.315 & 0\\ 0 & 0 & 0.408 & 0.592 & 0\end{bmatrix}$$
$$=(0.273 \quad 0.261 \quad 0.248 \quad 0.218 \quad 0)$$

For the index rank is ordered, so the maximum subordinate recognition rule is not perfect, then this paper turns to incredible recognition rule. Suppose threshold value $\lambda = 0.7$, and then we can know this enterprise's social responsibility level belongs to rank general. From analysis process, we also can know enterprise's bad performance on social contribution and relation with nature is the main reason lowering its social responsibility level.

21.6 Conclusion

Pointed to the problem of estate enterprise's social responsibility, this paper set ups one comprehensive index system, and then applies ANP and fuzzy theory into responsibility appraisal process. One specific case is given, which identity this model is feasible and reasonable.

The study of this paper can provide one tool to assess estate enterprise's responsibility quantitatively, thus avoiding traditional qualitative methods' shortcomings. In a word, the study of this paper will do good to estate industry's healthy development as well as the realization of harmony society.

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Chapter 22
Bottleneck Detection Method Based on Production Line Information for Semiconductor Manufacturing System

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Abstract Semiconductor wafer fabrication system is a typical complex manufacturing system, since it has large-scale, reentrant, multi-objective, uncertain and other characteristics. It's too difficult to achieve the capacity balance to lead the existence of the bottleneck. According to the theory of TOC, the accurate detection of bottleneck is the key to implement DBR thought. For the characteristics of semiconductor production line, this paper proposes a bottleneck detection method based on the starvation and blockage information of the production line. The method is verified on HP-24 model by simulation. Compared to the relative load method, the equipment utilization law and the queue length method; the experimental results show that this method makes performance better than them.

Keywords Bottleneck detection · DBR · Production line · Reentrant

22.1 Introduction

Drum-Buffer-Rope (DBR) theory is put forward by Doctor Goldratt based on the theory of constraints to solve the production scheduling problem (Rahman 1998). According to the theory, the whole system's output is decided by bottleneck's output and maximizing the utilization of the bottleneck's capacity is the key to improve system productivity and economic benefit. Bottleneck detection is a very important step for the operation and management of manufacturing enterprise, because it will not only affect the decision of the feeding strategy, but also influence the dispatching of the jobs on bottleneck equipment.

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E. Qi et al. (eds.), *The 19th International Conference on Industrial Engineering and Engineering Management*, DOI: 10.1007/978-3-642-38391-5_22,

At present, much research effort has been devoted to bottleneck detection and can be divided into two categories. One is to detect the bottleneck before the start of production system. Literature (Zhang and Wu 2012) firstly establishes an optimization model by reducing some traditional constraints of a standard Job-shop, then calculates the bottleneck's characteristic value and chooses the excellent by the simulated annealing algorithm. Literature (Zhai et al. 2010) uses the orthogonal table and different assigned rules to construct a test program, with production system job target as measurement index to identify bottleneck. The other method to identify bottleneck is to conduct collection, imitation and simulation analysis of the data from the production system which has been online for a period of time. As in (Roser et al. 2002, 2003), system bottlenecks are divided into independent bottlenecks and shift bottlenecks, they are identified by calculating the maximum active time of the machines, which is similar to the common equipment utilization method. Literature (Li et al. 2007, 2009; Wang et al. 2008) is based on the data of the production line, the blockage and starvation information are made full use of to detect bottlenecks. Literature (Kasemset 2009; Kasemset and Kachitvichyanukul 2009, 2010) classifies the candidate bottleneck equipment according to the static and real-time data from simulation and testifies the correctness of the bottleneck equipment selection via confidence interval level.

Semiconductor wafer fabrication system is recognized as one of the most complex manufacturing systems, which normally contains as many as three or four hundreds processing steps. In addition, wafer manufacturing has reentrant characteristics, namely the same product will go through some processing center more than once, which is different from the traditional Job-shop and Flow-shop system (Wu et al. 2006). Most methods mentioned above are applicable to Flow-shop; some can be used for Job-shop as in (Zhai et al. 2010). It will ignore some stochastic disturbance such as equipment failure or seasonal variation of need though it is faster and more convenient. Based on literature (Li et al. 2007), this paper mainly studies the semiconductor wafer fabrication system by changing its constraints and proposing a concept of relatively blocking rate, which can record the detailed variation of the count of the jobs in the buffer throughout the whole production system operation period. The method can make full use of outline and online information of the production line, and it is not necessary to consider machine sets, type, product type, processing route and all kinds of factors such as random fluctuation in the process of identification. Therefore, it is a convenient and accurate identification method.

22.2 Common Bottleneck Detection Methods

Due to the high complexity of the semiconductor manufacturing system, the existing manufacturing system bottleneck identification methods are not suitable as in (Sengupta et al. 2008), which identifies bottlenecks by analysing the departure time among the equipments. However, it does not exist the logic upstream and downstream equipments in semiconductor wafer fabrication system because of its serious reentrant characteristic. At present, common methods of bottleneck detection in semiconductor manufacturing system are as follows.

22.2.1 Analyze the Queue Length of the Equipment

In this approach, the queue length or waiting time of the equipment is measured and the one which has the longest queue length or waiting time is considered as manufacturing bottleneck, as is shown in formula 22.1

$$\text{Bottleneck} = \text{Machine}_j = \max_{1 \le j \le m}\left(\max_{0 < t \le T}(W_{tj})\right) \tag{22.1}$$

where T stands for simulation period, m is the number of the processing center in a system or a model, W_{tj} is the number of jobs in the buffer for equipment j at a certain time t during the simulation period.

22.2.2 Measure the Utilization Rate of the Equipment

The equipment which has the highest utilization rate is system bottleneck as is shown in formula (22.2) (Zhou and Rose 2009).

$$\text{Bottleneck} = \text{Machine}_j = \max_{1 \le j \le m}\left(\frac{WT_j(T) + OT_j(T)}{T}\right) \tag{22.2}$$

where T is the time period considered, m is the number of the processing center in a system or a model, WTj(T) and OTj(T) are the processing time and off-line time of equipment j during time period T.

22.2.3 Calculate the Relative Load of the Equipment

On the basis of the order, the load of every processing center is calculated according to the job's craft, and the machine which has the maximal relative load is system bottleneck (Ding et al. 2008), as is shown in formula (22.3) and (22.4).

$$L_B = \text{Max}(L_h) \tag{22.3}$$

$$L_h = \sum_{i=1}^{x} q_i \sum\nolimits_{j=1}^{y} \frac{\theta t_{ij}}{\mu}(h = 1, 2, \ldots m) \tag{22.4}$$

where L_B is the load of the system bottleneck, work center B is system bottleneck, i is the type of the job, x is the number of the type of the job, y is the step number of the job, θ is the related coefficient of the equipment (if some job is processed in the center, then θ is 1, otherwise θ is 0), t_{ij} is the processing time of step j of job i. The method can identify the system bottleneck through a simple calculation using some relevant technological parameters.

22.3 Bottleneck Detection Based on the Information of the Production Line

Using the blockage and starvation information in buffer to detect bottlenecks is a method based on data, the basic idea is that a bottleneck machine will often cause the upstream machines to be blocked and downstream machines to be starved, therefore, the bottleneck machine will often have a lower total blockage plus starvation time than its adjacent machines. LIN LI validates his theory according to the thought that the disturbance of the bottleneck equipment has the largest impact on the system. At last, he applies his idea to the production line including three and more machines (Li et al. 2007).

Semiconductor production line has a great difference with general industrial manufacturing line for its complex processing flow and serious reentrant characteristics. In the actual production line, bottleneck equipment is always the one which owns more reentry times and the jobs in the bottleneck buffer possibly come from multiple upstream machines, therefore, upstream or downstream machines can't be judged by physical location. In addition, the starvation rate and blockage rate can't be simply added together because there are lots of parallel and group equipments. This paper proposes a new method based on the thought of utilizing historical information in the production line aiming at the characteristics of semiconductor production line. At first, the capacity of buffer is set to be infinite. If the capacity is a fixed value, it will lead to buffer overflow when the production line is crowded and the block degree of different machines can't be distinguished. Secondly, the formula of the starvation rate is defined according to its basic concept. Finally, this method puts forward a concept of relative blocking rate and the formula is defined. The details are as follows.

(1) Starvation rate The idle time divided by processing period reflects when the machine is leisure in the production process. It can be expressed as $S_i = \frac{T_{idle}}{T}$ (i is equipment number, T_{idle} is leisure time, T is processing period);
(2) Relative blocking rate generally, each buffer will appear the phenomenon of accumulation, this paper proposes the concept of relative blocking rate to distinguish the congestion degree among different equipment at different times, namely the equipment is relative to other equipments in degree of obstruction. The computing method is: obtain the number of jobs in each

buffer at regular time called q_i (i is equipment number), calculate the total queue length of jobs of all the equipment buffers at the present moment called $\sum_{i=1}^{n} q_i$(n is the number of all the equipment), then the relative blocking rate of the equipment is $B_i = \frac{q_i}{\sum_{i=1}^{n} q_i}$. Assume that the collection period is Δt, the total simulation time is T, then the relative blocking rate is $\delta_{B_i} = \frac{\Delta t \sum \frac{q_i}{\sum_{i=1}^{n} q_i}}{T}$

In the real production line, bottleneck machine is the weak link of the whole system and its processing ability is the weakest. For that reason, the buffer before it often has a large accumulation of jobs waiting for processing. Compared to the other machines, blockage occurs more frequently in bottleneck machine and starvation is on the contrary. Thus, the starvation rate plus the opposite number of the relative blocking rate will be the least of all the equipments. To avoid confusion, the opposite number of the relative blocking rate is defined as non-blocking rate which is equal to $1 - \delta_{B_i}$. According to the above description, the method is expressed as:

$$\begin{aligned} \text{Bottleneck} = \text{Machine}_i &= \min_{0<i\leq n} (1 - \delta_{B_i} + S_i) \\ &= \min_{0<i\leq n} \left(1 + \frac{T_{idle} - \Delta t \sum \frac{q_i}{\sum_1^n q_i}}{T} \right) \end{aligned} \tag{22.5}$$

where i is equipment number and n is the total number of the equipments.

Because of the high complexity of semiconductor manufacturing system, it may exist multiple bottlenecks (Cao et al. 2010). When this method is used to detect bottleneck, the distribution of starvation rate and non-blocking rate of each equipment should be analyzed. For the equipment whose result of starvation rate plus non-blocking rate is similar to the system bottleneck can be considered as the second bottleneck. For the main aiming of this paper is single bottleneck detection, we don’t make much analysis on multiple bottlenecks.

22.4 Example Validation

This paper chooses the model of HP-24 semiconductor production line as object of study and EM-PLANT as simulation platform. HP-24 Model comes from silicon wafer production technology center lab and most parameters are collected from real devices. There are 24 equipment groups in the model and most of them are single machine except the lithography (one group contains two machines, the other group contains three machines). As one kind of simplified model, HP-24 only

Table 22.1 Parameters for machines in Hp-24 model (Murphy and Dedera 1996) and simulation data

Machine group		Count	Reentrant times	Starvation rate (%)	Nonblocking rate (%)
ID	Name				
1	CLEAN	1	19	14.73	97.72
2	TMGOX	1	5	23.97	99.31
3	TMNOX	1	5	20.89	99.50
4	TMFOX	1	3	58.23	99.90
5	TU11	1	1	83.30	100.00
6	TU43	1	2	56.30	99.98
7	TU72	1	1	81.39	100.00
8	TU73	1	3	59.87	99.93
9	TU74	1	2	71.97	99.98
10	PLMSL	1	3	65.82	99.96
11	PLMSO	1	1	78.44	100.00
12	SPUT	1	2	65.85	99.97
13	PHPPS	2	13	14.22	99.05
14	PHGCA	3	12	5.00	65.33
15	PHHB	1	15	63.23	99.94
16	PHBI	1	11	6.00	64.45
17	PHFI	1	10	53.88	99.93
18	PHJPS	1	4	57.36	99.91
19	PLM6	1	2	22.84	99.80
20	PLM7	1	2	67.12	99.96
21	PLM8	1	4	13.29	99.39
22	PHWET	1	21	37.82	99.44
23	PHPLO	1	23	26.00	99.36
24	IMPP	1	8	9.05	100.00

processes one type of products which has 172 processing steps (Ding et al. 2008). During the simulation period, the buffer information is collected every half an hour and the feeding method is subject to uniform distribution. The simulation period is set to be 1 year and the data collected is shown in Table 22.1. The starvation rate and non-blocking rate of each equipment are calculated by the formulas introduced in the third section.

As is shown in Table 22.1 and Fig. 22.1, the starvation rate of machine 14 is 0.05, the non-blocking rate is 0.64, so the starvation rate plus the non-blocking is 0.69, which is the smallest of all machines. Thus, Machine 14 can be considered as the bottleneck machine according to the thought of the method based on production line information. As machine 14 is a parallel processing machine, it can be regarded as the bottleneck processing center.

Bottleneck machine is the short and fat son of the system, so the system output depends on the processing speed of bottleneck machine. The following is comparisons among different bottleneck detection methods.

(1) To prove the effectiveness of the machine group 14, we feed jobs into the production line based on the processing speed of machine 14. Through

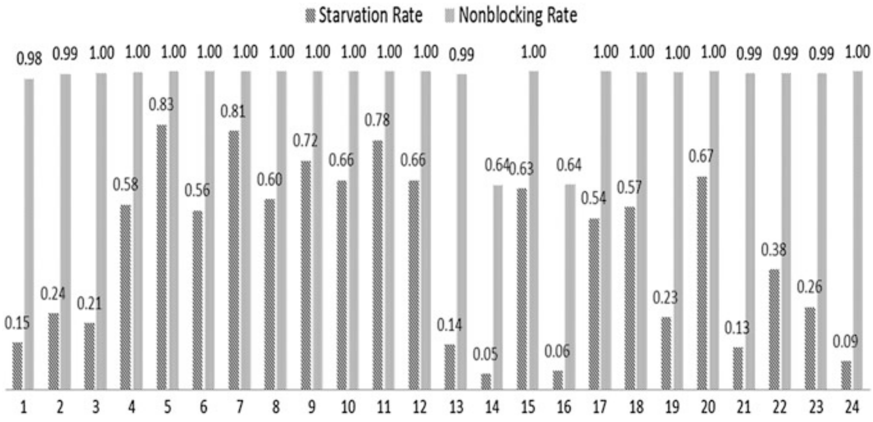

Fig. 22.1 Bar graph of starvation rate and nonblocking rate

calculation, the processing speed of machine 14 is $L_{14}= 31.28h$, namely machine 14 needs 31.28 h to process one lot of product.

(2) When we use the relative load method to identify bottlenecks, machine 16 holds the largest load according to the calculation formula introduced in Sect. 22.2. Thus, machine 16 is the bottleneck machine and its processing speed is $L_{16} = 32.56h$.
(3) Under the condition that the feeding speed obeys the uniform distribution, the equipment utilization of machine 24 is the highest. Thus, machine 24 is the bottleneck machine and its processing speed is $L_{24} = 30.88h$ by the method.
(4) By analyzing the queue length of every machine in the whole process, machine 1 has the longest queue length and it is the system bottleneck with processing speed $L_1 = 29.45h$.

The feeding tables of all kinds of methods are drawn up according to the analysis above and they are validated on HP-24 model by simulation. The dispatching rule of bottleneck machine and non-bottleneck machines is FIFO (first in first out). The strengths and weaknesses of different feeding methods and scheduling strategies need to be evaluated by performance and the common performance indexes including:

(1) Average processing period. In the reentrant manufacturing system, the time from when a raw job is put into the production line to the time the job leaves the system is processing period, which can be expressed as $CT = T_{out} - T_{in} \cdot$ T_{out} is the time the job leaves the processing system as finished product, T_{in} is the time the job enters the system. The scheduling goal is to make the average processing period minimum.
(2) Productivity. Productivity refers to the number of finished products per unit time, the formula is $PR = \frac{Q}{T}$. Q is the number of the finished lots during the processing period, T is processing period. Productivity is inverse to processing

Table 22.2 Performance of different bottleneck detection methods

	Average processing period	Processing period variance	Productivity	Wip	Bottleneck machine utilization
Production information	60024.49	6961.08	0.655	29.5	0.95
Relative load	63869.54	7097.10	0.643	30.57	0.93
Equipment utilization	78717.38	14856.57	0.634	39.96	0.921
Queue length	83229.23	20667.08	0.623	43.37	0.869

period. The shorter the processing period is, the higher the productivity will be. Productivity determines the cost of final product, processing period, customer satisfaction and so on.

(3) WIP (work in process) is the number of products in process online every day and the scheduling goal is to make the index minimum.

(4) Utilization rate of bottleneck machine. The formula is $U_B = \frac{T_{work}}{T_{open}}$, T_{work} is the time that the machine is in the state of process, T_{open} is the uptime of the machine. An overview of the comparison of different performance of each method is shown in Table 22.2

From Table 22.2 we can see that when we use the information of the production line to detect the bottlenecks, for average processing period, there is a 6.0 % reduction compared to the relative load method, a 23.7 % reduction compared to the equipment utilization, a 27.9 % reduction compared to the queue length. For processing period variance, there is a 1.9 % reduction compared to the relative load method, a 53.1 % reduction compared to the equipment utilization, a 66.3 % reduction compared to the queue length. For productivity, there is a 1.9 % increase compared to the relative load method, a 3.3 % increase compared to the equipment utilization, a 5.1 % increase compared to the queue length. For average day wip, there is a 3.5 % reduction compared to the relative load method, a 26.2 % reduction compared to the equipment utilization, a 32.0 % reduction compared to the queue length. For bottleneck machine utilization, there is a 2.2 % increase compared to the relative load method, a 3.1 % increase compared to the equipment utilization, a 9.3 % increase compared to the queue length. The relevant results are displayed in Table 22.3.

Table 22.3 Performance analysis of the other three bottleneck detection methods compared to the proposed method

	Average processing period (%)	Processing period variance (%)	Productivity (%)	WIP (%)	Bottleneck machine utilization (%)
Relative load	−6.0	−1.9	+1.9	−3.5	+2.2
Equipment utilization	−23.7	−53.1	+3.3	−26.2	+3.1
Queue length	−27.9	−66.3	+5.1	−32.0	+9.3

Data analysis presents that the proposed method in this paper has different range of ascension than other methods and thus proves its practicality and effectiveness.

22.5 Conclusion

Detecting bottleneck accurately is the first step to implement the DBR thought. Common bottleneck detection method has some limitations in the complex semiconductor manufacturing system. This paper utilizes the production line information to detect bottleneck which is based on data mining and obtains good effect. Historical data underlies the process information of manufacturing system and it can be regarded as a knowledge base which should be made full use of to detect bottlenecks. Future work: 1. There are many uncertain factors in a real production line, a single bottleneck feeding strategy may not be achieved good effect all the time, it should be combined with the bottleneck scheduling strategy. 2. How to further mine the underlying experience, knowledge and rules of the historical and online data to optimize the production line needs further study.

Acknowledgments This research was supported by Chinese National Natural Science Foundation (61034004), Science and Technology Commission of Shanghai (10DZ1120100, 11ZR1440400), Program for New Century Excellent Talents in University (NCET-07-0622) and Shanghai Leading Academic Discipline Project (B004).

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Chapter 23
Clinical Decision Support Model of Heart Disease Diagnosis Based on Bayesian Networks and Case-Based Reasoning

Man Xu and Jiang Shen

Abstract To boost the accuracy of clinical decision support systems and degrade their misdiagnosis rates, a hybrid model was proposed with Bayesian networks (BN) and case-based reasoning (CBR). BN were constructed with the feature attributes and their casual relationships were learned. The similarities of feature attributes were measured with the case matching method, as well as the knowledge of their dependent relationships. Therefore, the accuracy of the diagnosis system was enriched through the dynamic retrieval method.

Keywords BN · CBR · Heart disease diagnosis

23.1 Introduction

Reasoning mechanism is one core component of clinical decision support systems (CDSS). Rule-based reasoning (RBR) is a popular inference technology in most of the existing expert systems (ES), as well as model-based reasoning (MBR). However, the relationship between information and knowledge is complex and fuzzy (Kong et al. 2008) in the area of healthcare, especially in the process of medical diagnosis. But the medical rules are more difficulty in acquiring and matching.

Cased-based reasoning (CBR) is the process of solving new problems based on the solutions of similar past problems. In CBR, processes like retrieval and matching are typically assumed to be broadly general cognitive processes.

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E. Qi et al. (eds.), *The 19th International Conference on Industrial Engineering and Engineering Management*, DOI: 10.1007/978-3-642-38391-5_23,

Therefore, CBR is often used to solve complex problems with incomplete knowledge or difficulty in acquiring rules. The critical part of CBR is to find a suitable case retrieval method, which is determined to the efficiency and accuracy of the solution.

The process of case retrieval relies on the similarity measures for all the case attributes. The weights and similarities of features are given by physicians during medical diagnosis. Although the feature weights are taken into account with several algorithms, including feature evaluation (Shiu et al. 2001), introspective learning (Zhang and Yang 2001) and Neural Network (Zhang and Yang 1999), they omitted adaption strategies. Furthermore, Nearest Neighborhood (NN) method is adapted to case retrieval (Gu et al. 2003; Ling et al. 2006), but the solution cannot regenerate with database updating. The accuracy of NN decreases rapidly when dealing with incomplete data of medical problem, as well as its retrieval efficiency.

This paper built a hybrid model integrating CBR with Bayesian Networks (BN) for clinical decision supports (BN-CBR). Compared with conventional CBR, BN-CBR contributes to the optimization of the storage and retrieval process for medical cases, which improves the efficiency of CDSS. Moreover, BN-CBR aims to boost the accuracy of reasoning and to degrade the rate of misdiagnosis.

23.2 CDSS Based on the BN-CBR Hybrid Model

The diagnosis process of a clinician involves in synthesizing the information of a patient. This process also involves the circle of observation, diagnosis and treatment. From the perspective of clinic, the tasks of observation mainly consist of acquiring and mining the information of a patient completely, which reduces the uncertainty of the patient' condition to the greatest extent. With the available information, the clinician administers the treatment to the patient as well as his/her experience and medical knowledge. This diagnosis process can be regarded as a reasoning process, and its treatment is a solution for the medical problem. The treatment relies on the diagnosis and decision-making process, while its accuracy are determined by the belief and the adequacy of the acquired information during the period of observation (Ma et al. 2002). The framework of CDSS based on the BN-CBR model is demonstrated as Fig. 23.1.

As in Fig. 23.1, queries demonstrate the patients' condition (medical cases). The processor of CBR obtains the most similar case through the similarity measure. The conditional probabilities among the attributes of the cases are inferred through data training on Bayesian Networks (BN), which is an effective data mining tool. Therefore, the similarity function is formulated to measure the degree of similarity among cases. Medical knowledge and the information of patients are stored in the medical database, which is integrated into casebase after data screening and processing. The casebase as the main knowledge source for reasoning can be accumulated, refined and updated during the diagnosis reasoning episodes.

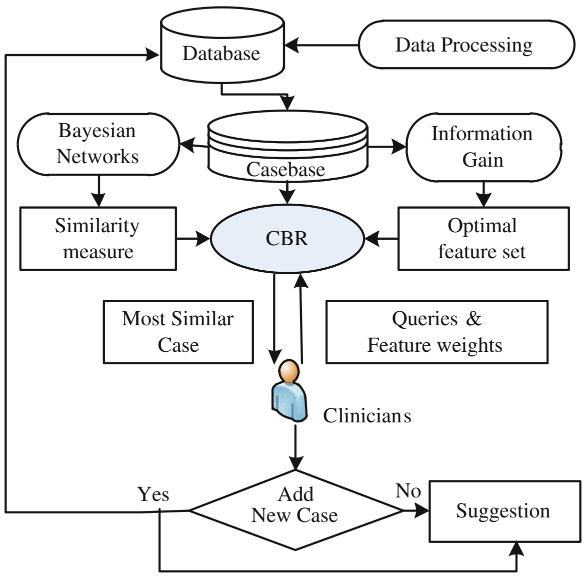

Fig. 23.1 The framework of CDSS based on the BN-CBR hybrid model

23.2.1 Knowledge Representation

Definition 23.1 A medical case is represented as

$$C_i = (Index, X_1, X_2, \ldots, X_m, S), \quad C_i \in CB, X_{\mathrm{i}} \in X \tag{23.1}$$

where CB denotes the casebase, which is a finite set; X denotes the set of medical features; $Index$ denotes the index of medical cases; S denotes the consequence or suggestion of the diagnosis.

Take the diagnosis of Coronary heart disease (CHD) for example. CB = (#, Age, Gender, Family history of CHD, chest pain type, blood pressure, cholesterol, class of CHD), where # is the index of cases. The class of CHD is binary, 0 indicating CHD while 1 indicating other health condition.

Definition 23.2 A medical case database is represented as $CB = [x_{ij}]_{m\times n}$, where x_{ij} denotes the jth attribute of the ith medical case, m denotes the number of features, and n denotes the size of casebase. CB consists of the specific knowledge of previous experiences or historical examples.

Definition 23.3 A medical query is represented as

$$MD = f(MP) = f(P, D, M, CB, K, M^{+}). \tag{23.2}$$

where MP denotes the medical problem; P denotes the patient; D denotes the possible states of the patient; M denotes the finite set of clinical symptoms; K denotes the knowledge set containing all the relationship among M, D and its causes of P; M^{+} denotes the vital signs set of the patient, $M^{+} \subset M$; DC denotes the diagnose/conclusion for the patient, $DC \subset D$; $f(\cdot)$ denotes the reasoning function of the clinician's cogitation.

Clinical symptoms and vital signs are the prerequisite of the inference mechanisms in CDSSs. The basic idea is to drive the conclusion from the vital signs set M^+ based on the medical case database *CB*, the symptoms set *M*, the knowledge set *K*, the possible states *D* and the reasoning process *f*.

Definition 23.4 The reasoning process of CDSSs based on CBR is formulated as $f_{CBR}(C, T, Sim) = DC$, where *T* denotes the clinical query, and its dimensions represent the attributes; *Sim* denotes the similarity measure for two cases, and $Sim : (C_\mathrm{i}, T) \rightarrow (0, 1)$.

23.2.2 Feature Selection

Information gain (IG), also named as mutual information, is an important machine learning tool for weighting attributes. IG is the average value of information about the class with or without a feature. When the value of IG is larger, the information added by the feature is also much larger. Therefore, the values of IG for all the features are measured during the feature selection epoch. The feature with the largest value of IG belongs to the optimized feature set.

The idea of feature selection is to calculate the values of IG for all the attributes in the feature set, and to remove the features whose value of IG are less than a default threshold. The vital signs set M^+ and the symptoms set *M* is Initialized and the threshold is set as *p*. The feature *f* ($f \in M$) is traversed. Given a data sample, entropy

$$I(S_1, S_2, \ldots, S_m) = -\sum\nolimits_{i=1}^{m} P(C_i) \log_2 P(C_i) \tag{23.3}$$

where $P(C_i)$ is the prior probability for samples with C_i, $P(C_i) = S_i/S$; *m* denotes the number of classes, S_i the number of samples labeled by C_i, and S_i the total number of samples.

Definition 23.5 Assume that the feature *f* has *v* values, $\{f_1, f_2, \ldots, f_v\}$. The data sample is divided into *v* subsets by *f*, $\{S_1, S_2, \ldots, S_v\}$, where S_j contains the cases with feature value f_j. The term $S_{1j} + S_{2j} + \cdots + S_{mj}/S$ is the weight of the *j*th subset. S_{ij} is the number of samples with class C_i in S_j, then

$$I(S_{1j} + S_{2j} + \cdots + S_{mj}) = -\sum\nolimits_{i=1}^{m} P_{ij} \log_2 P_{ij} \tag{23.4}$$

where P_{ij} is the probability of samples with class C_i in S_j, $P_{ij} = S_{ij}/S_j$.

Information gain corresponding to f *is*

$$Gain(f) = I(S_1, S_2, \ldots, S_m) - E(f),$$
$$E(f) = \sum_{j=1}^{v} \frac{S_{1j} + \cdots + S_{mj}}{S} I(S_{1j} + \cdots + S_{mj}). \tag{23.5}$$

The feature is added into M^{+} on the condition that $Gain(f)$ is larger than the threshold p.

23.2.3 Parameter Learning of BN

First, the conditional probability is calculated as $p(x_i, r_i | D_l, \theta^{(t)})$ for all the parameters in set D and the attribute x_i. Given set D, its likelihood is

$$l(\theta|D) = \sum_{l} \ln p(D|\theta) = \sum_{ijk} h(x_j^k, r_i^j) \ln \theta_{ijk}$$

where $h(x_j^k, r_i^j)$ denotes the assigned value in the database with $x_i = k$ and $r_i = j$. The maximum of the likelihood θ is

$$\theta_{ijk} = \frac{h(x_j^k, r_i^j)}{\sum h(x_j^k, r_i^j)} \tag{23.6}$$

Assuming the initial value $\theta^{(0)}$, the expectation of the current likelihood $\theta^{(t)}$ is

$$l(\theta|\theta^{(t)}) = \sum_{l} \sum \ln p(D_l, X_l|\theta) p(X_l|D_l, \theta^{(t)})$$

For any θ, if $L(\theta \big| \theta^{(t+1)}) \geq L(\theta \big| \theta^{(t)})$, then

$$L(\theta \Big| \theta^{(t)}) = \sum_{jlk} f\left(a_j^k, \pi(a_j)^l\right) \ln \theta_{jlk}$$

The next estimation of the likelihood is determined by finding its maximum likelihood (MLE),

$$\theta_{ijk}^{(t+1)} = \arg\max E[P(D|\theta)|D, \theta^{(t)}, S] \frac{f(x_j^k, r_i^j)}{\sum f(x_j^k, r_i^j)}$$

The conditional probability distribution is fixed through the above recursive algorithm, namely, the relation among the symptom features are formulated.

23.2.4 Case Retrieval

As mentioned above, case retrieval and matching is the core phase of CBR, in which the similarity is measured for the query with the historical cases. In the literature, the retrieval of CBR is to measure the difference among the features of cases, and Euclidean distance is an popular tool as the similarity measure function (Jain and Marling 2001).

$$Similarity(x,y) = -\sqrt{\sum_{i=1}^{m}(x_i - y_i)^2}$$

where x_i, y_i denote the observations of the ith feature ($f_i \in M^+$) corresponding to the case x and $y$respectively; m is the total number of features.

The problem is that this similarity assessment method omitted the cases during the updating episode, as a result of losing the relative information. Therefore, a new similarity measure function is proposed to solve the probability or BN-CBR.

Based on the BN of the features in M^+, the similarity of two medical cases x, y is

$$Similarity(x,y) = -\sqrt{\sum_{i=1}^{m} g(x_i, y_i)} \tag{23.7}$$

$$g(x_i,y_i)=\begin{cases} \|x_i, y_i\| & \text{when } x_i, y_i \text{ are numeric;} \\ 0 & \text{when } x_i \text{ is equivalent to } y_i, \\ & \text{and } x_i, y_i \text{ are symbolic;} \\ 1-p & \text{when } x_i, y_i \text{ are symbolic,} \\ & x_i = X, \text{ the observation of } y_i \text{ is missing;} \\ 1-q & \text{when } x_i, y_i \text{ are symbolic,} \\ & y_i = Y, \text{ the observation of } x_i \text{ is missing;} \\ 1 & \text{Others.} \end{cases}$$

where $p = P(y_i = X|y_1,\ldots,y_{i-1},y_{i+1},\ldots,y_m)$ and $q = P(x_i = Y|x_1,\ldots,x_{i-1}, x_{i+1},\ldots,x_m)$. The probabilities are obtained with BN to reveal their dependent relationships.

The best case is initiated as $BESTCASE = 0$, as well as the best similarity. All the cases are retrieved with the formula (23.7) for the query y. If $Similarity(x', y) > BESTSIM$, then $BESTSIM = Similarity(x', y)$ and $BESTCASE = x'$. The final *BESTCASE* becomes the retrieved case.

23.3 Conclusion

This paper proposed the CDSS based on the BN-CBR hybrid model. BN were established with the feature attributes of heart disease, which improved the accuracy of diagnosis reasoning through solving the problem of missing data in the database. Not only were the similarities of feature attributes measured, but also the case matching method integrated the knowledge of their dependent relationships.

Acknowledgments This work was supported by the National Natural Science Foundation of China (71171143), by Tianjin Research Program of Application Foundation and Advanced Technology (10JCYBJC07300), and Science and Technology Program of FOXCONN Group (120024001156).

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Chapter 24
Construction of Project Management Classification Frame and Classification Controlling Model Based on Project Portfolio

Chao Yang and Fa-jie Wei

Abstract Project portfolio management and project classification management are two important mutual connecting stages (Archer and Ghasemzadeh 1999). The former is based on project priority appraisal in fact; the latter is project execution management based on project execution collaboration and level-to-level controlling. Both organic combinations will carry out the whole process from the project portfolio management stage to the enterprise project strategy management stage. Therefore, It has also solved the problem that enterprise's strategy execution ability is insufficient and it is advantageous to enterprise's strategy implementation.

Keywords Control · Project portfolio management · Project classification management frame · 6s

24.1 Introduction

The so-called project is completed under certain resource constraints of the human, financial and other one-time activity of the target. The projects tend to include more than one task. The realization of each task needs to consume a certain amount of human, financial resources (Boddy and Macbeth 2000).

The project management is the project organizer operation system, the science theory and the method. Through carries on the plan, the organization, the coordination, the control to the project, is for the purpose of realizing the project goal management system.

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E. Qi et al. (eds.), *The 19th International Conference on Industrial Engineering and Engineering Management*, DOI: 10.1007/978-3-642-38391-5_24,

Project portfolio management is project choice process, that is, under the enterprise resources limited premise, how to chooses the corresponding project, to dispose appropriate resources, and to realize enterprise's strategic target better.

The project level-to-level management means that after having chosen the good project portfolio, according to the project involves the scope, the content, the complex degree, and project management personnel's knowledge and ability, it divides into the project the different rank, and has key carries on the level-to-level administration.

24.2 Introduce a Question

In the project management company, the daily work is the management, the implementation of project. Along with enterprise's development, the enterprise will face lots of projects, and the manager must consider two most essential questions: (1) How to guarantee the coherence of the project goal with enterprise's strategic target; (2) Under the condition of project multitudinous and limited resources, how to manage multiple projects on time, according to nature, according to budget management. The first question is Project portfolio management question, and it has solved the project priority problem; the second question was that under the condition of having solved in the project priority situation, it should not take common methods which was used in the progress of PM, but should consider all projects as a whole to carry on the management, because enterprise itself was a system strategic whole. In consider all projects as a whole to carry on the management in the process, because each project characteristic, the scope, the complex degree are different, which cause the scope and the content of the project management different. Simultaneously it needs the project personnel's different ability and knowledge, therefore it is important to carry on the level-to-level administration to the project. The classification management decides the project implementation management method and the control pattern. First, the project execution graduation will affect the authorized management way of the project. Next, the project execution graduation has decided the project resources disposition way. Finally, the project graduation has decided the project controlling mode (Cheng et al. 2003).

24.3 Project Classification Standard

According to scope and complex degree, project management scope and content, as well as personnel's knowledge and ability involved, may divide into enterprise's in project the enterprise project, the department level project and the project level project. According to the different rank project situation, the enterprise determined the project carries on the starting time, the scope and completes the time and so on. Enterprise project graduation standard was shown in Table 24.1.

According to its the complexity and innovativeness, the enterprise project was strategic and chrematistic, and it should be carried on the special single row management by the enterprise project office. This may centralize resources and the time, and avoid the excessively many business management activity waste in document (document) and the conference.

The department level project according to its key degree and enterprise's strategic sense, suitably enter the project office according to the project group way to management; the individual project may promote according to the situation as the company level, and carries on the single row management in the project office (Dye and Pennypacker 1999).

Table 24.1 Project management standard

Appraisal standard Classification	Range and complexity	PM range and content	Knowledge and ability of PMP
Project of enterprise	The widest range and the most complexity	• Detail plan • Comprehensive cost control • Strict progress plan and control system • Intact document notes • Comprehensive risk management • Regular meeting	• Systematic knowledge of PM, and expert ability • With ability to deal with multiple mission
Project of organization	Wide range and more complexity	• Moderate detail plan • Moderate control plan • Moderate detail programme plan • Periodic report and notes • Moderate risk consciousness • Moderate frequency meeting	• Mastering knowledge of PM; • With elementary ability ti deal with high risk P
Project alone	Incomprehensive and no complexity	• Simple plan and no charging program • Logical budget, no control • No detail period • Oral communication • No risk plan • No meeting	• Primary knowledge of PM; • With elementary ability of PM

The project level project, according to the research and development' the technological innovation, the management, may divide into the project group, and carried on the management by each group.

The project execution graduation is carried out after specific priority, and different projects can be carried out through different program and sequence.

24.4 Integrated Application of PM 6S System

In the project implementation, the 6s system of project management is integrated application (Froese 1992; Zhang and Zhang 2009). 6S is a important link that decides the project management success or failure, also is foundation of Project portfolio management, the project implementation level-to-level administration, and the construction project level-to-level administration frame. Project management 6s system integrated application is shown in Fig. 24.1.

In the project management 6s system, it may divide into following three levels: (1) project decomposition level, including EPS/WBS; (2) resources safeguard level, including OBS/CBS/RBS; (3) knowledge support level, including KMS.

24.5 How to Construct Project Management Classification Frame and Classification Control Model Based on Project Portfolio

On the basis of project level-to-level administration 6S system, we have constructed the project level-to-level administration logical frame which is shown in graph 3: Enterprise project management platform EPS, the department level project management platform (Luiten et al. 1998; Van Der Merwe 2002), the

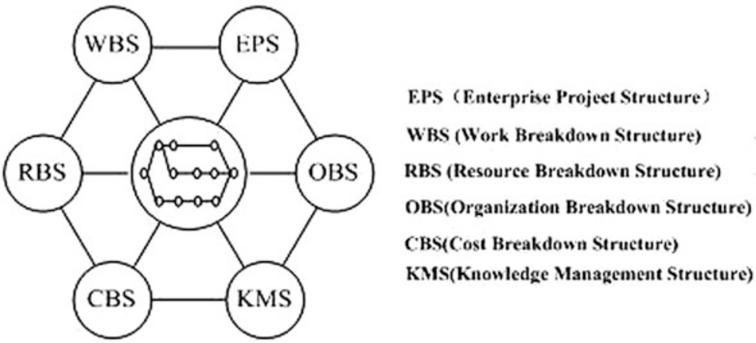

Fig. 24.1 6s-system of project management

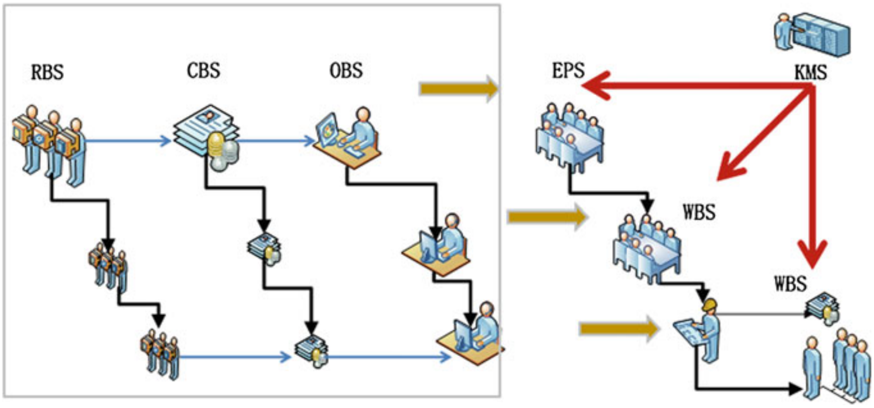

Fig. 24.2 Project classification management frame

project level project management platform. The project of different platform is different in the resources disposition, the cost management, aspects and so on risk guard.

In Fig. 24.2, the enterprise project, according to the importance, the strategic characteristic, should equip with the manpower, the financial resource, and the material resources sufficiently. Simultaneously it should be carried on the strict cost, the progress, the quality control. In the project implementation, knowledge management system (KMS) is necessary to manage the documents material, the project material of the project entire life cycle, for document accumulation may provide the reference for the enterprise similar project execution, and may save certain cost.

According to the department level project characteristic and the important level, it should dispose the corresponding personnel resources reasonably, and should have certain risk consciousness (Ward and Chapman 1995). The department level project management also is a very important level in three level frame based on 6s.

As to unimportant project, because of its multitude, low important level, we may reduce suitably in resource investment. Of course it should not do harm to the enterprise project and department project.

Figure 24.2 has given merely project level-to-level administration logical frame based on the 6s, where as Chart 4 shows the concrete control pattern of different kinds of project.

It can be seen from Fig. 24.3: classification control pattern emphasizes the resources coordination assignment in the enterprise level on the basis of many projects, and solves project implementation control management question of different project ranks. As to enterprise driven by projects, the former in fact is project portfolio management on the basis of project optimal appraisal, the latter is the project execution management based on project level to level management. Both organic syntheses will realize the complete process from the project portfolio management to the enterprise project strategy management (Yan et al. 2000), thus

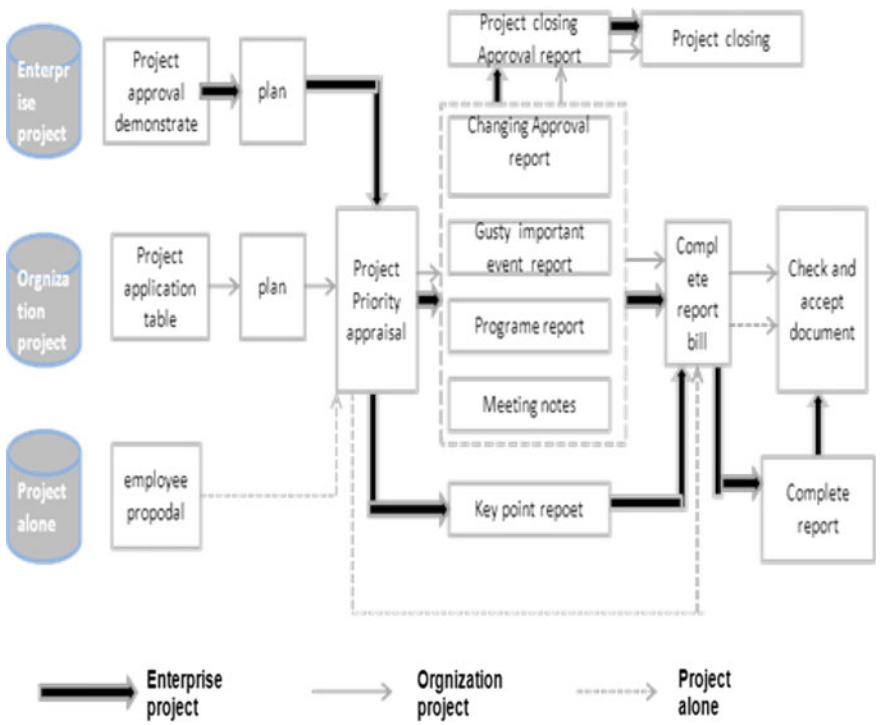

Fig. 24.3 Project classification control model

has also solved the problem: enterprise strategy executive ability insufficient, and will be advantageous to enterprise's strategic implementation.

The author believed that, the level-to-level administration frame and the control pattern is necessary to solve above questions. Therefore, the enterprise should adopts the different management and the control pattern to the different rank project, according to its condition, its cope and the complex degree, the project management scope and the content, as well as project management essential factor reasonable.

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Chapter 25
Product Material Combination Image Method Based on GEP

Ke Su and Sheng-li Kong

Abstract Materials are the stuff of design. From the very beginning of human history, materials have been taken from the natural world and shaped, modified, and adapted for everything from primitive tools to modern electronics. Aiming at the need for product material combination, this study presents a product material combination decision-making method based on Gene Expression Programming (GEP). The semantics differential method is utilized to extract user image, multidimensional scaling is utilized to select cognitive samples. GEP was utilized to construct the image and the material models. Finally, implementation of this proposed method is demonstrated high stability via a seat case.

Keywords GEP · Image · Material combination · Product design

25.1 Introduction

In the new century, the market has highly competition, and is simultaneously affected in globalization, localization, and individualization. Traditionally black-boxed designing model can't match what the consumers require, exactly and effectively, not mentioning the numerous chooses in the present. Mass customization relates to the ability to provide customized products or services through flexible processes in high volumes and at reasonably low costs. The concept has emerged in the late 1980s and may be viewed as a natural follow up to processes that have become increasingly flexible and optimized regarding quality and costs. In addition, mass customization appears as an alternative to differentiate companies in a highly competitive and segmented market. Therefore, the designers' responsibilities are for the choices of appropriated use, suitable size, the favorable

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E. Qi et al. (eds.), *The 19th International Conference on Industrial Engineering and Engineering Management*, DOI: 10.1007/978-3-642-38391-5_25,

texture, the satisfactory style, and right message transformation in products. Let products fit in human and let users conduct products designing. Then they are really product that consumers really need.

Many scholars have done researches on product image research (Hsiao and Tsai 2004; Tsai et al. 2006; Xu et al. 2007; Liu et al. 2009; Kejun et al. 2008, 2009; Chen 2008; Nagamachi 1995; Su and Li 2005). Hsiao used gray theory and back-propagation neural network for the color image evaluation of children's walker; Tsai used fuzzy neural network and gray theory for electronic locks color image evaluation; Xu used genetic algorithms to build images and product modeling optimization model. The above study focused mainly on the relationship between product image and modeling and color, but is rarely involved product material. In this paper, based on the GEP, the relationship between image and semantic are constructed by quantification I. GEP was utilized to construct the image and the material models. Finally, implementation of this proposed method is demonstrated high stability.

25.2 An Overview of Gene Expression Programming

The flowchart of a gene expression algorithm (GEA) is shown in Fig. 25.1 (Ferreira 2001). The process begins with the random generation of the chromosomes of the initial population. Then the chromosomes are expressed and the fitness of each individual is evaluated. The individuals are then selected according to fitness to reproduce with modification, leaving progeny with new traits. The individuals of this new generation are, in their turn, subjected to the same developmental process: expression of the genomes, confrontation of the selection environment, and reproduction with modification. The process is repeated for a certain number of generations or until a solution has been found.

Note that reproduction includes not only replication but also the action of genetic operators capable of creating genetic diversity. During replication, the genome is copied and transmitted to the next generation. Obviously, replication alone cannot introduce variation: only with the action of the remaining operators is genetic variation introduced into the population. These operators randomly select the chromosomes to be modified. Thus, in GEP, a chromosome might be modified by one or several operators at a time or not be modified at all.

25.3 Material Image Decision-Making Model Based on GEP

Gene expression programming (GEP) is, like genetic algorithms (GAs) and genetic programming (GP), a genetic algorithm as it uses populations of individuals, selects them according to fitness, and introduces genetic variation using one or

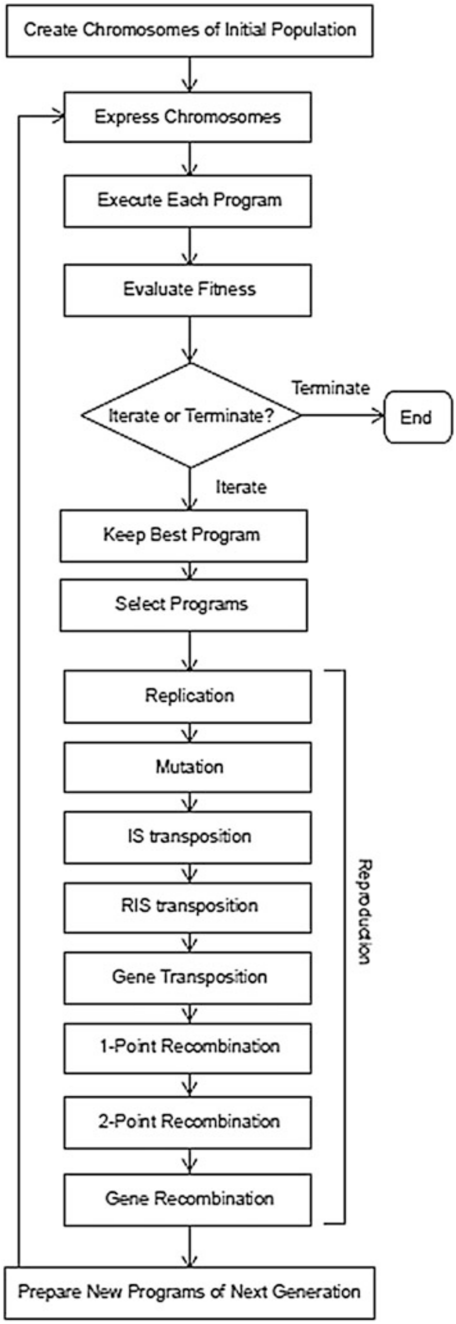

Fig. 25.1 The flowchart of gene expression algorithm

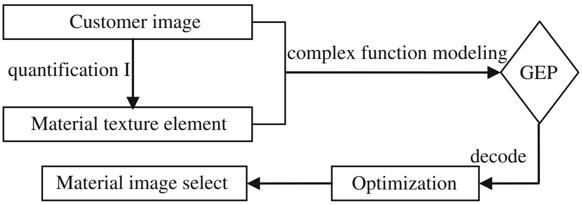

Fig. 25.2 Framework of the image material based on GEP

more genetic operators. The core technology of GEP is separated the assessment and the variation process completely (Ferreira 2001). Its variation process uses fixed-length linear string symbols; assessment process uses ET (Expression Tree), line with the overall image and the constituent element of the distribution mechanism, thus suitable for this study. The image of the material based on GEP research framework shown in Fig. 25.2.

Based on the overall image and the constituent element, function set F = {'+', '−', '*', '/', 'S', 'C', 'Q', 'e', 'ln', 'pow', 'abs'}. S is sine function, in is Natural logarithm function, pow is Power function, abs is absolute value function.

End set T = {constitute element}, can be expressed as T = {x1, x2, x3,..., xn}. x1, x2, x3,..., xn is the parameter set.

In the experiment, if population size is N, according to reference documentation (Ferreira 2001), then fitness function is:

$$f_{fitness} = 1000 \times \frac{1}{E+1} \tag{25.1}$$

The equation above:

$$E = \frac{1}{m}\sum_{j=1}^{m}(F(x) - F_j)^2$$

is mean square error of the experimental sample, m is the total number of training set samples, $F(x)$ is mathematical expression based on GEP, F_j is jth training set output observations. Gene encoding with the relevant parameters which affects the overall image and construct an initial population, calculate the fitness value of population by Eq. 25.1, use the principle of survival of the fittest to guide the evolution of populations.

25.3.1 Complex Functions Modeling

GEP complex functions modeling includes the following steps:

In this study, author selected parameters from F and T randomly, and selected parameters as a locus. After the completion of this operation we will get a population of individuals. Repeating times of individual coding, the initialization of population will complete. Figure 25.3 is a gene A with length 13, head length of

Fig. 25.3 Gene A with length of 13

1	2	3	4	5	6	7	8	9	10	11	12	13
S	+	+	*	/	+	x_4	x_5	x_1	x_2	x_3	x_4	x_5

gene A is 6, tail length of gene A is 7. Suppose A is the initial population of genes. Set functions F = {S,+,−,*,/,e}.x1, x2, x3, x4, x5 belong to end set T, to represent the proportion of metal, plastic, wood, leather, fabric of product respectively.

In accordance with the GEP tree composition rules, gene A expression tree shown in Fig. 25.4 (13th gene is discarded):

According to the rules of the expression tree (Su and Li 2005), we get Eq. (25.2), that is $F(x)$:

$$F(x) = \sin(x_1/x_2 + x_3 + x_4 + x_4x_5) \tag{25.2}$$

Fitness solution: parameters are evaluated by Eq. 25.2, the value obtained is evaluated by Eq. 25.1, repeated N times, and all the individual fitness values will appear. The best fitness value individual is the best one, then algorithm terminates. Otherwise, enter the evolutionary steps: generate a new population.

Generate a new population: generate new populations of genetic manipulation, including variations, restructuring, insert string, etc. Suppose gene A was chosen to undergo gene mutation, *function change into +function, obvious, the corresponding expression tree may be changed, read the expression tree to get the mathematical expression is:

$$F(x) = \sin(x_1/x_2 + x_3 + x_4 + x_4 + x_5) \tag{25.3}$$

25.3.2 The Statistical Results

In this study, authors use the mean square error (S^2) and correlation coefficent (R^2) to test the validity and predictive power of algorithms. S^2 calculated as:

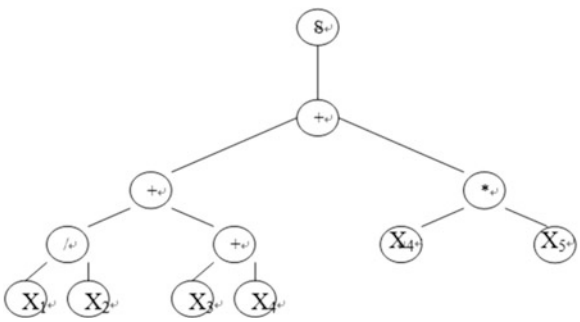

Fig. 25.4 Gene A expression tree

$$S^2 = \frac{1}{n}\sum_{1}^{n}(P_{(ij)} - T_j)^2 \tag{25.4}$$

$P_{(ij)}$ is predictive value of individual j in population i, T_j is the observations of individual j.

R^2 calculated as:

$$R^2 = \frac{Cov(T, P)}{\sigma_t \cdot \sigma_p} \tag{25.5}$$

Above the equation, $Cov(T, P)$ is covariance, σ_t and σ_p are the standard deviation respectively.

25.4 Experimental Verification

In order to rule out other factors influenced the image experiment, simple form product should be used as a subjects. In this paper, we select high-speed train seat to illustrate the effectiveness of the method.

25.4.1 Product Image Vocabulary Collection and Screening

The vocabularies were described by a questionnaire, and we get 30 words. After that, factor analysis extracted vocabulary according to principle of "the factor eigenvalue must be greater than 1 and greater than 85 % of the total contribution rate", the words semantic compose of seven image vocabulary: popular, practical, simple, simple, refined, elegant, creative (Fig. 25.5).

Fig. 25.5 Product image sample

25.4.2 Elements of the Material Sample

According to the research of Jian (2002) and Ke (1997), we selected five common material: wood, leather, metal, plastic, fabric. The 120 subjects (20 designers and 100 consumers) in this study taken part in the research (100 sets of data is training data, 20 sets of data is test data) viewed the virtual images with 144 material combinations and evaluated their value on a 100 mm measuring scale. The extreme left side of the measuring scale represented ''exceedingly disagree'' and the extreme right represented ''exceedingly acceptance''. After the assessment process is completed, the scores are transferred into quantified values between 0 and 1.

25.4.3 GEP Experimental Data Processing

The sample data corresponding to each word was selected for testing. For example: Select the data corresponding to "public" participate in this experiment. There are five data collection parameters. The property name is shown in Table 25.1.

25.4.4 Experimental Data Processing

In the experiment, the extracted parameters are shown in the Table 25.2 GEP:

In the experiment, we used C++, 2.80G Intel Core Duo CPU, 4G RAM, the best individual mathematical expression is

$$\begin{aligned} F(X) = {} & \sin\sin(-9.932985) + \frac{x_5 \times (x_2 - x_5)}{7.256194 \times x_5 + 2x_2} \\ & + \cos x_8 + \sin(x_3 - 21.864838) - x_5 + x_4 + \frac{x_2 - x_1}{x_3} \\ & + x_5 - x_2 + \sin(x_1 - \cos(-7.34278) + \mathrm{x}_5) \\ & \times x_3 \cdot \sin\sin(x_1 + x_4) - x_4 \\ & + \frac{x_2 - x_4}{1/2 \times (x_5 + x_3 + x_2 + x_4 - x_1)} \end{aligned}$$

Table 25.1 Paraments property

Parameter name	Parameter description
X1	The proportion of metal
X2	The proportion of plastic
X3	The proportion of wood
X4	The proportion of leather
X5	The proportion of fabric

Table 25.2 GEP Parameter set modeling

Parameter name	Parameter values
Termination of algebra and population size	1000,1000
Set of functions	$F = \{+, -, \times, \div, \sin, \cos\}$
End set	$T = \{x_1, x_2, x_3, x_4, x_5\}$
The number of genes and gene head length	5,15
Additional field Dc length and code range	16,(−10,10)
Genetic connection	+
Mutation rate	0.044
Single point, two points recombination rate	0.2
Gene recombination rate	0.05
IS, RIS, Gene transposition rate	0.05
IS, RIS number of translocation element	1, 2, 3

From the experimental results, MSE and CC of $F(X)$ is 0.0385.

25.4.5 Experimental Verification

In order to verify the validity of this method, check the 20 experimental data in the original model. MSE and CC of $F(X)$ is 0.0517, 0.9431. The mean-square error and correlation coefficients of the GEP material image model is ideal. In addition, experiments also showed that GEP algorithm had high efficiency, the total time for running 100 times is only 3521 s, and 94 times gained sub-optimal solution which close to the optimal solution.

25.5 Conclusion

Product customization employs virtual images to allow consumers to choose product material via the Internet/Intranet recently. After choosing different material combinations, consumers often become confused and are unable to choose material with more selections. This study presented a design decision-making support model for customized product material combination. This decision-making support model composed of the GEP approach and the image compositing technique that can be used to create a virtual image support system for product customization, allowing consumers to choose their preferred product style and weight to the image words according to their own preferences, and then consumers can clarify which product material and impressions they prefer. Also, the design decision-making support model of this study can be extended to other products or industries. It can also be used in any customization problems where a hierarchy of decisions needs to be made to extract appropriate list of choices.

Acknowledgments This work is supported by the fundamental research funds for the central universities project (2010QNA5042); Nation natural science foundation, China (No. 61070075, 61004116, 61002147, 61003147); Zhejiang major science and technology projects (2011C14018); Wenzhou Science and technology project (H20100042).

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Chapter 26
D2-Index: A Dynamic Index Method for Querying XML and Semi-Structured Data

Yin Zhang, Hua Zhou, Zhi-hong Liang, Jun-hui Liu, Yun Liao, Peng Duan and Zhen-li He

Abstract To facilitate queries over XML and semi-structured data, various structural indexes acting as a structural summary have been proposed. Structural index is derived directly from the data and serve as indices for evaluating path expressions on XML and semi-structured data. We propose D2-Index: a path-based dynamic index method for querying XML and semi-structured data. D2-Index is prefix-based and based on the concept of ORDPATH and BSC. It uses binary fraction to encode and can be completely capable of static encoding. More importantly, it can insert nodes into any position efficiently without re-encoding the existing indexes. According to the experimental results, it shows that the query plans using D2-Index is feasibility, accuracy and efficiency.

Keywords Prefix-based · Semi-structured data · Structural index · XML

26.1 Introduction

With the growing importance of XML (eXtensible Markup Language) and semi-structured data in information storage, exchange and query, much research has been done to provide query mechanisms to extract information from XML and semi-structured data. XML is an example of semi-structured data which are different

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E. Qi et al. (eds.), *The 19th International Conference on Industrial Engineering and Engineering Management*, DOI: 10.1007/978-3-642-38391-5_26,

from traditional data models, such as relational or object-oriented models. Instead, the underlying data model of semi-structured data is a labeled graph (Chen et al. 2003), and XML is more like a tree (Cohen et al. 2002). In this paper, it discusses XML as an example of semi-structured data. Generally, XML data is stored in documents separately, or in relational databases or native XML databases. No matter how to be stored, a structural index of an XML data can not only provide efficient insertion but also support extremely high-performance query plans.

Several query languages, including XPath (Clark and De Rose 1999) and XQuery (Chamberlin 2007), have been proposed for querying semi-structured XML data. However, these languages based on path expression extract data by traversing, but their consumptions are too large clearly. We would like to build a structural index to speed up the evaluation process. Usually, each node of an XML data is assigned a unique index, which can be used to identify the relation between any nodes and get the structural information. An efficient XML index method should have the following two characteristics:

- The index method should support structural queries directly (Wang et al. 2003a). It can quickly find the XML node by path or other structural expression.
- The index structure should allow dynamic data insertion, deletion, update, etc. (Wang et al. 2003a). When the XML data is updated dynamically, and the existing structural index does not need change.

In this paper, it proposes a new index method called D2-Index, which is prefix-based. This method not only supports dynamic update but also quick and efficient queries of XML data.

26.2 Related Work

Existing XML index methods can be divided into two categories. One is region-based, and the other one is prefix-based. The early research of XML index method is mostly region-based, which has been unable to solve the problem of dynamic update. Therefore, it has been gradually replaced by prefix-based (Wu et al. 2003).

According to the tree structure of XML data, prefix-based index encodes each node with two parts, prefix and layer ID (Amagasa et al. 2003; Wang et al. 2003b). The prefix is the code of parent node, and the layer ID is the unique identifier of each node which is different from other sibling nodes. DewyIDs (Duong and Zhang 2005) and ORDPATHs (O'Neil et al. 2004), are prefix-based and used widely. And both of them reserve code range for insertion to avoid re-encoding other sibling nodes and their children when inserting a new node. However, when the nodes inserted are too much, the code range reserved cannot meet demand and re-encoding is still inevitable. DLN (Bohnle and Rahm 2004) solves this problem by variable encoding. DLN defines layers with fixed-length binary string, and creatively defines layer separator, which avoids re-encoding effectively. Yet its encoding is complex and no flexible. BSC (Wang et al. 2008) presents an encoding by using binary fraction, which is indeed effective to avoid re-encoding. However, the binary representation of BSC has limitations, because it needs to introduce parameters to encode and decode.

Based on the above methods, this paper proposes a new dynamic index method for XML data, called D2-Index (Divide by 2-Index). The method completely avoids re-encoding, and it is able to represent with binary.

26.3 Fundamental D2-Index Concepts

In D2-Index, the binary code of each complete index consists of three parts: a unique identifier including several layer IDs, the offset of the node in the XML data, and the length of the node. Figure 26.1 shows the composition of the code for each node in D2-Index.

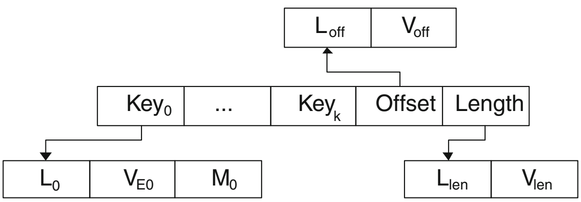
The most important component of the binary encoding in Fig. 26.1 is pairs of variables and their lengths. L defines the length in bits of the succeeding variable V bitstring, which is familiar with ORDPATH. This encoding has the following important properties (O'Neil et al. 2004): (1) we know where an L starts and we can identify where it stops, (2) each L bitstring specifies the length in bits of the succeeding V bitstring, (3) from the two properties above, we see how to parse the code bitstrings.

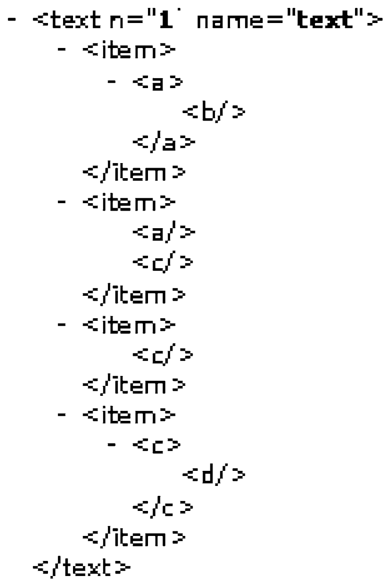
D2-Index uses binary fraction to encode layer IDs, which is different from ORDPATH. The binary storage of fraction generally references the standard of IEEE, which makes presentation easily but is not flexible and usually encodes useless bits because it defines a fraction with a certain length in bits. Thus we propose a new encoding in this chapter, which can accurately represent a fraction in relatively short bits.

26.3.1 Motivating Example

In D2-Index, the initial value of each layer ID is $\frac{1}{2}$, and each node's layer ID is the previous sibling one's divided by 2. That is the reason why it is called D2-Index. For instance, Fig. 26.3 shows the structural index of the XML data in Fig. 26.2 through D2-Index. It illustrates the results with tree structure in order to make it easier to be understood.

Fig. 26.1 Composition of the code for each node in D2-Index





```
- <text n="1" name="text">
  - <item>
    - <a>
        <b/>
      </a>
    </item>
  - <item>
      <a/>
      <c/>
    </item>
  - <item>
      <c/>
    </item>
  - <item>
    - <c>
        <d/>
      </c>
    </item>
  </text>
```

Fig. 26.2 Sample XML data

26.3.2 Detail Encoding Design

In general, the encoding of index without offset and length (If not described specially, the following text will be the same) should follow the principles as follows:

- Uniqueness: Different node has different code.
- Orderly: The order of nodes’ appearance in the XML data should be reflected in encoding.

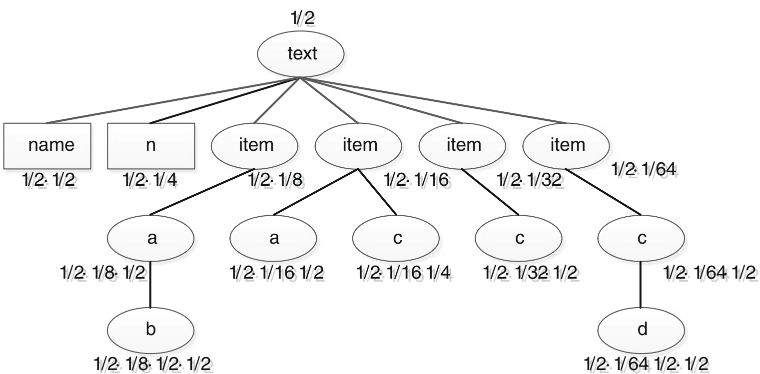


Fig. 26.3 Index tree for XML data of Fig. 26.2

- Practicality: The process of index encoding and decoding should be practical and simple.

The most important part of D2-Index is binary fraction presentation for the layer ID of each node in the XML data. In order to reduce the code length, we propose a variable-length encoding based on the IEEE standard of fraction storage, and it meets all the requirements above. In the specification of the IEEE, a fraction is stored with its binary scientific notation, and it consists of three parts: Sign, Exponent and Mantissa.

In D2-Index, all the fractions are between 0 and 1, so Sign can be omitted. And Exponent can be represented by Variable/Length pairs as ORDPATH. The most difficult part is how to store Mantissa. It cannot be stored in fixed-length bits because that makes the code length is too large, and contain a lot of useless bits. Moreover, we cannot represent it with Variable/Length pairs because of the particularity of Mantissa. For example, there are two binary fractions 0.11 and 0.101. Obviously, 0.11 is bigger than 0.101. The length of 11 is 2 and 101 is 3, and this presentation makes 0.101 is bigger than 0.11 because length is the prefix of variable.

Therefore, we propose a new presentation, which encodes Mantissa scalability in bit that 10 defines 1 and 01 defines 0. Exponent is presented with Variable/Length pairs, so we can know where Mantissa starts. And the succeeding bitstring is an L of another Variable/Length pair. Then if L starts with 00 or 11, it will be distinguished with Mantissa. In addition, the integer part of binary scientific notation is always 1 and it has only 1 bit, so we encode it together with Mantissa in order to reduce the complexity of encoding and decoding.

It is obvious that L must match the Fano condition that no code is prefix of another code. In Table 26.1, it describes the prefix encoding schemes for L bitstrings in D2-Index. The L bitstring 110 defines a component Variable/Length encoding with assigned length $L = 3$, indicating a 3-bit V bitstring. The following V bitstrings (000–111) represent V value of the first eight integers (0–7). Thus, 110110 is the bitstring for D2-Index "6". In the next row in Table 26.1, bitstring 10100 identifies an encoding with $L = 4$, and the 4-bit V bitstrings that follow represent the range [8,23]; in particular, $V = 8$ is represented by bitstring 0000, 9 by bitstring 0001, …, up to 23 by bitstring 1111. Similarly, V in the rage [−8,−1] is associated with the L bitstring 011, with −8 represented by the lowest bitstring 000 and −1 represented by the highest bitstring 111.

Example 26.1 Using L values of Table 26.1, we would generate "$\frac{1}{2} \cdot \frac{3}{4} \cdot \frac{3}{8}$" in Table 26.2.

We can directly compare D2-Index values without decoding, and it will be elaborated in the next section.

Table 26.1 Lengths L with V ranges represented

Bitstring	L	Value range
01000010	64	[−18447025552981299544,−281479271747929]
01000011	48	[−281479271747928,−4295037273]
0100010	32	[−4295037272,−69977]
0100011	16	[−69976,−4441]
010010	12	[−4440,−345]
010011	8	[−344,−89]
01010	6	[−88,−25]
01011	4	[−24,−9]
011	3	[−8,−1]
100	3	[0,7]
10100	4	[8,23]
10101	6	[24,87]
101100	8	[88,343]
101101	12	[344,4439]
1011100	16	[4440,69975]
1011101	32	[69976,4295037271]
10111100	48	[4295037272,281479271747927]
10111101	64	[281479271747928,18447025552981299543]

Table 26.2 The result of Example 26.1 after generating

$\frac{1}{2}$			$\frac{3}{4}$			$\frac{3}{8}$		
1×2^{-1}			1.1×2^{-1}			1.1×2^{-2}		
001	111	10	001	111	1010	001	110	1010
$L_0 = 3$	$V_{E0} = -1$	$M_0 = 1$	$L_1 = 3$	$V_{E1} = -1$	$M_1 = 11$	$L_2 = 3$	$V_{E2} = -2$	$M_2 = 11$

26.3.3 Comparing D2-Index Values

In the previous section, it mentioned that the order of nodes' appearance in the XML data should be reflected in encoding. In other words, we can know the order and relative position of nodes in the XML data by comparing the encoding values. In Table 26.3, it lists several encoding values and their binary representation. From top to bottom it is the order of nodes' appearance in the XML data, the document order.

Then we examine whether the results of comparing encoding values in bits yielding the document order from the aspects as follows:

- Comparing ancestor-offspring nodes (as 1 and 2): It shows that the parent's code is the prefix of the child's, and the child's bitstring starts with 00. Obviously, we can know that the order of parent is before their child with their bitstring.
- Comparing sibling nodes (as 1 and 5), non-sibling nodes with the same depth (as 2 and 4), and non-ancestor-offspring node with different depth (as 1 and 4): When comparing sibling nodes, there are two cases. One case is that the lengths

Table 26.3 Sample encoding values and their binary representation in document order

Order	Key code	Bitstring
1	$\frac{3}{4}$	001 111 1010
2	$\frac{3}{4} \cdot \frac{1}{2}$	001 111 1010 001 111 10
3	$\frac{1}{2}$	001 111 10
4	$\frac{1}{2} \cdot \frac{1}{2}$	001 111 10 001 111 10
5	$\frac{3}{8}$	001 110 1010
6	$\frac{5}{16}$	001 110 100110
7	$\frac{1}{8}$	001 101 10

of their bitstrings are equal, such as node 1 and 5. In this case, the simple bitstrings or byte by byte comparison yields document order, and the larger one is former. The other case is that the lengths of their bitstrings are not equal, such as node 1 and 3. In this case, we compare their bitstring in the shorter length, and the larger one is former, such as node 3 and 5. But if the comparison result is equal, the one with longer bitstring will be former, such as node 1 and 3.

In summary, the comparisons in the latter three cases are the same. Furthermore, the nodes with the equal length of bitstring can be compared directly. If not equal, they will be compared in the shorter length. If the comparison result is not equal, the larger one will be former. Else we will check the rest of the node with longer bitstring. If the rest part of its bitstring starts with 00, it will be the other one's parent (or ancestor) and it will be former. Otherwise, it is latter than the other one in document order.

Clearly, in D2-Index method, the index values decrease when the document order increasing, which complies with the principle of orderly.

26.3.4 Arbitrary D2-Index Insertions

According to the position, D2-Index insertion can be divided into three cases: leftmost of the siblings, rightmost of the siblings and between two siblings. With different position, the encoding of insertion is different. It describes the specific encoding process of inserted layer ID in Algorithm 26.1.

Algorithm 26.1 The Insertion Layer ID Encoding Algorithm

Input The layer ID of the node on the left side of inserted position, left, and the layer ID of the node on the right side of inserted position, right.

Output The layer ID of inserted node, insertion.

1. If left does not exist (it means the inserted position is at leftmost of the siblings);

Table 26.4 The result after insertion in Example 26.2

Key code	Bitstring
$\frac{1}{2}\cdot\frac{7}{8}$	001 111 10 001 111 101010
$\frac{1}{2}\cdot\frac{3}{4}$	001 111 10 001 111 1010
$\frac{1}{2}\cdot\frac{5}{8}$	001 111 10 001 111 100110
$\frac{1}{2}\cdot\frac{1}{2}$	001 111 10 001 111 10
$\frac{1}{2}\cdot\frac{1}{4}$	001 111 10 001 110 10

- Insertion := (right + 1)/2;

2. Else if right does not exist (it means the inserted position is at rightmost of the siblings);

- Insertion := left/2;

3. Else (it means the inserted position is between the two siblings);

- Insertion := (left + right)/2;

Example 26.2 It assumes that "$\frac{1}{2}\cdot\frac{3}{4}$" and "$\frac{1}{2}\cdot\frac{1}{2}$" are two existing sibling nodes, and there are three nodes need to insert at the leftmost, rightmost of them and between them. In Table 26.4, it shows the results after insertion.

We can see the indexes after insertion still yield document order as before. In addition, all the codes are unique and their lengths are variable, so insertion will not affect the existing node has been encoded.

26.4 D2-Index Query Plans

26.4.1 Secondary Indexes

In the previous chapter, we discuss the primary indexes. In practical we need prove the query plans with secondary indexes. There are two of the important secondary indexes as follows (O'Neil et al. 2004):

- Element and Attribute TAG index, supporting fast look up of elements and attributes by name.
- Element and Attribute VALUE index.

In this chapter we discuss another secondary index called PATH index. Actually it is familiar with TAG index. The difference between them is that TAG index is based on the node's tag, but PATH index is based on the path which consists of all the nodes' tags from root to itself. In D2-Index, every different path has a separate storage space to store all the nodes' primary index keys, not the whole index, with such a path.

26.4.2 Query Plans

XPath (XML Path Language) is a language for selecting and processing parts of an XML document, and it is published by W3C. In D2-Index, we use XPath to express the path of the query plans, and get the results from the XML data with the collection of their primary index keys found by secondary index (He and Yang 2004). The basic steps of query plans are as follows:

1. Enter a query expression.
2. Find the secondary index and get the collection of primary index keys.
3. According to the keys, obtain the offsets and lengths of the nodes.
4. Get the results.

26.5 Experiment

In this section we present results of testing D2-Index, evaluating three aspects: encoding length, index size and query efficiency. Table 26.5 shows the detailed information of the main XML data in the experiments, which are from XML Data Repository (http://www.cs.washington.edu/research/xmldatasets/).

In Table 26.6, it shows the average and maximum length (bit) of D2-Index, the size of all index files including primary and secondary index, and the expansion ratio compared with their source files.

Table 26.5 Detailed information of the main XML data in the experiments

File Name	File size	Elements	Attributes	Max-depth	Avg-depth
reed	277 K	10546	0	4	3.19979
sigmodRecord	467 K	11526	3737	6	5.14107
nasa	23.8 M	476646	56317	8	5.58314
treebank_e	82 M	2437666	1	36	7.87279
SwissProt	109 M	2977031	2189859	5	3.55671
dblp	127 M	24032673	6102230	6	2.90228

Table 26.6 Indexes size and expansion ratio of D2-Index

File name	Avg-length	Max-length	Index size	Expansion ratio
reed	36.36	47	200 K	0.72
SigmodRecord	60.53	75	384 K	0.82
nasa	59.41	87	11.6 M	0.49
treebank_e	79.58	305	293 M	3.57
SwissProt	51.08	74	100 M	0.92
dblp	53.9	81	75.5 M	0.59

Table 26.7 The time consumption of the query plans by D2-Index

XPath	Results	Time (s)
/dblp/book/@key	845	15.7
/dblp/article/title/sub/sup/i	1	28.5
/dblp/book[300]	1	19.1

We can see that the encoding length and expansion ratio of D2-Index are not directly related to the number of nodes in XML data, but its depth. As the depth increases, the encoding length shows a clear upward trend. Moreover, the size of index files is affected by the depth more than the size of XML data.

In Table 26.7, it shows the time consumption of the query plans with three XPath expressions to the XML document DBLP by D2-Index, and the query results are consistent with XQuery (Goldberg 2009).

26.6 Conclusion and Outlook

In this paper, it proposes D2-Index: a path-based dynamic index method for querying XML and semi-structured data. It uses binary fraction to encode and can be completely capable of static encoding. More importantly, it can insert nodes into any position efficiently without re-encoding the existing indexes. According to the experimental results, it shows that the query plans using D2-Index is feasibility, accuracy and efficiency.

As for the future work, the research will focus on lexical analysis of both English and Chinese, which can be used to create Elements and Attributes VALUE index and full-text index.

Acknowledgments This work is funded by the Open Foundation of Key Laboratory of Software Engineering of Yunnan Province under Grant No. 2011SE13, A Study on XML-based Adaptable-Event-Driven Integrated Software Framework of Yunnan Science Foundation under Grant No. 2009CD009, and the Postgraduates Science Foundation of Yunnan University under Grant No. YNUY201131.

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Chapter 27
Data Preprocessing in Web Usage Mining

Xiang-ying Li

Abstract At present, the study on Web Usage Mining mainly focuses on pattern discovery (including Association Rules, sequence pattern, etc) and pattern analysis. However, the study on the main data sources, that is to say, the study on web-log pre-process is relatively rare. Given that high-quality data helps a lot in improving Pattern mining precision, this paper studies from this aspects, and proposes the high-effective data preprocessing method.

Keywords Client identification · Date cleaning · Path completion · Web usage mining

27.1 Introduction

The main data resource of Web Usage Mining is web log, from which we can know the browsing behaviors of clients. Based on the browsing behaviors of clients (Shao 2009), we can (1) modify the corresponding web link; (2) get to know the interested points of clients, and provide personalized pages for them; (3) subdivide the clients, carry out different promotion strategies for different customers aiming to improve (ROI) return on investment; (4) find out clients' clicks on ads, based on which modify the ads setup (Cooley 1997a).

Data preprocessing is the first part in Web Usage Mining. Whether the data preprocessing is good or bad will directly influence the effect of the following links (Zhao 2003; Wu 2002), such as Association Rules mining, Sequence Pattern discovery and the categorical and clustering of clients and so on.

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E. Qi et al. (eds.), *The 19th International Conference on Industrial Engineering and Engineering Management*, DOI: 10.1007/978-3-642-38391-5_27,

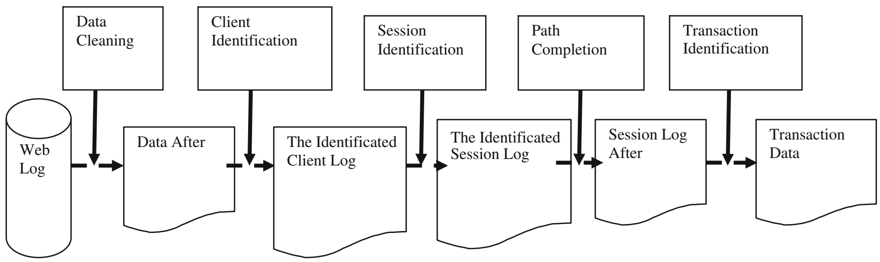

Fig. 27.1 Mining process of web use

In a word, Data Preprocessing can greatly improve the quality of Data Mining and shorten the time needed in practical Data Mining. Web Usage Mining, whose object is mainly web log, is even more affected by Data Preprocessing, for web log, different from the traditional well-structured data base or data from Data Warehouse, is semi-structured. In addition, the incomplete data in web log lead by all kinds of reasons, and the purpose of Web Usage Mining (Liu 2007a; Zhang 2006; Liu 2007b), which is unlike that of transaction data mining, require log files to be preprocessed before mining, converting the log files to format easy to mining and laying foundation for improving the accuracy and effectiveness of final pattern mining. As the Fig. 27.1 shows that it is a complete process of Web Usage Mining. And the paper pays attention to the module of Data Preprocessing, of which several steps, Data Cleaning, Identify Clients, Session Identification and Path Completion are included, as shown in Fig. 27.1.

27.2 Data Preprocessing

27.2.1 Data Cleaning

The task of Data Cleaning is to delete data unrelated to mining, such as pictures of GIF, JPEG and jpg format. These pictures are in WebPages in large numbers, when clients visit WebPages, pictures and cartoons exist in log files as independent records. For most mining task, they can be ignored (of course, we have to reconsider if the websites is special for pictures). Though deleing these records contributes nothing to improve mining effect (Wang 2000; Liu 2003; Tang 2002; Xu 2003; Ji 2009), it can decrease the data to be processed afterwards, improve processing rate and reduce the effect of invalid data upon mining process. The experimental data adopted is a week's logs files (2012\3\1–2012\3\7) from http://my.sdyu.edu.cn/, in all 132 M bytes. Before Data Cleaning, there are 1,274,051 records. After Data Cleaning as the above method, 336,741 records are left. Thus we can see that this step can greatly reduce the data to be processed later, and improve the processing rate.

27.2.2 Clients Identification

Clients' identification is to identify from logs files which clients visit the website and each client visits what web pages.

The clients registered are easy to be identified. However, many clients unregistered surf the internet by web proxy server or several clients share one computer, and the existing of firewall and a client using different browsers, all these add difficulties to client identification. Certainly we can confirm the visiting clients by Cookies, but taken personal privacy into consideration, Cookies are forbidden by many clients' browsers.

How to distinguish many visiting clients using the same computers? Some ideas are to detect whether we can directly visit the page from the page we have visited last time by topology map in websites (Pirolli 1996), if we can't, it is probably that many clients use one computer, and then we can identify clients by Client Session Automatic Generation Technique based on Navigation Patterns (Cooley 1997b).

Considered that the two methods above can only partly solve the problem of clients' uncertainty, the paper proposes an algorithm—Client and Session Identification Algorithm (CSIA). This algorithm takes comprehensive consideration, and combines Client_IP, topology diagram in websites, the browsers version and Referer_Page to identify individual clients, with good accuracy and expansibility. Meanwhile, the algorithm—CSIA also can complete the task of Session Identification, the specific content of the algorithm will be given in Session Identification part, and the paper will first proposes the definition of client as followed:

Definition 1 Clientsi = <Client_ID, Client_IP, Client_URL, Client_Time, Client_RefPage, Client_Agent > , $0 < i < n$, n represents the total numbers of clients, Client_ID is the identification of clients identification and Client_IP, Client_URL, Client_Time, Client_RefPage, Client_Agent respectively stands for the IP address of clients, the pages visiting, the time of visiting pages, the pages visited and operating system clients used and the version of browsers, from which the unique client is confirmed.

27.2.3 Session Identification

The time scan of a log file is different, from 1 day, one week–one month etc. In such a long time, a client can not visit a website only for one time, so how to distinguish client's access record left by one—time visit or many times visits? And this involves the problem of Session Identification. A session is time serials of URLs in the process that the client visits a webpage. The relative definition is given as followed:

Definition 2 The definition of $Sessions_i$: $Sessions_i = \langle ClientID, S_j, [refpage_{j1}, refpage_{j2}, \ldots\ldots refpage_{jk}] \rangle$, $0 < i < n$, n represents the total numbers of sessions, ClientID is the identification identified in the process of clients identification,

S_j refers to the j session of the client, $refpage_{jk}$ is the assemble of Refpages-the visited pages in session.

The most simple and most commonly used way to distinguish two different sessions of one client is to set a timeout, usually 30 min. If the request time interval for two web pages exceeds the threshold preset, then the client is thought to begin a new session. Taking 30 min as the timeout has been tested by much practical application, and it is simple and easy to carry out, so the paper adopts this method.

Definition 3 Cube is the saving mode of clients and sessions identified by the algorithm—CSIA. The definition is that Cube = <ClientID, S_j, Client_IP, [$refpage_{j1}(t_{j1})$, $refpage_{j2}(t_{j2})$,……, $refpage_{jk}(t_{jk})$], among them, ClientID, S_j, $refpage_{jk}$ have the same definition as that in first one, and different from definition 2, in definition 3, Client_IP and t_{jk} are added, of which t_{jk} is the page-visiting time.

The thought of algorithm:

A large number of continuous record fragments exist in log files, and each record fragment is from the same Client_IP. If we inspect the record fragments item by item through isExistedIP (Cube) and isSameClient ($Clients_i$), then the running efficiency is dramatically lowered. Therefore the thought of algorithm in this paper is as followed: first judge whether the current record has the same Client_IP as the last one, if they have the same Client_IP, then they are supposed as the same client; or judge whether the client has been identified, the specific judgments are shown in the algorithm below.

This refers to a hypothesis that if the several continuously appeared records is from the same IP address, and then supposes that the continuous records are from the same client. The hypothesis is based on the following two points:

(1) The acceptable client identification accuracy: In order to check the accuracy of client identification under the above hypothesis, we exact 200 record fragments as mentioned above from log files (each continuous fragment is from different IP address). As the hypothesis shows, they are considered as from 200 different clients, however, they are identified as 202 different clients by isExistedIP (Cube) and isSameClient ($Clients_i$) respectively. So it is clear that the above hypothesis has little effect on the accuracy of client identification, and it is acceptable.
(2) The efficiency of algorithm: Adopting the above hypothesis can avoid checking large numbers of records item by item, thus greatly improving the running efficiency of program.

Algorithm: CSIA

Input: log files; TimeSpan

Output: ClientID, Session

(for the specific Algorithm occupies too much space, here proposes the framework in JAVA language limited to space constrains)

```
String [ , ,] Cube;
// Define three-dimensional array, to store Client_ID, the client visiting
Urls sequence (time sequence) and the visiting time for each web page and the
total number of each session visit.
for (Record r∈Log)    // Record Record shows the records in web log, r
represents an individual record;
 {
  if (r.IP<>Last-r.IP)
// The IP address of the current record is not the same as the last one, and
Last-r. IP idicates the last record;
  {
   if ( isExistedIP(Cube)= =false )    // the new Ip address, clients
identified donít have the IPaddress;
        {
// Store Client_ID, Client_IP, r.Url, r.Time of current client information in to
Three-Dimensional Array;
        Client_ID++; //client identification add one;
           SaveCube ( i, j, k, Client_ID, r.IP, r.Url, r.Time );
          }
      else if (isSameClient ( Clients_i, r)==ture )
      // the current client and indentified client in Clientsi is the same
visitor;
       {
           if (r.Time- Cube [i, j, 1]<TimeSpan)
         // If The timespan of two times visiting of web page is less
than the timeout, then it is regarded as the same session;
         {
               j=j+1;
        Cube [i, j, 0]= r.Url;
        Cube [i, j, 1]= r.Time;
           }
           else  // if overtime,then begin a new session;
           {
          Cube[i, 0, 1]=j-2;  //j means the total numbers of web
         pages that client visited last session ;
```

```
                i=i+1;
                k++;
                j=0;   //for the new seesion begins , j is set as 0;
               SaveCube ( i, j, k, Client_ID, r.IP, r.Url, r.Time );
                }
          }
   else   //not the same visitor ;
               {
             Client_ID=Client_ID+1;
             i=i+1;
             SaveCube ( i, j, k, Client_ID, r.IP, r.Url, r.Time );
               }
}
```

else *// the IP address of the current record is not the same as that of the last one ,then suppose that they should be the same visitor;*

```
       {      j=j+1;
          Cube[i, j, 0]= r.Url;
          Cube[i, j, 1]= r.Time;
             }
          }

   public void  isExistedIP ( Cube, r.IP )

   {

     // Search for the Client_List_i that have been identified   definition 3, if the
         IP address exists,then return to ture, or false;
     }
   public void  isSameClient ( Clients_i, r)

   {
```

// take comprehensive consideration onto *Clients$_i$ definition one, to identify whether the current client is the same client as that identified in client-list, if is ,then return to ture, and the exisiting number of session k, or false*

```
   }
```

```
public void SaveCube ( i, j, k, Client_ID, r.IP, r.Url, r.Time )
{
    // Put Client_ID, r.Url, r.Time store Client_ID, r.Url, r.Time into three-dimensional array;
        Cube [i, j, 0]= Client_ID+ì －î + k; // Represents the k session of the same client;
      Cube [i, j＋1, 0]= r.IP;
        Cube [i, j＋2, 0]= r.Url;
      Cube [i, j＋2, 1]= r.Time;
```

The advantages and disadvantages of algorithm:

(1) High accuracy: Overcome the disadvantage of low identification accuracy caused by the traditional way adopting only IP address to identify visitors.
(2) High efficiency: Realize the client identification and session identification; overcome the low efficiency caused by identifying client and session respectively.
(3) Good data store formats: Store the client and session identified into dynamic three-dimensional array construed by CSIA, avoiding the waste of store space, as shown in Fig. 27.2: client-session axis means client and session identified, among them, n is the total number of clients, k is the k session of some client, and different sessions are shown by different Client ID, such as 1-1, 2-1, 3-1, …, n-k, the same client may have several different sessions, such as the client 3 with two sessions 3-1 and 3-2 in Fig. 27.2. IPn is the ip address of the n client. IP-Urls sequence axis shows the sequence of Urls visited by client in an individual session, and the sequence is arranged by time, for example, the Urls of web pages represented by A, B, C, D, E, F… time axis stores the time that client visit some page, for 2012-3-1 10:21:36 is the time that client 1 visits the page A, this contributes to the sequence pattern mining after data preprocessing. The Fig. 27.2 represents client 1 visits seven pages in one individual session. In this way, it is convenient to store the results of client identification and session identification and related useful information, thus laying foundation for further improving the efficiency and accuracy of pattern mining.
(4) Disadvantage: in judging whether the current client and the client identified is the same visitor, many factors must be considered, thus causing the decrease of the operating rate of algorithm. But the analysis of web log file mining is not real-time, so operating rate is not the top factor considered, and it is worthy of weighing identification accuracy and operating rate.

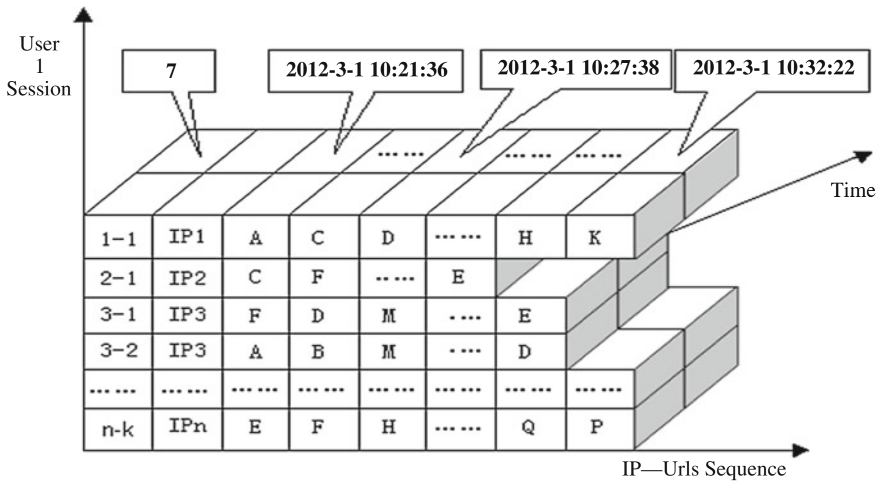

Fig. 27.2 A three- dimensional array data storage

27.2.4 Path Completion

Another important step of pre-processing is Path Completion. The number of URLs those clients browse recorded in web log is less than the actual number those clients browse, because of the page resident in local cache or agent cache in Web Browser, the important information transmitted by Post technique unrecorded in web log and the use of back button in browsing, which also lead to the incomplete of URLs sequence related to client browsing in log files. Therefore to remedy the effect of the question upon pattern mining, path completing is needed.

To avoid this question of the incomplete of access path caused by customers' buffer, we can adopt the HTTP/1.1 agreements that forbid buffering. Though the current website trends to provide dynamic information service, and buffering can not be considered for websites adopted dynamic technique, static HTML page is also applied in website practice, so the treatment of buffering is of great importance for session identification. Meanwhile, only one method can not solve the problem of incomplete access path caused by back button, so some strategies need to take. One strategy is to analyze with the help of topological graph in websites, if the pages visited by uses include the link pointed to the current page, then suppose that request should be sent by the present page (Cooley et al. 1999), so the omitted URLs can be added to the existed path. Though the method can not guarantee the one hundred percent accuracy, it can yet be regarded as an accessible way for it can achieve good effect indicated by experiment.

27.3 Results

Object by a week's log files (2012\3\1–2012\3\7) from http://my.sdyu.edu.cn/, in all 132 M bytes, the log files with 336,741 records remaining after data cleaning, with Athlon (tm) XP 1700+ as test-bed and internal memory 256 M, the test identifies 5,625 clients and 18,536 sessions by CSIA. If only identifies by IP address then only 5,270 be indentified, with 5,625−5,270 = 355 clients being ignored, thus we can see the high client identification accuracy of CSIA. From the view of marketing and customer service, if the 355 clients are clearly indentified, and provide personalized service for each of them, then it may be probable that quite a significant proportion of clients turn to the loyal customers, bring more interests to company.

27.4 Conclusion

The paper pays attention to the data preprocessing module in web usage mining, focusing on the specific realization of preprocessing, and proposes the algorithm CSIA that can better identify client and session simultaneously, with higher identification accuracy than the common identification algorithm. And the paper hopes that the work done can help web usage mining researchers.

At present the study on Web Usage Mining at aboard is abundant, and some universities and research institute at home also have studied on this aspect, but the influential one is not that much. Considering the business value, wide application prospect and the large developing space of its related technique of Web Usage Mining, much more research strength will be put into this area. The focus of research will have more tendencies on the visualization of pattern analysis and analysis results, and man–machine interaction aspect based on the continuous study on pattern discovery.

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Chapter 28
Design Knowledge Reduction Approach Based on Rough Sets of HCI

Qing Xue, Qi-qi Yin, Li-ying Feng and Min-xia Liu

Abstract With the application of high-tech in the battlefield, the battlefield environment became complicated. Whether the weapon is easy to use or not depended on its interface, and determines the success or failure of the war. In order to design weapon display interface and improve the usability of interactive system, an approach to adaption reasoning based on rough sets is proposed. Condition attributions of decision tables in the knowledge systems could be reduced, and it simplified the adaption inference rules and related human-computer interface design knowledge, which could be applied into the design practices easily. And concise friendly adaptive human-computer interface could be designed to improve the efficiency of operations.

Keywords Context · Decision table · Rough set · Weapon display interface

28.1 Introduction

The theory of rough sets was originally proposed by Pawlak as a formal tool for modeling and processing intelligent systems characterized by insufficient and incomplete information (PawIak 1991; PawIak 1982). Its main advantage is that through rough set we can find the connection and characteristics of the data and extract the implied rules without the apriori knowledge and additional information (Zhou and Wu 2011).

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E. Qi et al. (eds.), *The 19th International Conference on Industrial Engineering and Engineering Management*, DOI: 10.1007/978-3-642-38391-5_28,

A domain U and a equivalence relation R of U is given in the rough set, $\forall A \subseteq U$. The upper and downer approximate set of A is:

$$\overline{R}(A) = \{x|[x]_R \cap A \neq \varnothing\}$$
$$\underline{R}(A) = \{x|[x]_R \subseteq A\}$$

If $\overline{R}(A) \neq \underline{R}(A)$, then said that set A is rough set of equivalence relation R in domain U (Li and Cercrone 2005; Miao and Li 2008).

Because of the large quantity of targets, complex cooperation relations and frequent tactical movements in modern wars, it is very difficult to accept an increasing number and types of data, and process them into information of weapon system (Zhang et al. 2003; Pawlak 2002). In order to improve the efficiency of operations and avoid misoperation, concise and friendly interface of multimedia becomes more and more important. But in the design process, weapon context information is complex, changeable and indistinguishable. In this paper, the authors defined the weapon context as follows: context is to decide or influence weapon display control calculation and the information of man-machine interactive process, which may come from users, equipments and systems, the external environment, and other entities. If we establish all interfaces corresponding to all the context knowledge respectively, this will be a very big job (Zhang and Liang 1996; Wang et al. 2006). And there is a lot of information to deal with in the system, which is a complicated constraint-based reasoning process.

At present, the basic methods of uncertain measurement in the rough set theory are (Zhang et al. 2001): Precision, rough membership function, attribute dependency attribute significance, inclusion degree and conditional information entropy etc. Zhang (Cai and Yao 2009) has put forward the concept of inclusion degree as a measurement of rough set data analysis, indicating that every measurement can be concluded as inclusion degree. Beauboude et al. (Dai and Li 2002) introduced a method of measuring the uncertainty of rough set based on information entropy, which is better to reflect and can measure the uncertainty more precisely.

Design knowledge reduction approach based on rough sets of weapon display interface is put forward in this paper.

28.2 Design Knowledge Expression System

We get the knowledge acquisition through the knowledge representation system, and find useful information through analyzing the original data. We should take the original knowledge expression into a new target expression form (easily for computer process). Knowledge discovery based on the rough set theory, mainly use such an effective knowledge expression-information list. The basic elements of information list are the set of samples. Knowledge of samples described through designating properties (characteristics) and their property values (characteristic value) of the samples.

Table 28.1 Part of the decision table

U	C				D Against measure
	Con_1 Target distance (km)	Con_2 Target speed (m/s)	…	Con_m Target type	
X_1	24	500		Cruise missile	D_1
X_2	18	300		Boomer fighter	D_2
X_3	6	280		Tactical missile	D_3
…	…	…		…	
X_n	35	560		Air-to-ground missile	D_t

Through observing the practical operation situation and the use of weapons' interface to get a record form, it can be considered as a knowledge representation system, KRS for short. In the KRS table, row presents research objects; and column presents attribute (Cheng and Sun 2007; Wei et al. 2006). A list can be regarded as a cluster of equivalence relation of attributes' definition, and this kind of list is usually called the decision table.

According to part of the provided data, the decision table has been constructed as shown in Table 28.1:

In Table 28.1, domain $U = \{x_1, x_2, \ldots, x_n\}$ means that there are n contexts and interface mode records; condition attribute set $C = \{Con_1, Con_2, \ldots, Con_m\}$ mean that there are m different weapon equipment contexts, such as presenting target distance, and presenting target speed. Decision attribute set $D = \{UI_1, UI_2, \ldots, UI_t\}$means that there are t different interfaces.

28.2.1 Pretreat the Decision Table

In order to obtain valuable knowledge from the decision table, the original data must be pretreated first. The common pretreatment mainly includes two aspects: totalize the incomplete data and discrete normalize the attribute value (Wei 2006).

28.2.1.1 Totalize the Incomplete Data

The context information of battlefield environment is often incomplete. For example, sensor errors may cause target information lost partly. Therefore, before establishing the decision table, totalize the incomplete data is very necessary. KRS contains incomplete data, taking Table 28.2 as an example. Totalizing the incomplete data method is presented as follows.

Table 28.2 is a KRS which contains incomplete data. It records the context information Con_1, Con_2 and the corresponding interface decision attributes D.

Table 28.2 KRS which contain incomplete data

U	Con_1 Target distance (km)	Con_2 Target speed (m/s)	D Against measure
X_1	15	500	D_1
X_2	25	680	D_2
X_3	10	400	D_3
X_4	3.5		D_4
X_5	6	800	D_5

(1) Elimination method

Delete the row record which has attribute values missing, and get a complete decision table. In Table 28.2, the object X_4 should be deleted. Obviously, this method is very simple, and we use it when in the decision table the incomplete information object number is far less than complete information data; otherwise, we cannot use this method.

(2) Compensation method

For the KRS which contain incomplete data, we use the following approaches to add the missing data and complete the KRS:

(i) According to the actual requirements, take incomplete attribute value as a kind of special value; (ii) Using statistical principle, assess the missing attribute values according to the rest of the record object attribute value. If the missing value is numerical, take the arithmetic mean value of this property in other objects as a supplement; and if the missing value is no-numerical, take the highest frequency value of this property in other objects as the supplement. In Table 28.2, the arithmetic mean value of Con_2 in other objects is $(500 + 680 + 400 + 800)/4 = 595$. We take 595 as a supplement. In addition, there are some other methods of compensation, such as condition combination compensation method, and compensation method based on the indiscernibility relation.

28.2.1.2 Discrete Normalize the Attribute Value

The weapon context information with numerous types, some are numerical while some not, some are continuous while others not, and they have different value confines and measurement units. It is hard to create a decision table with clear structure, if we do not discrete normalize the attribute value. Discrete normalize the attribute value must meet the needs of the two aspects: One hand, the dimension of the attribute value should be reduced. On the other hand, the information loss should be avoided to the greatest extent. There are two ways of discrete normalize the attribute value.

(1) Partial discretization and normalization

In this method, we consider only one attribute in the decision table. As for a continuous attribute a, with its range $[a_{\min}, a_{\max}]$, discrete and normalize mean the generating set of a group, $\{[d_1, d_2], [d_2, d_3], \ldots [d_{n-1}, d_n]\}$ and $d_1 = a_{\min}, d_n = a_{\max}$. When they are in the same range of values, we use $(a_{\max} - a_{\min})/k = (d_2 - d_1) = (d_3 - d_2) = \cdots (d_n - d_{n-1})$ as a division. If the number of the attributes is m, and there are k levels, every sample size of value range is m/k.

(2) Global discretization and normalization

In this method we manipulate all the attributes in the decision table, such as the method based on Boolean logic and rough set theory. Main processes of operation are as follows: the attribute values can be shown by the set and symbolic which are used to represent the gap between contact attribute values; disjunction types are used to represent different decisions; conjunction expressions are used to represent the disjunction types and could be translated into disjunction types; discretization results could be obtained from one of the disjunction types.

28.2.2 Reduce the Decision Table

When we design the weapon human-computer interface, there are many data samples and condition attributes in the decision table. The decision table is very complex, and it is hard to find the implied knowledge from the data. The reduction process of decision table is deleting the redundant data, reducing condition attribute dimensionality and reducing the sample size.

In the actual battlefield, the situation of the battlefield is diversity and uncertainty. Sometimes, we got the same sample information, but we made different decisions; so it is an inconsistent decision table. When we process the inconsistent decision table, we usually transfer it into a consistent table. The reduction method is as follows:

(1) Firstly, merge the repeat record and reserve the inconsistent part;

(2) Secondly, simplify the condition attributes. Delete every condition attribute in turn, if the table changed into inconsistent, the attribute cannot be reduced, or it can be reduced;

(3) Thirdly, simplify the decision rule. On the basis of above, delete an attribute for every decision rule. If the table changed into inconsistent, the attribute cannot be reduced, or it can be reduced. Then get the core value table of decision;

(4) Finally, according to the core value table generated the simplest decision table. That is to say, if we delete some core value, the decision rule is the same with others, so it is the simplest decision table.

The core part of above method is, specific algorithm of reducing attribute, and it is shown as follows (Meng et al. 2008):

Algorithm: The algorithm of reducing attributes

Input: condition set $C = \{a_i | i = 1, 2, \ldots, n\}$, and decision set D;

Output: the minimum reduction decision table.

Let $B = CORE_D(C), A = C - CORE_D(C)$.

Step1. [Is $|B| = 0$?], if $|B| = 0$, $RED_D(C) = C$ and exit; else, calculate and go to Step4.

Step2. For each a_iÎ A, calculate $k_{B\text{È}\{a_i\}}(D)$

Step3. For a_iÎ A, satisfied $k_{B\text{È}\{i\}}(D) = \min\left(k_{B\text{È}\{i\}}(D)\right)$; $A = A - \{a_i\}, B = B \cup \{a_j\}$

Step4. If $((k_B(D)) = k_C(D)$, then $RED_D(C) = B$; else go to step2.

Through reducing the decision table, we get a more simple decision rule. Not only reducing redundant data, but also improving the decision efficiency obviously. It can help to establish a simple expression from context space to interface design space. Using this method can realize the adaptive interfaces easily.

28.3 The Design of a Weapon Defense Interface

The rapid development of modern optoelectronic technology, greatly promotes the military photoelectron technology to be mature and perfect. In military applications, the photoelectric precision technology and photoelectric detection technology develop extensively and rapidly. Currently it became a more perfect equipment system (Mi and Li 2009). This example is the generation of optoelectronic countermeasure interface in different battlefield situation. The condition attributes are target distance a_1 (km), target type a_2, target speed a_3 (m/s), and route shortcut a_4 (km); and decision attributes d, which are different interfaces with different optoelectronic countermeasures. In this example the decision attribute d are information apperceive 1, laser alarm 2, laser countermeasure 3, smoke set 4, and optical camouflage 5.

According to the provided data, construct the original decision table as shown in Table 28.3.

28.3.1 Attribute Discredited

Before establishing the final decision table, the original decision table should be discredited. In this paper, due to the attributes have different nature, we use local discrete method and adopt experts subjective designed to discrete the attributes. Discrete standards are provided by application unit shown in Table 28.4.

Table 28.3 Original decision table

Sample no.	a_1	a_2	a_3	a_4	d
1	24	Helicopter	380	20	1
2	16	Cruise missile	560	13	2
3	6	Helicopter	360	5	3
4	2	Cruise missile	540	1	2
5	15	Tactical missile	1200	16	2
6	25	Boomer fighter	760	22	1
7	0.06	Air-to-ground missile	460	0.05	4
8	12	Helicopter	340	8	2
9	30	Boomer fighter	660	15	1
10	0.9	Air-to-ground missile	740	0.7	4
11	18	Air-to-ground missile	800	14	2
12	0.05	Cruise missile	700	0.02	5
13	5	Air-to-ground missile	350	18	1
14	3	Helicopter	320	1	4
15	8	Tactical missile	780	7	3
16	26	Boomer fighter	680	15	2
17	0.08	Air-to-ground missile	460	0.06	5
18	7	Tactical missile	1000	5	3
19	5	Tactical missile	750	2	4
20	8	Cruise missile	720	6	3
21	17	Boomer fighter	780	12	2

Table 28.4 Discrete standards

	1	2	3	4	5
A_1	Above 10	5–10	0–5		
A_2	Helicopter	Boomer fighter	Cruise missile	Air-to-ground missile	Tactical missile
A_3	0–250	250–500	500–750	750–1000	Above 1000
A_4	Above 15	7–15	0–7		

In Table 28.4, A_1 represents target distance, A_2 represents target type, A_3 represents target speed, A_4 represents route shortcut. The decision table after discrete is shown in Table 28.5.

28.3.2 Reduction the Decision Table

Given that the condition set of decision table is $C = \{a_1, a_2, a_3, a_4\}$, and decision attribute set is $D = \{d\}$. Let the initial attribute core is $\mathrm{CORED}(C) =$. From the decision table, we get that $U/C = \{\{X_1\}, \{X_2\}, \{X_3\}, \{X_4\}, \{X_5\}, \{X_6\}, \{X_7\}, \{X_8\}.\{X_9, X_{16}\}, \{X_{10}\}, \{X_{11}\}, \{X_{12}\}, \{X_{13}\}, \{X_{14}\}, \{X_{15}\}, \{X_{17}\}, \{X_{18}\}, \{X_{19}\}, \{X_{20}\}, \{X_{21}\}\}$, and $U/D = \{\{X_1, X_6, X_9, X_{13}\}, \{X_2, X_4, X_5, X_8, X_{11}, X_{16}, X_{21}\},$

Table 28.5 The decision table after desecrating

Sample no.	a_1	a_2	a_3	a_4	d
1	5	1	2	1	1
2	4	3	3	2	2
3	3	1	2	3	3
4	2	3	3	3	2
5	4	5	5	1	2
6	5	2	4	1	1
7	2	4	2	3	4
8	4	1	2	2	2
9	5	2	3	2	1
10	2	4	3	2	4
11	4	4	4	2	2
12	1	3	3	3	5
13	5	4	2	1	1
14	2	1	2	3	4
15	3	5	4	2	3
16	5	2	3	2	2
17	1	4	2	3	5
18	3	5	5	3	3
19	2	5	3	2	4
20	3	3	3	3	3
21	4	2	4	2	2

Table 28.6 The decision table after reducing

Sample no.	a_1	a_3	a_4	d
1	5	2	1	1
2	4	3	2	2
3	3	2	3	3
4	2	3	3	2
5	4	5	1	2
6	5	4	1	1
7	2	2	3	4
8	4	2	2	2
9	5	3	2	1
10	2	3	2	4
11	4	4	2	2
12	1	3	3	5
13	5	2	1	1
14	2	2	3	4
15	3	4	2	3
16	5	3	2	2
17	1	2	3	5
18	3	5	3	3
19	2	3	2	4
20	3	3	3	3
21	4	4	2	2

Table 28.7 The minimum reduction decision table

Sample no.	a_1	a_3	a_4	d
1,13,6				1
2,5,8,11,21	4			2
3,15,18,20	3			3
4	2		3	2
7,14	2	2		4
9	5	3	2	1
10,19	2		2	4
12,17	1			5
16	5	3	2	2

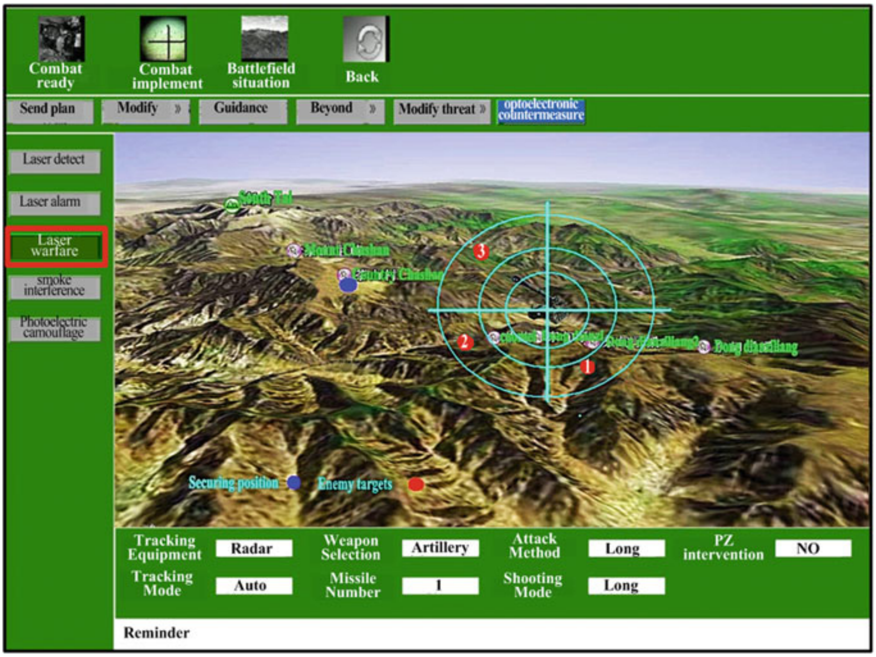

Fig. 28.1 Adaptive human-computer interface of weapon system

$\{X_3, X_{15}, X_{18}, X_{20}\}, \{X_7, X_{10}, X_{14}, X_{19}\}, \{X_{12}, X_{17}\}\}$. According to the algorithm, we get, $POS(C, D) = \{\{X_1\}, \{X_2\}, \{X_3\}, \{X_4\}, \{X_5\}, \{X_6\}, \{X_7\}, \{X_8\}, \{X_9\}, \{X_{10}\}, \{X_{11}\}, \{X_{12}\}, .\{X_{13}\}, \{X_{14}\}, \{X_{15}\}, \{X_{16}\}, \{X_{17}\}, \{X_{18}\}, \{X_{19}\}, \{X_{20}\}, \{X_{21}\}\}, k_C(D) = 19/21$. So the decision Table 28.5 is inconsistent. And we get that inconsistent of decision table is because sample X_9 and sample X_{16} have the same condition attributes but different decision attributes. After remove a_1, get $k_{C-\{a_1\}}(D) = 11/2^1 \neq k_C(D)$, so cannot be remove. That is to say, a_1I CORED(C). Similarly, we can obtain the dependency of other condition attributes to the decision attribute D, $k_{C-\{a_2\}}(D) = 15/2^1 \neq k_C(D)$, $k_{C-\{a_3\}}(D) = 19/21$, $k_{C-\{a_4\}}(D) = 19/21$. Minimum attribute reduction set is $\{a_1, a_3, a_4\}$. Table 28.6 shows the decision table after reducing.

Similar attribute reduction, remove the decision table redundant condition attribute value, and with the same rules, finally obtained such as the minimum reduction decision table shown in Table 28.7.

The reduced decision table made the task context and optoelectronic countermeasure form decision knowledge simply. Then we reasoned and simplified the design rules. In addition, these rules more simplified than the original records.

28.3.3 Example

Weapons systems require a good real-time and stability, so we choose VxWorks as the system platform, and use WindML development tools to develop weapon system interface. We have got the reduction decision table above, and made the goal situation and photoelectric form decision knowledge simplified. The adaptive interface for against measures can be obtained according to the sensed actual context and decision reasoning rules. It is shown in Fig. 28.1.

28.4 Conclusion

In this paper, we used rough sets to reduce conditional attributions of decision tables' in the knowledge systems. Also we extracted key attributes from a lot of original data and established simple expression from context space to interface design space. The adaptive interfaces realized easily using this method.

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Chapter 29
Diagnostic Testing and Analysis of CAN Data Bus Based on the Sagitar Power Transmission System

Wen Fang

Abstract Based on the Sagitar power system of CAN data bus, analysis of a power transmission system network structure, elaborated the power system of CAN data bus termination resistor working principle and test method. Diagnostic testing by the BOSCH FSA740 standard engine analyzer, a power system CAN data bus circuit breaker, CAN_H and CAN_L data between the wire short circuit, CAN data bus to the positive or negative electrode short-circuit diagnostic testing and analysis.

Keywords CAN · Data bus · Diagnosis · Testing · Power transmission system

29.1 Introduction

Through the network can satisfy the people to the modern vehicle driving safety, comfort, emission performance and fuel consumption growing demand, reducing wire and connector number reduces the required space and the weight of a vehicle. But the automobile network application for repair and technical personnel raised taller requirement, is the current automotive electrical network repair of a problem.

Automobile network structure for various manufacturers varies, generally divided into a power transmission system, comfortable and infotainment systems, combination of instruments and diagnostic interface system, each system data exchange through CAN data bus. Wiper motor, light and rain sensor and anti-theft alarm device assembly using the LIN data bus. Due to the adoption of the central diagnosis interface or gateway, so the CAN data and the LIN data can be cross-border data exchange. In this chapter, based on the FAW-Volkswagen power of

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E. Qi et al. (eds.), *The 19th International Conference on Industrial Engineering and Engineering Management*, DOI: 10.1007/978-3-642-38391-5_29,

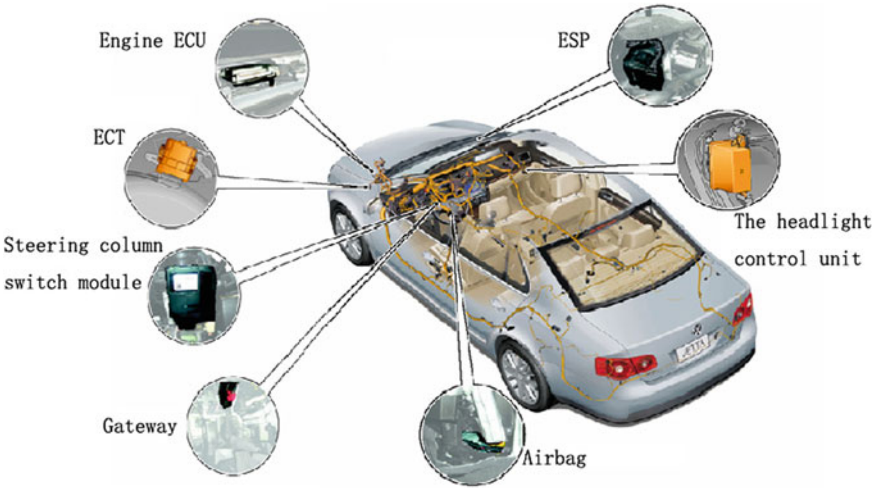

Fig. 29.1 Sagitar power system network structure

CAN data bus, through a vehicle network diagnostic test for repair, technical staff to provide a good reference.

29.2 Network Structure of Power Transmission System

Power CAN data bus sub-system includes engine management system control unit, automatic transmission, with EDS ABS, steering column electronic device, illumination distance adjusting device and airbag. The data transmission rate of 500 kbit/s, each control unit receives information by CAN data bus continuously from the other control unit, and immediately on power system working condition changes, for real-time bus. The data bus of short circuit or open circuit causes the bus off (Fig. 29.1).

29.3 The Principle and Detection of Power System CAN Data Bus Terminal Resistance

29.3.1 The Principle of Power System CAN Data Bus Terminal Resistance

For the CAN data bus signal, bus wire end is equivalent to the role of independent transmitter, so at the end of wire will produce reverse operation of the signal, the signal is superimposed on the effective signal will cause the distortion, must be in the high frequency bus network end termination abort signal, which might otherwise occur reflection. The process of reflection and crashed into a dock embankment, then reflection and with follow-up wave superposition is similar, terminal resistance effect is like sand, if the wave washed onto the beach, the beach will absorb the energy of waves and causing no wave superposition. So the data bus to be connected to a terminal resistor termination data transmission, absorption signal operation to the data wire end when the energy.

High speed bus connects the CAN physical interface typically uses the standard ISO11898. This standard stipulated the transmission medium for a two bus lines, two terminal resistances are provided for 120 ohm. But not all manufacturers are using the standard ISO11898, in the Sagitar power transmission system on the CAN data bus, the data wire end without installing the standard two 120 ohm resistor. But the engine management system control unit of resistance of 66 ohm resistor to assume a central, power transmission system bus remaining on the control unit has a high resistance, each of the resistance for 2.6 k ohms. Because the control system of the resistance is connected in parallel, so according to the following way of calculating the load resistance of the total resistance value:

$$\mathrm{R}_{ges} = \frac{1}{R1} + \frac{1}{R2} + \frac{1}{R3} + \frac{1}{R4} = \frac{1}{2600} + \frac{1}{2600} + \frac{1}{2600} + \frac{1}{66} = 61.35\,\Omega$$

29.3.2 The Detection of Power System CAN Data Bus Terminal Resistance

In the system can use the resistance measuring device for short and open fault diagnosis. As the power transmission system of CAN data bus through a bus terminal 15 is switched on and in short-term continue operation after shut down completely, so it will be in the interval after the time, allowed pull off the control unit plug, check the CAN_H and CAN_L data between the wire resistance. If the resistance value is greater than 250 ohms, show that the engine control unit of a data conductor circuit; if the resistance value is less than 30 ohm, show that the data wires may exist between short circuit; if the CAN_L or CAN_H data wire and a grounding between measured resistance value is less than 300 ohm, then the negative short circuit (Fig. 29.2).

29.4 Power Transmission System CAN Data Bus Diagnosis Test and Analysis

When the automobile multiplex system for information transmission link (or communication lines) have a fault occurs, the communications line short circuit,

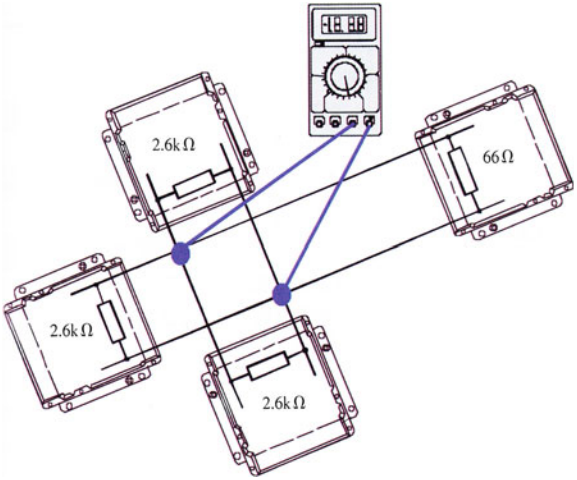

Fig. 29.2 The Sagitar power system CAN data bus termination resistor connection

broken circuit and circuit physical nature of the communication signal attenuation or distortion, will cause multiple electronic control unit not working or electronic control system error action. Power transmission system CAN data bus failures that may occur with the power transmission system of CAN data bus circuit, CAN_H and CAN_L data between the wire short circuit, CAN data bus to the positive or negative electrode short circuit. Through the BOSCH FSA740 standard engine analyzer diagnostic test, observation different of data communication signal and standard communication data signal.

29.4.1 Power Transmission System CAN Data Bus Normal Waveform Test

From the oscillogram, CAN_H signal, the CAN_L signal, signals are under the symmetrical arrangement. Level from dominant to recessive state switching state without interference. CAN_H and CAN_L signal recessive level is 2.5 V, dominant state CAN_H signal voltage value is about 3.5 V, CAN_L signal voltage value is about 1.5 V. According to the bus load, these values may be vary in the hundreds of millivolt range. Voltage signal curve depends largely on the use of oscilloscope. The general rule is: the higher resolution, signal display more clearly (Fig. 29.3).

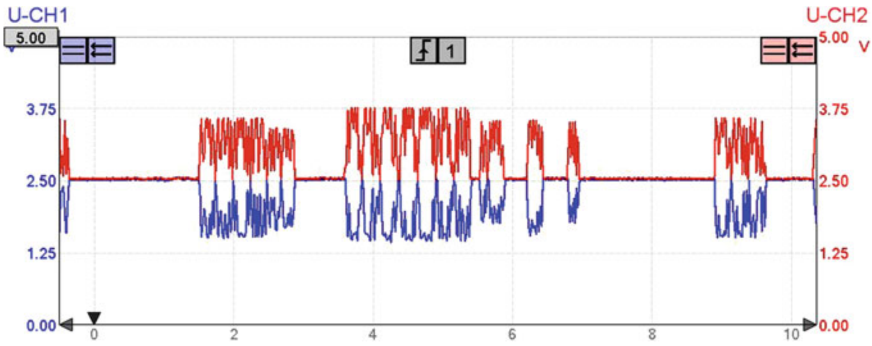

Fig. 29.3 Normal system oscillogram

29.4.2 Power Transmission System CAN Data Bus Circuit Breaker Waveform Test

29.4.2.1 CAN_L Wire Breaker

Oscilloscope preferably using two channel and measurement data wire signal voltage to ground for diagnosis, can be more easily analyzed voltage level and fault diagnosis. Relative measurement data wire on the voltage signal display the voltage difference. From the oscilloscope, CAN_H and CAN_L signal level are 2.5 V recessive dominant state CAN_H signal voltage value of about 3.5 V, is normal waveform; the voltage of the CAN_L signal values of approximately 3 V, is abnormal waveform. Thus can judge CAN_L wire circuit breaker (Fig. 29.4).

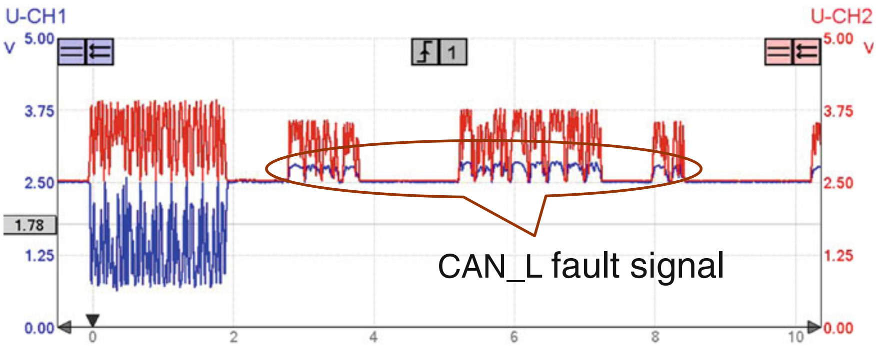

Fig. 29.4 CAN-L wire breaker oscillogram

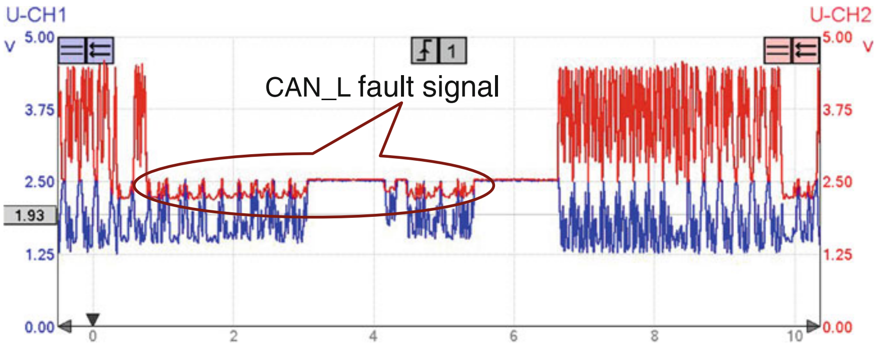

Fig. 29.5 CAN-H wire breaker oscillogram

29.4.2.2 CAN_H Wire Breaker

From the oscilloscope, CAN_H and CAN_L signal level are 2.5 V recessive. Dominant state CAN_H signals voltage value of about 2.3 V is abnormal waveform; the voltages of the CAN_L signal values of approximately 1.5 V, is normal waveform. Thus CAN_H wire circuit breaker can be judged (Fig. 29.5).

29.4.3 Power Transmission System CAN Data Bus: On the Positive or Negative Electrode Short Circuit

29.4.3.1 CAN_L Short Circuit to Negative or Positive Electrode

CAN_L line voltage is 0 V if the CAN_L data wire short circuit to ground. CAN_H wire recessive level becomes 0.2 V from about 2.5 V, at the same time the voltage level becomes the dominant state from the recessive state; if the CAN_L data wire short circuit to positive electrode, and the engine is shut off and the connection without contact resistance, CAN_L signal voltage level is increased to the voltage value 12 V (Fig. 29.6 is about 11.75 V), while in the data wires cannot be observed changes from the recessive state level to the dominant state (Fig. 29.7).

29.4.3.2 CAN_H Short Circuit to Negative or Positive Electrode

The oscilloscope must be observed two data wires without voltage signal if CAN_H data wire on the negative short. CAN_H data wire voltage level becomes 0 V, CAN_L becomes 0.2 V wire level; if the CAN_H data wire short circuit to positive, CAN_H signal voltage level is increased to the voltage value 12 V when the engine is shut off and the connection without contact resistance, at the same

Fig. 29.6 CAN_L short circuit to negative electrode

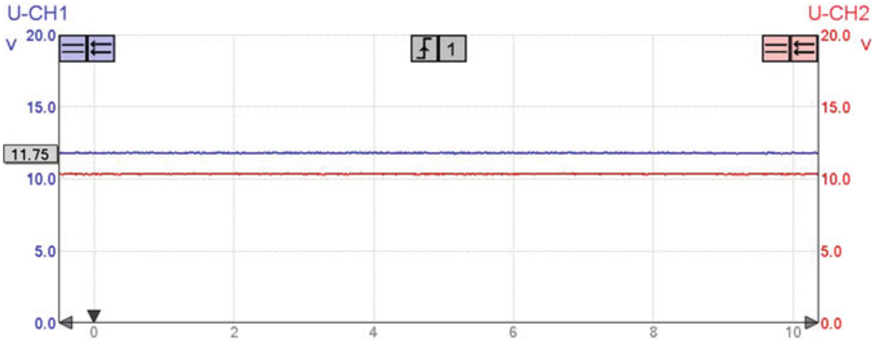

Fig. 29.7 CAN_L short circuit to positive electrode

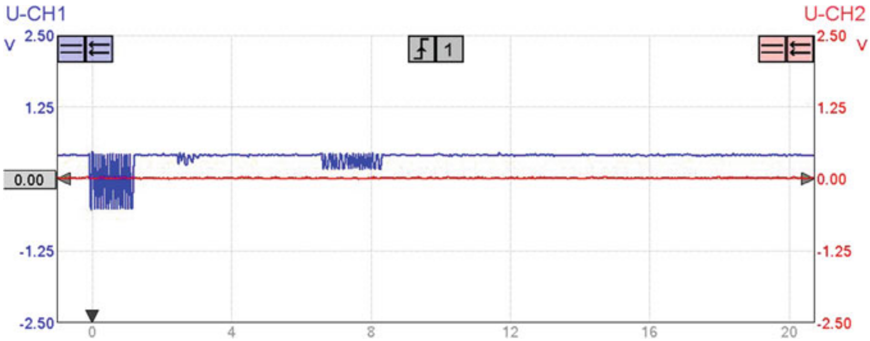

Fig. 29.8 CAN_H short circuit to negative electrode

time in the two data wires cannot be observed changes from the recessive state level to the dominant state (Figs. 29.8 and 29.9).

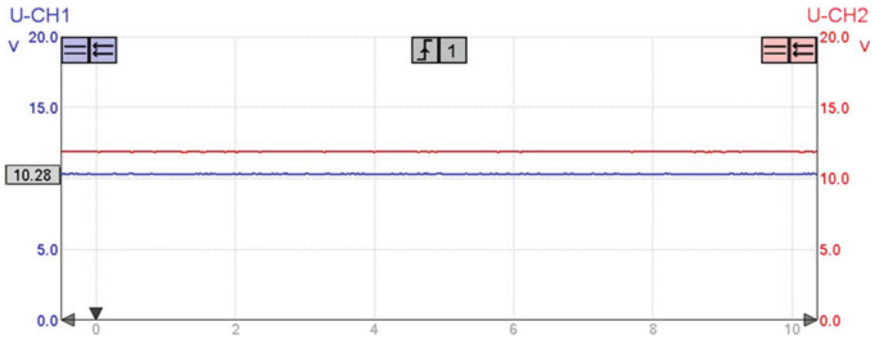

Fig. 29.9 CAN_H short circuit to positive electrode

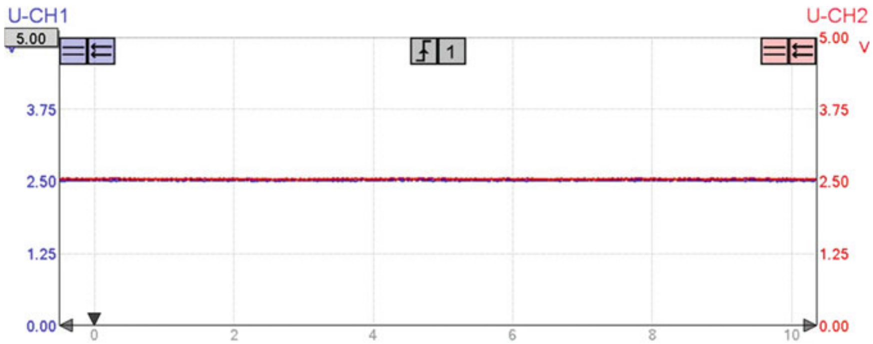

Fig. 29.10 Between CAN_H and CAN_L data wires short circuit oscillogram

29.4.4 Between CAN_H And CAN_L Data Wires Short Circuit

Oscillogram shows two voltage signals overlap each other and curves of the same if data wires are connected to short circuit each other. The two signal voltages are 2.5 V approximately (Fig. 29.10).

29.5 Conclusion

CAN bus (multiplex transmission system) is one of the most promising buses; its application field is constantly expanding. Multiplex transmission system has incomparable advantages to the traditional automobile wiring. Because high technology content, there are still some fault can not accurately find and eliminate via the test equipment. Automobile repair and technical personnel must be find fault by the systematic analysis of multiplex network basic structure and signal transmission principle, the flexible application of multiplex transmission network specific diagnostic methods, multi-path transmission network diagnostic test, find out the multiplex network structure inherent laws.

Chapter 30
Effectiveness to Driving by Interbeds in Channel Sand of River Delta System

Lun Zhao, Shu-qin Wang, Zi-fei Fan, Lei Zhang and Ben-wei Li

Abstract Heterogeneity of remaining oil distribution makes it difficult to recover. This paper analysed the interbed in the channel sand which is the one of the main factors to form remaining oil, and simulated respectively water and polymer flooding for channel sand with all kinds of interbeds, and then nailed down the affect to the distribution of remaining oil by different driving means. Horizontal interbed which developed mainly in the braided channel and straight distributary channel would obstruct the fluid during flowing vertically, and the remaining oil congregates under the horizontal interbed. Polymer driving can accelerate the moving of most remaining oil, but it is unconspicuous for the one under the interbed. Lateral interbed which mainly deposit in the meandering and low curving distributary river would shelter from sideway markedly. The degree of this effect is based on the relation of directions of interbed and driving.

Keywords River Delta System · Channel sand interbed · Polymer driving

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E. Qi et al. (eds.), *The 19th International Conference on Industrial Engineering and Engineering Management*, DOI: 10.1007/978-3-642-38391-5_30,

30.1 Introduction

In China, the Mesozoic and Cenozoic basins of continental sediments are widespread with rivers and developed sands.

The river-deltaic sandstone dominates the continental basins. It is ascertained that in China the majority of oil reserves are located in the river-delta deposition system. Songliao Basin is China's largest continental depression-type basin of oil and gas with the typical dual-structure featured by lower rifting and upper depression. Before the early Cretaceous Denglouku it is the depression evolution stage of the basin. The Quantou Period-Neijiang Period marks the evolution stage of depression (Liu et al. 2010), in which the formation of oil and gas at the middle and lower part of Daqing Placanticline is a large river-delta depositional system of depression sediments. The channel sand is the main part of oil and gas reserves. It is found through the study of depositional mechanism of channel sand and during the oil field development process that, channel sands are not homogeneous connection (Wang et al. 2009). Changes in various factors like hydropower conditions, provenance supply and climate lead to the extensive heterogeneity (Sun et al. 2008) within the channel sand; particularly the prevalence of impermeable interbed affects the laws of fluid flow.

The knowledge of interbed of channel sands and genesis and the analysis of driving effects of various flooding means are particularly important for the development of oil fields.

In recent years, there is a growing research of interbeds. Jiao Hongbing once mentioned in the "Influences of Interbed Distribution of Meandering River on the Development Effective Driven by Water" that: factors like interbed dip angle, spaces and the ratio of interbed depth to reservoir depth. As the dip angle (3–15°) is increased, the rate of recovery driven by water is also increased and the 7–15 folds is a moderate growth; the increased interbed space (10–40 m) and the recovery driven by water exhibits a nearly linear rise; H interbed/H oil layer (0–2/3) is increased and the recovery driven by water is lowered. After the comprhesive collection of distribution features of all kinds of channel sands in Daqing Oilfield, a study of types, genesis of the channel sand interbed and their influences on the driving effects of various driving means.

30.2 Type and Genesis of Interbeds

Daqing Placanticline Puyi Formation is a well-shaped river-delta deposition, developed with flood plain, distributary plain, delta-front facies (Fig. 30.1) from north to south and various fluvial facies sands like braided river, meandering river and straight distributary (Zhang et al. 2009). The channel interbed consists of two categories: horizontal interbed and lateral interbed.

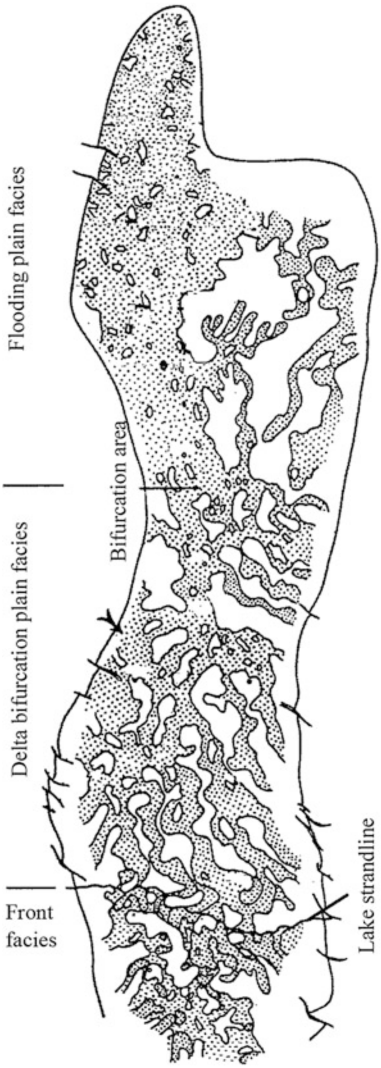

Fig. 30.1 Distribution of unit channel sand, Daqing Placanticline PI23 (study on the "Detailed Reservoir Sedimentolog of Songliao Basin", authored by Zhao Hanqing modified)

30.2.1 Horizontal Interbed

Horizontal interbeds mainly are located in braided rivers of oilfields like Lamadian and Saertu, low-bend distributary channel of oil fields like Xingshugang and straight distributary channel. There are two major genetic types: (1) due to changes in the hydropower condition or provenance supply during the deposition process, interbeds are formed among sandy laminae reservoir of fluvial facies, including the muddy intercalation and conglomerate interbed cemented by muds; (2) interbed arising from physical and chemical effects during the diagenesis of sediments. Such interbed is mainly calcareous (Yu et al. 2010). In addition, there is a marked difference in the lithology of sediments, the upper and lower part of reservoir. Because the vertical accretion of the suspended sediment featured by fine lithology, small depth, extensive distribution and wide scope, are capable of forming an vertically upward impermeable shelter (Li et al. 2009) during the crest concussion process in the flood event of braided river.

30.2.2 Lateral Interbeds

Lateral interbeds are mainly developed in the meandering rivers of oils fields like Shaertu and Xingshugang. Under the action of lateral interbeds, each flood forms a lateral accretion. An argillaceous layer can be formed during the dry season and interflood period between two floods (Zhang et al. 2008). The oblique crossing of lateral accretion with the formation boundary and of overlaying argillaceous layer with the formation boundary form the argillaceous lateral interbed in the channel. Generally, the argillaceous lateral interbed is only developed at the upper and middle part of point bar, thus forming a "semi-connection" featured by the connected bottom, disconnected upper and middle portions of the point bar of meandering river.

30.3 Impacts of Horizontal Interbeds on Different Means of Driving Effects

30.3.1 Mechanism of the Horizontal Interbed Affecting Infiltrating Fluid

The presence of horizontal interbeds affects the flow of reservoir fluids and changes the distribution of entire field of infiltrating fluid (Wang and Zeng 2008). The higher the development frequency of interbeds, the more complex distribution of oil and water movement. The development of a large number of unstable interbeds reduces the sinking speed and gravity action of injected water along the moving direction for the sand bed of fining upwards sands, favorable for the vertical swept volume and and oil driving efficiency; but for coarsening upward sands, it prevents the the effect of gravity sinkage on the swept volume during the water driving oil process. The fining upwards sands without interbeds are greater than the those with interbeds in the flooded intensities. The flooded intervals of the bottom appears earlier. While the unstable interbeds of the coarse upward sands reduces the oil scavenging cofficients and oil driving efficiency of gravity in the coarse upward sands. It is of severe implications on the development effects. The longer or more interbeds, the worse development effects. It mainly lies in that the oil driving efficiency near the lower part of interbeds is far less than other regions. The dead oil area is formed during the latter stage of high water content.

30.3.2 Impacts of Horizontal Interbeds on the Remaining Oil During the Water Flooding and Polymer Flooding Process

According to the reservoir distribution characteristics of major oil reservoirs of Daqing Placanticline Lamadian and Saertu Puyi Formation, the three-dimensional geological model of braided river sand of developed interbeds are set up to carry out the numerical simulation of water flooding and polymer flooding.

During the water flooding process, when the water content accounts for 92.5 %, the region of oil saturation from 0.4 to 0.6 is narrow, the line of 0.6 and line of 0.7 are basically coincident. If the water content reaches 0.98 with the sustained water driving, the remaining oil will continue to "be floated". The obstruction effect of interbeds remains obvious. But generally, the remaining oil is floated on the upper layer (Fig. 30.2). The horizontal interbeds under specific conditions (within a small area) can serve to prevent crossflow between layers and expand swept volume. A portion of water advances along the upper side of interbeds, so that the recovery of reservoir above the interbed is high (Su 2004). But if the hydropower is not strong, a lot of crude oil will remain under interbeds, particularly those at the middle and lower part of reservoirs with most obvious blockage. The more interbed area, the more remaining oils.

If polymer flooding is used when the water content is 0.925, the profile control of polymers changes the original fluid direction, the above crude oil will move downwardly and then upwardly. If the crude oil moves downwardly and meets the blockage of interbedds, it is favorable for the recovery. If the crude oil moves downwardly below the interbeds, then rises and is blocked by interbeds, then it is unfavorable for the enhanced oil recovery. The interbed itself also blocks the

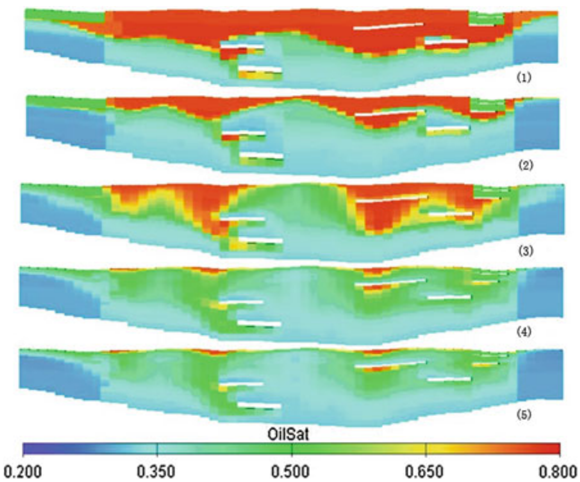

Fig. 30.2 Profile of So. at different stages of braided river sands (*1*)–(*5*) are water driving with 92.5 and 98 % of water content, the polymer flooding with water content dropped to 64.6 % and water driving until reaching the water content of 98 % after the end of polymer driving

polymer and exerts negative impacts on the expanded swept volume of the polymer profile control.

Through the comparison of Fig. 30.2 (3) with (4), it can be seen in the polymer flooding process, the remaining oil near the interbeds is not significantly improved. Through the comparison of Fig. 30.2 (1) with (4), the remaining oil is diffused in the local areas after the polymer flooding. The region with the oil saturation of between 0.4 and 0.6 is much wider than the that before the polymer flooding. Only in local aeras like interbed bottom and top, etc., the oil saturation of remaining oil is as same as that before polymer flooding. It shows the polymer flooding can develop remaining oil in most regions within the braided channel sands. But due to the presence of the horizontal interbeds, the remaining oil at the bottom has not been significantly improved.

30.4 Impacts of Lateral Interbed on Different Means of Driving Effects

The impacts of lateral interbed on the distribution of the remaining oil are closely related to the combination of direction of dip and injection direction (Ling et al. 2008). There are three major combination relationship of the injection direction and interbed inclination, namely the direction, against along the interbeds, or the extension direction of interbeds fluvial ldirection) (see Fig. 30.3). For the study of different combinations of direction and the impact of lateral interbeds on the distribution of remaining oils, three dimensional conceptual model of three combinational directions are set up for the numerical simulation.

30.4.1 No Interbed Development

It is relatively homogeneous in the channel sand without the interbed development. In the water flooding process, without the blockage of interbeds, the water flooding process is mainly controlled by the channel deposition model and is easier based

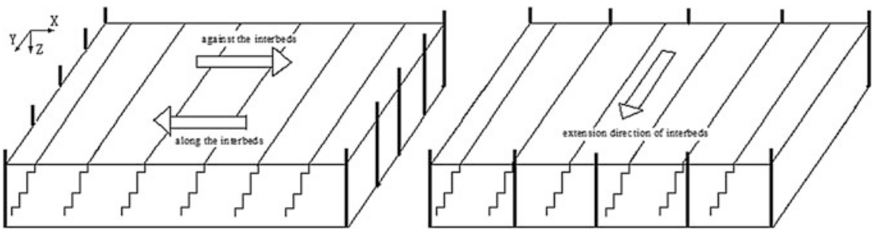

Fig. 30.3 Schematic view of combinational relationship of lateral interbed and injection direction

on sedimentary rhythm. Figure 30.4 is a profile of oil saturation at different stages of water flooding. In Fig. 30.4 (2) the unused remaining oil distributed in the triangular area formed by the connecting line of the middle part of oil well and water well and the reservoir top when the water content is 0.925. If you continue with the water flooding, the unused remaining oil only stays on the reservoir top (see Fig. 30.4 (3)). When the water content is 0.925, the recovery rate is 35.51 %; when the water content by the water flooding reaches 0.98, the recovery rate is 41.28 %.

If polymer driving is used when the water content is 0.925, the phenomenon of “Oil Wall” will appear.

Because the viscosity of polymer solution is greater than that of water, the pressure on the water well should be increased from 15 to 26 MPa at the time of water driving during the polymer injection. At the same time the injection grout is increased by folds. After the polymer solution enters the formation, the pressure cannot be transferred quickly, the pressure gradient surrounding the water well is great, the dip angle of water testing surface becomes bigger. Based on the Hubbert potential formula, the dip angle of oil–water interface dip angle will also become larger, thus a part of oil will move downwardly. As the pressure advances towards the oil well, an oil wall is formed in front of polymer aggregation with the V-shaped profile which appears to move downwardly driven by polymers. When the oil wells arrive at the oil well, a sudden peak will appear in the oil well yield while the rear oil wall disappears gradually and the oil well output is decreased

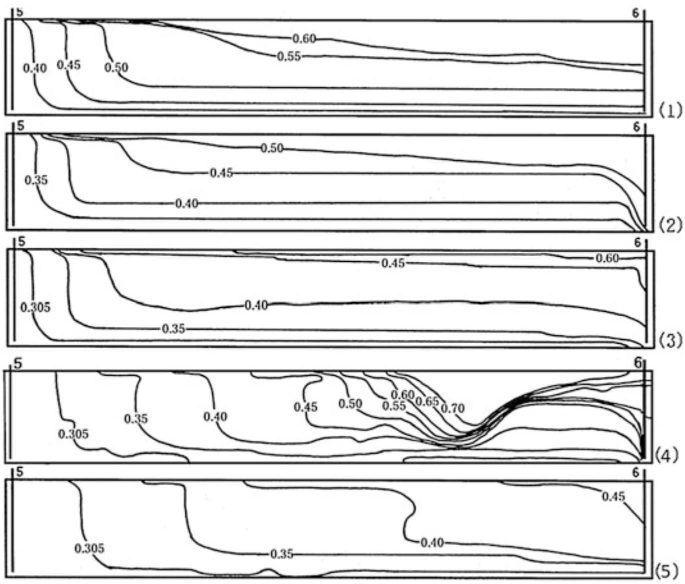

Fig. 30.4 Cross-section of oil saturation with the water content of 0.8, 0.925 and 0.98 with water driving at the homogeneous sandstone oil reservoir without interbed and the water content of 0.98 through the follow-up water driving

dramatically. The appearance of oil walls or the obvious oil wall is related to the reservoir non-homogeneity and well spacing. In general, the more severe heterogeneity, the greater differences in the positive rhythm, the less likely to appear the oil wall. The braided channel sand due to sound connectivity of reservoir has less penetration rate differences, thus the obvious oil wall appears. At the same time the appearance of oil wall is controlled by well space. Due to the upper lateral interbed and lower belts of high permeability of meandering river sands, the injected polymer solution suddenly ingresses along the bottom. In addition, when the remaining oil in the interbed is displaced, it only flows out of the bottom of lateral interbed, thus no V-shaped oil wall will be formed.

The polymer flooding is used when the water content is 0.925. Figure 30.4 (4) and (5), respectively show the profile of oil saturation when stopping the polymer injection and the follow-up water driving until the water content reaches 0.98, the remaining oil is still distributed on the top of reservoir near to the oil well. The ultimate recovery rate for 0.70 PV of injected polymer is 42.43 %. (Table 30.1 shows the equivalent of the relationship between the injection of different volume of polymers and recovery rate. The ultimate recovery rate after displacement refers to the corresponding value of ultimate recovery when the follow-up water driving enables the water content to be 0.98 after the injection of polymer of 0.70 PV). Compared with the water driving, the ultimate recovery rate only grows by 1.15 %. It can be seen that the effects of water driving is significant. Under this circumstance, the effects of polymer driving are insignificant and may be uneconomical.

30.4.2 Driving Along the Interbeds

When injection is along the direction of interbeds, the impact of interbeds on the development of remaining oils can be seen in Fig. 30.5. After the polymer driving, more distribution of remaining oil at one side of the water well towards the lateral interbed and the structural top formed by two interbeds is related to the tilting direction of oil–water interface and hydrodynamic direction. Due to the obstruction of interbeds, the recovery rate for the water content of 0.925 by water driving

Table 30.1 Relationship between different volumes of polymers and recovery rate

Driving direction	Water content of 0.925	Water content of 0.98	0.2 PV	0.4 PV	0.6 PV	0.7 PV
No interbeds	35.51	41.28	41.24	40.78	41.73	42.43
Injection along interbeds	26.00	30.96	35.05	34.18	36.57	37.26
Injection against interbeds	23.38	28.57	34.87	35.78	36.74	36.78
Injection along the fluvial direction	34.94	41.11	40.99	38.73	38.59	41.94

is 26.00 %. The recovery rate for the water content of 0.98 by complete water driving is 30.96 %. The recovery rate can reach 37.26 % when the polymer driving is employed. The three values drop 9.51, 10.12 and 5.17 % in comparison with those without interbeds. It can be seen that due to the obstruction of interbeds, the recovery rate decreases around 10 % compared with those without interbeds. After the polymer driving, the obstructed crude oil has been remarkably improved. The differential value in the crude oil recovery is reduced to 5 % or so.

30.4.3 Driving Against the Interbeds

Figure 30.6 is a cross-sectional view of oil saturation at all stages of injection against the interbed. Compared with the injection along the interbed, there are more remaining oil, mainly due to the more surrounding area of oil–water interface and the interbed at the time of injection against the interbeds. The included angle formed by the interbed and the top is a "dead area" which is also the remaining oil enriched region. Due to the obstruction of interbeds, the recovery ratio for water content of 0.925 with water driving is 23.38 %. The recovery rate is 28.57 % when the complete water driving with the water content up to 0.98. The recovery rate can reach 36.78 if the polymer driving is used. The three values drop 11.13, 12.71 and 5.65 % in comparison with those without interbeds. It can be seen that due to the obstruction of interbeds, the recovery rate decreases around 10 % compared

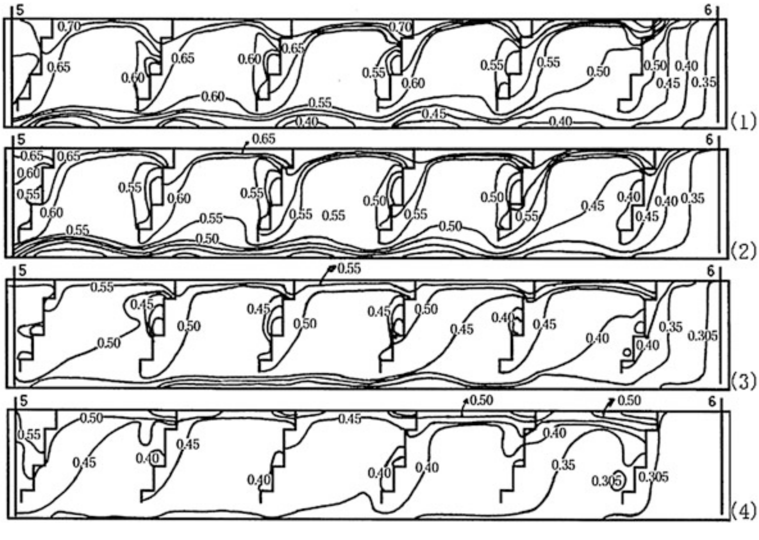

Fig. 30.5 Cross-section of oil saturation with the water content of 0.8, 0.925 and 0.98 with water driving and the water content of 0.98 through the follow-up water driving along the interbeds

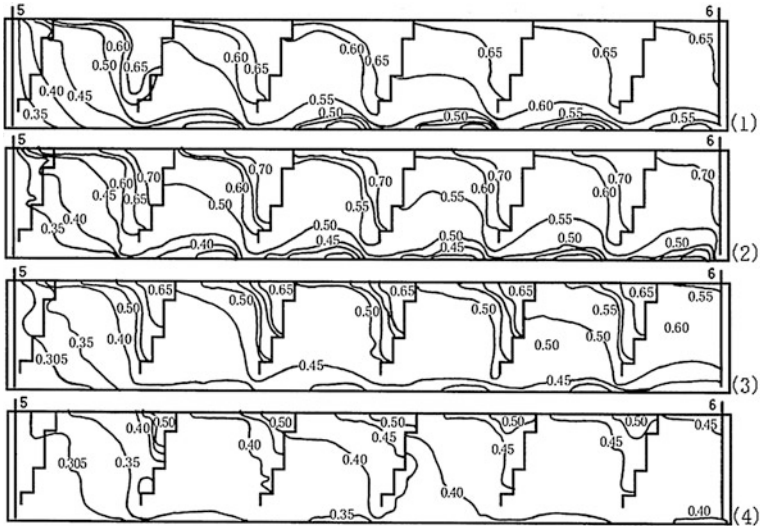

Fig. 30.6 Cross-section of oil saturation with the water content of 0.8, 0.925 and 0.98 with water driving and the water content of 0.98 through the follow-up water driving against the interbeds

with those without interbeds. Through the polymer driving, the differences in the crude oil recovery is reduced by over five percents.

30.4.4 Driving Along the Extension of Interbeds

The injection along the interbed has the least resistance in theory (maximum permeability along the fluvial direction without direct obstruction of lateral interbed) and excellent water driving effects. Figure 30.7 shows a profile of oil saturation at all stages of injection in the direction. The remaining oil is mainly located on the reservoir top near to the oil well when the water content is 0.98 with the follow-up water driving. On the profile, the remaining oil between two oil wells is V-shaped. The unobvious obstruction can be seen near some lateral interbed. The recovery rate is up to 34.94 % when the water content is 0.925. The ultimate recovery rates for the follow-up water driving and polymer driving are high, reaching respectively 41.11 and 41.94 %. The water injection along the interbed has higher recovery rates than those without interbeds. But under this situation the recovery rate improvement is small, only 0.83 % for the polymer driving effects. Within less than 7 years of polymer driving, the recovery rate can even be lowered.

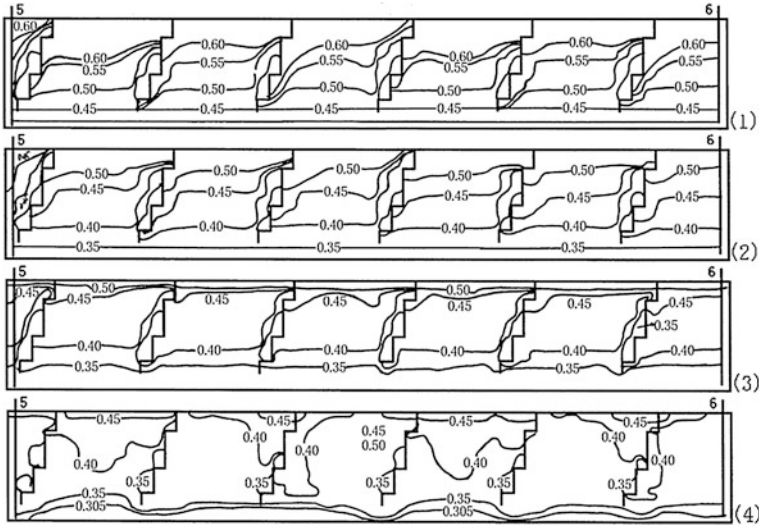

Fig. 30.7 Cross-section of oil saturation with the water content of 0.8, 0.925 and 0.98 with water driving and the water content of 0.98 through the follow-up water driving along the fluvial direction

30.5 Conclusion

The distribution location, scale, injection mean, recovery means and reservoir rhythm of horizontal interbeds have direct bearing on the distribution law of remaining oil, capable of preventing upward movement of oil and gas while obstructing the downward movement of water on the interbeds, thereby expanding the swept volume. It is an important reason for the formation of remaining oils. The horizontal interbeds can serve to flood in intervals and prevent the interbed water breakthrough to a certain extent. During the polymer driving, the horizontal interbeds can change the fluid direction to prevent oil and gas flow, reducing the displacement effects.

The lateral interbed in the meandering river is a major factor for the formation of remaining oil. Although the rise of bottom water can not be obstructed, but at the upper part of lateral interbed, especially the acute angle formed by the interbed and top surface is the highest concentration of remaining oils. In most cases, the closer to oil wells, the more remaining oils in the angle.The lateral interbed will increase the resistance to oil driving and make the polymer injection difficult. At a certain time of polymer injection, the recovery rate of crude oil at some stages may be lower than that at the time of complete water driving. In the sand of developed lateral interbed, different directions of water injection affect the recovery rate of crude oils and also make the distribution location of remaining oil in the interbeds different. In general, the injection directions leading to crude oil recovering rate from high to low are: driving along the extension of interbeds (river direction), along the lateral interbed and against the lateral interbed.

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Chapter 31
Effectiveness Valuation of Electronic Countermeasure on Ground Air Defense and Anti-missile

Yong-ling Yan, Zhi-feng Zhang, Qing-bo Zhang and Tao Dong

Abstract The effectiveness valuation of electronic countermeasure on ground air defense and anti-missile has turned into one of the hot subjects of present research. To the complexity and changefulness of the diverse random events deciding the competency matrix C and the fact that some criterions lack quantified representation in ADC method, innovation of the ADC method is proposed in the thesis. Through combination of qualitative and quantitative process, ADC method, analytic hierarchical process and Delphi method are used jointly to implement the effectiveness valuation of electronic countermeasure on ground aerial defense and anti-missile system. Availability A, dependability D, competency matrix C and the computational models of their sub models are set up respectively. It is proved that the model is in validity by example.

Keywords Analytic hierarchy process · Delphi method · Electronic countermeasure system · Effectiveness valuation · Improved ADC method

31.1 Introduction

As the electronic technology in air strikes and air defense against are extensive used in the field, electronic against becomes an important part of the modern war. As one of the important forces in ground to air defense, we air-defense unit of the ground will certainly put up drastic rivalry in electronic against conditions. So, how to evaluate the electronic against effectiveness is an important issue.

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E. Qi et al. (eds.), *The 19th International Conference on Industrial Engineering and Engineering Management*, DOI: 10.1007/978-3-642-38391-5_31,

31.2 Methodology

31.2.1 Improving Evaluation Methods

Currently, there are many methods to evaluate the effectiveness. But in all of the methods the ADC is more comprehensive, precise and its index is more clear which can reflects weapon system's physical advantages. There are also limitations in this method that every index must have a specific expression (AD A 109549 1981). As the ground to air defense electronic against system is complex and lack quantitative indexes, it is difficult to analyse its *C* matrix (Meng et al. 2003; Sang 2008; Li and Wang 2008).

So this article talks about how to ameliorate the ADC model, and its main part uses the improved ADC method to have a strict process and get an authentic outcome. In the premise of using as much analytical method as possible, calculate the weight by APH for some uncountable index and find out the point with Experts consult method to solve the calculation problem. Combining the quality and quantity can use the ADC to good advantage and can also make up its disadvantages, so that we can evaluate electronic against effectiveness effectively.

31.2.2 Building the Evaluation Index System of Ground to Air Defense Effect in Electronic Countermeasure Conditions

Combining with improved ADC model elements, the index system as follows: the evaluation of ground to air defense effect in electronic against conditions is decided by *A*, *D*, *C* three matrixes (AD A 109549 2010), *A* and *D* are decided by maintenance and reliability, *C* is decided by anti-jamming matrix C_1, the electronic reconnaissance capability matrix C_2, the anti-radiation missile resistance capability matrix C_3, the anti-stealth ability matrix C_4, the survival ability matrix C_5.

31.2.3 Building the Model of Effectiveness Valuation of Electronic Countermeasure

31.2.3.1 Analyzing the States of Electronic Countermeasure

Though ground to air defense electronic against systems are different in theory, function and structure, but the typical electronic against process is: Firstly, reconnaissance equipment such as satellite, radar and photoelectricity equipment reconnoitre the radiation source. Secondly, the Data-Processing-Center find out its

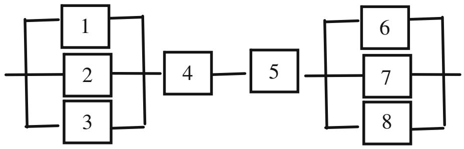

Fig. 31.1 Reliability chart of electronic countermeasure system

position and radiation source recognition system identify and pick up features such as the working frequency. Thirdly, our ground to air defense electronic against systems takes soft killing or hard killing according to the obtained information. Soft against methods include radar jamming equipment and photoelectricity jamming equipment. Hard killing methods are launching missiles to against ARM.

According to its typical process, building elementary model can find out system's reliable frame as Fig. 31.1, and it can also discover system's original state as Table 31.1.where:

1 -Equipment of radar reconnaissance;
2 -Equipment of photoelectricity reconnaissance;
3 -Equipment of secondary plane reconnaissance;
4 -Center of data processing;
5 -System of radiation sources identifies;
6 -Equipment of radar disturbing;
7 -Equipment of photoelectricity disturbing;
8 -Equipment of hard destroys.

Explanation: the number in the picture shows the serial number of each part.

31.2.3.2 Building Evaluation Model

The basic model of ADC mean is:

$$E_s = A^T[D][C] \tag{31.1}$$

Table 31.1 Work state of electronic countermeasure system

Order	State
1	All of the parts are normal
2	Part 1 conk out, others are normal
3	Part 2 conk out, others are normal
4	Part 3 conk out, others are normal
5	Part 6 conk out, others are normal
6	Part 7 conk out, others are normal
7	Part 8 conk out, others are normal
8	The system conk out

E_s —system's effectiveness vector;
A^T —availability vector;
C —competency matrix
D —dependability matrix

(1) *the sub models of* availability A

Electronic countermeasure system is made up of eight parts. The availability level of each part can be got by the formula (Yan et al. 2008):

$$A_i = {}^{MTBF_i}/_{MTBF_i + MTTR_i} \quad (i = 1, 2, \ldots, 8)$$

where:

i-number in Fig. 31.1.

Combining eight states in Table 31.1, availability A of electronic countermeasure system can be got by the calculable models of combined system.

$$\begin{aligned} A &= (a_1\, a_2\, a_3\, a_4\, a_5\, a_6\, a_7\, a_8) \\ a_1 &= \prod_{i=1}^{8} A_i \quad a_2 = (1 - A_1)\prod_{i=2}^{8} A_i \quad a_3 = (1 - A_2)\prod_{i=1,\neq 2}^{8} A_i \quad a_4 = (1 - A_3)\prod_{i=1,\neq 3}^{8} A_i \\ a_5 &= (1 - A_6)\prod_{i=1,\neq 6}^{8} A_i \quad a_6 = (1 - A_7)\prod_{i=1,\neq 7}^{8} A_i \quad a_7 = (1 - A_8)\prod_{i=1}^{7} A_i \quad a_8 = 1 - \sum_{i=1}^{7} a_i \end{aligned} \tag{31.2}$$

(2) *the sub models of dependability D*

The factors of D are decided by dependability level. The dependability level's expression of each parts in electronic against system is

$$R_i = \exp(-\lambda_i \mathrm{t}) \quad (i = 1, 2, \ldots, 8)$$

where:

λ_i is the parts' invalidation possibility, and can be got by: $\lambda_i = 1/MTBF_i$

State transfer probability d_{11}–d_{88} can be got by system's original state and every part's dependability. The d_{11} means the probability that system runs normally from beginning to the end. The d_{12} means the probability that system runs normally at beginning but radar reconnaissance equipment conk out at last. It can be got by

$$d_{12} = (1 - R_1)\prod_{i=2}^{8} R_i$$

In the same way dependability D can be found out by:

$$D = D(t) = \begin{cases} d_{ij}, & i \le j \\ 0 & i > j \end{cases} \quad (i, j = 1, 2, \ldots, 8) \tag{31.3}$$

(3) *the sub models of competency matrix C*

Competency matrix C is determined by anti-jamming matrix C_1, the electronic reconnaissance capability matrix C_2, the anti-radiation missile resistance capability matrix C_3, the anti-stealth ability matrix C_4, the survival ability matrix C_5.

a. anti-jamming Capability C_1

Anti-jamming capability can be expressed by the change of radar maximum detection distance in jamming conditions. If there is no jamming, the maximum detection distance of radar (Schrick 2008) that it can be denoted by R_{max} is

$$R_{\max} = \left[\frac{p_t G_t^2 \lambda^2 \sigma}{(4\pi)^3 K T_0 \Delta f_r F_n L (S/_N)_{\min}} \right]^{\frac{1}{4}} \tag{31.4}$$

where:

P_t	—radio power;
G_t	—antenna gain;
λ	—wavelength;
σ	—RCS;
K	—Boltzmann constant;
T_0	—receiver noise temperature, it can be denotation by 290 K;
Δf_r	—receiver bandwidth;
L	—the loss factor of system;
F_n	—noise coefficient;
$(S/N)_{\min}$	—minimum SNR

Radar maximum detection distance in jamming conditions (Yan and Zhang 2009) is

$$R'_{\max} = \frac{1}{3} \sqrt{\frac{R_j}{\theta_{0.5}}} \sqrt{\frac{\pi P_t G_t \sigma K \Delta f_j}{K \gamma_j P_j G_j \Delta f_r}} \tag{31.5}$$

where:

r_j	—polarization loss, $r_j = 0.5$;
P_j	—jamming power;
G_j	—interference machine lord disc plus;
Δf_j	—jamming signal bandwidth.

C_1 can be got by it:

$$C_1 = 1 - \overline{C_1} = 1 - \left(R_{\max} - R'_{\max}\right) \Big/ R_{\max} \times 100\% \tag{31.6}$$

b. The electronic reconnaissance capability matrix C_2

C_2 is mainly decided by anti-signal intercepted capability N_1 and anti-signal analysis capability N_2, where:

$$N_1 = 1 - K_1 P_1 \quad K_1 = \frac{\theta_t}{\theta_{t0}} \frac{\Delta f}{\Delta F} \frac{R_t}{R_{to}} \tag{31.7}$$

K_1 —reconnaissance relative cover coefficient;
P_1 —intercept probability;
θ_t —actual cover range in the detectable orientation of system;
θ_{t0} —expected or demanded by campaign mission cover range in the detectable orientation;
Δf_t —actual cover range in the detectable frequency orientation of system (Ribeiro 2006);
ΔF_t —expected or demanded by campaign mission cover range in the detectable frequency;
R_t —actual reconnaissance distance of system;
R_{t0} —expected or demanded by campaign mission reconnaissance distance (Zhou and Tao 2007)

$$N_2 = P_2 \rho \tag{31.8}$$

where:
P_2 —signal processing probability;
ρ —recognition confidence

we can get:

$$C_2 = \omega_1 N_1 + \omega_2 N_2 \tag{31.9}$$

where:
$\omega_1 \omega_2$ are decided by experts, $\omega_1 = 0.43$, $\omega_2 = 0.57$.

c. The anti-radiation missile resistance capability matrix C_3 (Liu 2010)*, the anti-stealth ability matrix* C_4

Because of the complexity and changefulness of the diverse random events deciding the competency matrix C_3, C_4, and the fact that some criterions lack quantified representation in ADC method, innovation of the method is proposed in the thesis. Through combination of qualitative and quantitative process with ADC method, hierarchical analytic process and Delphi method are used jointly to implement the effectiveness valuation of electronic countermeasure. And they can be broken up to index system in Table 31.2 (Ti 2005a).

The weight of each index can be decided by hierarchical analytic process and every index's relative importance can be shown by using ratio build judge matrix 1–9. Taking the anti-stealth ability matrix C_4 for an example: assuming that the sub model's tactics measure and techniques ability constitute the matrix of remark collection:

Table 31.2 The standard of grade

Index	Subindex	The standard of grade (point)			
		0.75–1	0.5–0.75	0.25–0.5	0–0.25
Anti-radiation missile resistance capability (Wu et al. 2010)	Concealment distance (km)	>300	200–300	100–200	<100
	Warning time (Chrazanowski)	>60 s	45–60 s	20–45 s	<20 s
	Jamming and inveiglement capability	Very good	Good	Not bad	Bad
	Attack and against ability	Very good	Good	Not bad	Bad
The anti-stealth ability (Ti 2005b)	Meter wave band radar	Most sensitive	More sensitive	Sensitive	Not sensitive
	Anti-stealth drilling	Most continual	More continual	Continual	Not continual
	Radar web	Very good	Good	Not bad	Bad
	Increase aperture multiplication of radar power	>30	20–30	10–20 s	<10
	Increase the number of impulses dealed with phasic parameter	>100	80–100	50–80	<50

$$T = (t_{mn})_{2\times 2}\begin{bmatrix} 1 & 3.03 \\ 0.33 & 1 \end{bmatrix} \tag{31.10}$$

The eigenvector of judge matrix can be calculated by “addition method” according to expression (31.10).

$$\omega_m = \frac{1}{2}\sum_{n=1}^{2}\frac{t_{mn}}{\sum_{k=1}^{2} t_{kn}}$$

And the weight can be got as:

$$\omega = (\omega_1, \omega_2)^{\mathrm{T}} = (0.66, 0.34)^{\mathrm{T}}.$$

Then ten experts mark basing on Table 31.2, and calculate the average figure. At last it can be got by linearity addition method:

$$C_4 = \sum_{m=1}^{2}\omega_m\left[\sum_{k=1}^{m_n}\omega_{mk}\times F_{mk}\right] \tag{31.11}$$

where:

m_n —the number of sub index;

ω_m —the weight of the third layer index;

ω_{mk} —the weight of sub index's coefficient;

F_{mk} —the sub index point given by experts.

d. the survival ability C_5

The survival ability can be showed by survival probability. In order to improve survival ability, we usually assume that there are m information centers which are redundancies of each other. So the survival probability is

$$C_5 = P_{cam} = 1 - \prod_{k=1}^{m} p_k = 1 - \prod_{k=1}^{m}\left(\prod_{i=0}^{Q} p_{ik}\right) \tag{31.12}$$

where:

K —the number of ruined center;

P_{0k} —the probability of raided on the center;

$P_{1k}, P_{2k},\ldots, P_{Qk}$ —the probability of destroying the center after all effective against measures are taken.

(4) *Calculating system's effectiveness Es*

As analyzed above, the formula can be got:

$$C = \prod_{k=1}^{5} C_K \tag{31.13}$$

and formula (31.1)can be changed to

$$E_S = AD\prod_{k=1}^{5} C_K \tag{31.14}$$

The improved ADC method which can evaluate the effectiveness of electronic countermeasure on ground air defense and anti-missile can be got by joining formulae (31.2)–(31.6), (31.9), (31.11), (31.12) to formula (31.14).

31.3 The Example

The effectiveness of two supposed typical ground air defense and anti-missile systems in electronic against conditions which can be evaluated by the model have been got. System 2 is partly advanced to system 1 by improving reliability level and radar's anti-stealth ability of every part in System 2. The numerical value of each parameter of 2 systems above can be got from figure Tables 31.3 and 31.4.

Table 31.3 Reliability parameter

	$MTTR_1$	$MTTR_2$	$MTBF_1$	$MTBF_2$
Radar	25	13	180	300
Photoelectricity equipment	10	10	200	600
Satellite	50	30	300	1470
Date center	30	20	200	980
Radiosource recognition system	21	20	300	500
Radar jamming equipment	26	20	300	410
Photoelectricity jamming equipment	10	7	400	470
Hard killing methods	40	20	180	650

Elucidation: in Table 31.4, the number which follows every index is its weight; other numbers in Table 31.4 are points.

From Table 31.3:

$$\mathrm{A}_1 = [0.4279 \quad 0.0595 \quad 0.0214 \quad 0.0713 \quad 0.0371 \quad 0.0107 \quad 0.0951 \quad 0.277]$$

$$\mathrm{D}_1 = \begin{bmatrix} 0.6392 & 0.0041 & 0.0720 & 0.0168 & 0.0002 & 0.0008 & 0.0001 & 0.2668 \\ 0 & 0.6943 & 0.0028 & 0.0513 & 0.0014 & 0.0003 & 0.0002 & 0.2497 \\ 0 & 0 & 0.7101 & 0.0082 & 0.0312 & 0.0051 & 0.0001 & 0.2453 \\ 0 & 0 & 0 & 0.7452 & 0.0362 & 0.0014 & 0.0006 & 0.2166 \\ 0 & 0 & 0 & 0 & 0.7642 & 0 & 0.0012 & 0.2346 \\ 0 & 0 & 0 & 0 & 0 & 0.8013 & 0.0004 & 0.1983 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0.8537 & 0.1463 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 \end{bmatrix}$$

$$\mathrm{A}_2 = [\, 0.7934 \quad 0.0012 \quad 0.0132 \quad 0.0162 \quad 0.0387 \quad 0.0118 \quad 0.0245 \quad 0.101\,]$$

$$\mathrm{D}_2 = \begin{bmatrix} 0.7421 & 0.0052 & 0.0810 & 0.0170 & 0.0004 & 0.0009 & 0.0002 & 0.1532 \\ 0 & 0.7841 & 0.0032 & 0.0812 & 0.0040 & 0.0006 & 0.0001 & 0.1268 \\ 0 & 0 & 0.8021 & 0.0044 & 0.0923 & 0.0061 & 0.0004 & 0.0947 \\ 0 & 0 & 0 & 0.8428 & 0.0060 & 0.0998 & 0 & 0.0514 \\ 0 & 0 & 0 & 0 & 0.8690 & 0.0091 & 0.0760 & 0.0459 \\ 0 & 0 & 0 & 0 & 0 & 0.9215 & 0.0410 & 0.0375 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0.9705 & 0.0295 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 \end{bmatrix}$$

From Table 31.4: $C_{41} = 0.664$; $C_{42} = 0.814$.

To predigest the problem, these parameters of system1 and system 2 such as anti-jamming C_1, the electronic reconnaissance resistance capability C_2, anti-radiation missile resistance capability C_3, the survival ability C_5 can be supposed to equal to 1.

So it can be got that: $E_{S1} = 0.426$; $E_{S2} = 0.603$.

According to the analysis of result, the conclusion can be made that the effectiveness of electronic countermeasure can be strengthened obviously with

Table 31.4 Points given by experts to the anti-stealth ability of radar

Sub index	The third layer index	System 1	System 2
Tactics measure 0.66	Meter wave band radar 0.313	0.62	0.84
	Anti-stealth drilling 0.227	0.87	0.94
	Radar web 0.460	0.74	0.89
Techniques ability 0.34	Increase aperture multiplication of radar power 0.461	0.63	0.88
	Increase the number of impulses dealed with phasic parameter 0.327	0.75	0.82

radar's anti-stealth ability and the reliability of system2's improving. The result is accordant with practice (Yan et al. 2007; Chin 1998; Packer 2003; Whatmore 2005; Hall and Betts 1994; Rius et al. 1993). And it is fully proved that the improved ADC method is in validity to evaluate the effectiveness of electronic countermeasure on ground air defense and anti-missile.

31.4 Conclusion

In conclusion, the improved ADC model is used to evaluate the effectiveness of electronic countermeasure on ground air defense and anti-missile, and it is proved by example that the model is in validity (Volakis 1994; Zhang et al. 2000; Levison and Badler 1994; Badler et al. 2006). Currently, the model has been used to evaluate C^4ISR air defense systems, and a synthetically effectiveness valuation software has been developed. So the improved ADC model is proved to be worthful.

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Chapter 32
Energy Consumption and Economic Growth: Cointegration and Granger Causality Test

Jing-wei Liang and Zhou Liu

Abstract In this paper, we use cointegration technique and VEC model to study the relationship between energy consumption and economic growth in China from 1953 to 2008 and have the following conclusions: 1. Long-term cointegration relationship exists between energy consumption and GDP growth. 2. In the long-term, energy consumption and economic growth have no Granger causality; in the short term, a bi-direction Granger causality between energy consumption and GDP exits.

Keywords Cointegration · Economic growth · Energy consumption · Granger test

32.1 Introduction

With the process of industrialization, energy is becoming the most important material basis for social development and economic growth. Scholars from various countries are focusing on the interdependence relationship between energy consumption and economic growth. Although the academic community has done many researches on the issue since the 1970s, an accordant conclusion is never agreed by the academics. Due to the different samples from different countries and different statistical methods, a diverse conclusion is presented on the relationship between energy consumption and economic growth. Therefore, a study on different countries and regions in different time interval of energy consumption and

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E. Qi et al. (eds.), *The 19th International Conference on Industrial Engineering and Engineering Management*, DOI: 10.1007/978-3-642-38391-5_32,

economic growth has an important theoretical significance. Meanwhile, the implementation of appropriate energy policies which is based on the empirical research of the relationship between energy consumption and economic growth has a crucial impact on a country's economic development; the issue means a practical significance. In this paper, cointegration model with vector error correction model (VECM) is used to portray the long-run equilibrium and long-term and short-term Granger causality between energy consumption and economic growth in China, relevant policy recommendations is based on the empirical results of the study.

The rest part of the paper is organized as follows: the second section gives a literature review of the empirical research between energy consumption and economic growth; the third section presents an explanation of cointegration theory and vector error correction model; the fourth section gives the necessary explanation of variables and data acquisition, preliminary data processing and parameter estimation; the fifth section presents an economic analysis of the empirical results and policy recommendations.

32.2 Literature Review

Kraft and Kraf (1978) gave the first study on the relationship between energy consumption and economic growth. They used GNP and energy consumption data of U.S. from 1947 to 1974, obtained the one-way causal relationship from GNP to energy consumption. This means that a conservative policy of the energy will not cause greater impact on the GNP growth. However, Akarca and Long (1980) used same method as Kraft, with less sample size, cannot draw the same conclusion. This means that Kraft's conclusions sound less robust to the impact of sample size. Since then, much research has focused on using a different sample, different modeling methods, different measurement methods to explore the inherent relationship between energy consumption and economic growth. Masih.et al studied the case of Asian countries (Masih and Masih 1996). They studied eight countries and regions in Asian of their income to total energy consumption, the results showed an inconsistent Granger causality among the eight countries. Cheng and Lai (1997) studied the situation in Taiwan from 1955 to 1993, the results showed that one-way causal relationship only GDP to energy consumption is accepted. Ghali and Elsakka (2004) used the Cointegration technique to explain the Canadian situation. They established a neo-classical production function model including four variables which is output, capital, labor and energy consumption, the results showed that a long-term co-integration relationship was existence among these four variables. Lee and Chang (2007) established linear and nonlinear models in Taiwan using 1955–2003 data, they concluded the existence of a U-shaped relationship between energy consumption and economic growth in Taiwan, and the non-linear model can better fitting the relationship between the two. Gross (2012) applied ARDL technique to study industrial, commercial and transport sectors' energy consumption and growth, the findings showed that a single causal relationship between growth and energy consumption of the commercial sector; a two-way causal relationship of growth and energy consumption in the transport sector. Cointegration methods and Granger test are also widely used in this topic (Apergis and Payne 2009; Jumbe 2004; Yoo 2006; Yang 2000; Yu and Choi 1985; Yu and Jin 1992; Yu et al. 1988; Wolde-Rufael 2005).

32.3 Cointegration Theory and Vector Error Correction Model

According to the characteristics of the data generation process, time series data can divided into two types: stationary and non-stationary process. For non-stationary random process, if after d times difference, the stochastic process becomes a stationary process, and d-1 times the differential is still a non-stationary process, we call it an I(d) process. For non-stationary time series, there will be a serious problem known as the "spurious regression" by using the ordinary least squares method, and the resulting of the estimated value and the parameter are not valid. Cointegration theory proposed by Granger and Engle can deal with the two non-stationary time series data for the long-run equilibrium study. Given two I(1) data series, if a linear combination of the series is I(0),we call the two series cointegration.

The vector error correction model (VEC) is a VAR model with constraints. It applies to non-stationary sequence which is known to have co-integration relationship. When there is a wide range of short-term dynamic fluctuations, VEC expression of endogenous variables will limit the long-term behavior in order to make them converge to the long-term cointegration relationship. Due to a series of partial short-term adjustment can correct the deviation from the long-run equilibrium, the cointegration term is also known as error correction. The error correction term can reflect the dynamic mechanism of the long-run equilibrium short-term fluctuations deviate from the self-correction. This method can separate the long-term and short-term Granger cause. Because of the error correction term contains the long-term cointegration relationship, the long-term Granger cause can be detected by the significant of the error correction coefficient.

Before using the error correction model, a unit root testing is required. Commonly used unit root statistic tests are ADF test, KPSS test, PP test. Then, we must test the exits of the long-term equilibrium relationship between the non-stationary random variables, namely the existence of cointegration relationship between them. Granger pointed out that there must be an expression of error correction model among cointegration I(1) variable. The usual test methods are EG two-step method and JJ trace statistic method.

32.4 Empirical Research

32.4.1 Cointegration Study

This paper selects the annual GDP and energy consumption data from 1953 to 2008. The real GDP using 1978 constant prices, energy consumption is calculated by coal consumption calculation. All data are from the New China 60 years statistics compilation. All variables are transformed into their natural logarithm.

First, the ADF test is applied to detect the unit root of the two sets of data. We choose the equation test including the intercept and time trend, lag order is determined by the Akaike Information Criterion (AIC). Table 32.1 shows the test results:

As shown above, under the 10 % significant level, the *P* values of both lngdp and lnec are greater than 10 %, therefore, both cannot reject the existence of a unit root hypothesis; the first-order differential data can reject the null hypothesis, so the differential data is I(0) (Table 32.2).

After the unit root test, we began to study the cointegration relationship between two variables. We use the E-G two-step method to determine the existence of a cointegration relationship between two variables. The model is set as Eq. (32.1):

$$\ln gdp = \beta_0 + \beta_1 \ln ec + u_t \tag{32.1}$$

Using the OLS method,we can get the following equation:

$$\ln gdp = \underset{(0.534)}{-4.34} + \underset{(0.049)}{1.19} \ln ec$$

Using the ADF test to detect the stationary of the residuals of Eq. (32.1), we can conclude that, under the 10 % confidence level, the residual is I(0).

The residual is I(0) process means that long-term cointegration relationship between lngdp and lnec exits. Economic growth and energy consumption in the long-run equilibrium mechanism can be portrayed by Eq. (32.1).

Energy consumption and GDP in the long-term co-integration relationship described the long-run equilibrium situation between the two. The error correction model can describe the short-term fluctuations. Short-term fluctuations can be described by the following equation:

Table 32.1 ADF test

	ADF test	Lag	P-vaule
lngdp	−1.750	3	0.674
Δlngdp	−4.660	3	0.010
lnec	−3.1179	0	0.1238
Δlnec	−4.650	0	0.010

Table 32.2 The residual ADF test

ADF	Lag	P-value
−3.4198	3	0.0618

$$\Delta \ln gdp = 0.048 + 0.396\Delta \ln ec + 0.007ecm_{t-1}$$

This equation describes the short-term fluctuations between GDP and energy consumption. The error correction coefficient is positive, indicating that the adjustment mechanism of the reverse does not exist; and the error correction term coefficient is not significant, indicating that in one period, the system cannot automatically do the amendment process.

32.4.2 VECM and Granger Causality Test

In this section, we establish a bivariate vector error correction model to explore the long term Granger causality between energy consumption and economic growth. The model is as follows:

$$\Delta \ln gdp_t = \alpha_2 + \delta_2 ECM_{t-1} + \sum\nolimits_{i=1}^{m} \beta_{2i}\Delta \ln gdp_{t-i} + \sum\nolimits_{t=1}^{m} \gamma_{2i}\Delta \ln ec_{t-i} + \varepsilon_{2t}$$

$$\Delta \ln ec_t = \alpha_1 + \delta_1 ECM_{t-1} + \sum\nolimits_{i=1}^{m} \beta_{1i}\Delta \ln gdp_{t-i} + \sum\nolimits_{t=1}^{m} \gamma_{1i}\Delta \ln ec_{t-i} + \varepsilon_{1t}$$

$$ECT_t = \ln gdp_t - \phi \ln ec_t$$

where, α, β, γ, φ, stands for estimated coefficient, Δ means the differential operator, ECT for error correction term, the lag order is determined by the AIC criterion

By the AIC criterion, the lag order is 2, and the model estimated coefficient is shown in the Table 32.3. From Table 32.3, we find that only the GDP in the first order lag is statistically significant, the other lagged variables affect the dependent variable are not significant. The coefficient of error correction are positive, the reverse correction mechanism does not exist, and the error correction coefficient is not significant, indicating that in the long-run equilibrium, there is no Granger causality from GDP to energy consumption; at the same time, there also does not exist a causal relationship from energy consumption to GDP. In other words, the long term, increase or decrease of the energy consumption of GDP does not explain the increase or decrease.

After exploring the long-term Granger causality, we study the relationship of short-term Granger. Short-term Granger relationship in the Table 32.4.

As we can seen from Table 32.4 the two hypothesis under 1 % significant level is rejected. This shows a bi-direction short-term Granger causality between GDP and energy consumption. The inconsistency between Long-term Granger causes

Table 32.3 Estimated coefficient

	α_1	α_2	β_{11}	β_{12}	β_{21}	β_{22}	γ_{11}	γ_{12}	γ_{21}	γ_{22}	δ_1	δ_2	ϕ
Cof.	0.036	0.063	0.033	0.250	0.685	0.250	0.306	0.060	0.219	0.045	0.015	0.019	0.797
s.d.	0.030	0.016	0.048	0.227	0.254	0.227	0.286	0.286	0.105	0.150	0.035	0.019	0.007

Table 32.4 Granger causality test

lag	Null hypothesis	F Value	P Value	Conclude (1 %sig. level)
2	Energy consumption does not Granger cause GDP	7.6032	0.001331	Reject
2	GDP does not Granger cause Energy consumption	5.1206	0.009561	Reject

and short-term Granger cause may be caused by the lack of control variables. In the long run, the relationship between energy consumption and GDP could be impact by other important variables (capital, labor, and import and export, etc).

32.5 Conclusions

In this paper, we use cointegration technique and VEC model to study the relationship between energy consumption and economic growth in China from 1953 to 2008. We have the following conclusions: 1. Long-term cointegration relationship exists between energy consumption and GDP growth. 2 In the long-term, energy consumption and economic growth have no Granger causality; in the short term, there is a bi-direction Granger causality between energy consumption and GDP.

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Chapter 33
Estimation of Lead Time in the RFID-Enabled Real-Time Shopfloor Production with a Data Mining Model

Ray Y. Zhong, George Q. Huang, Qing-yun Dai and Tao Zhang

Abstract Lead time estimation (LTE) is difficult to carry out, especially within the RFID-enabled real-time manufacturing shopfloor environment since large number of factors may greatly affect its precision. This paper proposes a data mining approach with four steps each of which is equipped with suitable mathematical models to analysis the LTE from a real-life case and then to quantitatively examine its key impact factors such as processing routine, batching strategy, scheduling rules and critical parameters of specification. Experiments are carried out for this purpose and results imply that batching strategy, scheduling rules and two specification parameters largely influence the LTE, while, processing routine has less impact in this case.

Keywords Data mining · Lead time · Radio frequency identification (RFID) · Real-time · Shopfloor production

33.1 Introduction

Lead time estimation (LTE) is significant since it exclusively influences customer relations and shopfloor management practices (Alexander 1980). The direct outcome of LTE is due data quoting which indicates the commitment to meet

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E. Qi et al. (eds.), *The 19th International Conference on Industrial Engineering and Engineering Management*, DOI: 10.1007/978-3-642-38391-5_33,

customer orders on time (Chen and Prorok 1983). Shorting lead time is commonly used in the manufacturing companies to improve their images and future sales potentials. However, only its shorting is not adequate because customers always require the accurate and precise estimation of lead time so as to ensure their production and delivery due date.

There are several challenges when contemplating to carry out LTE. Firstly, large number of factors such as the process routine, batching strategy, and scheduling rules affects the lead time. The studies of their influences on the LTE are limited, not only in qualitative aspects, but also quantitative facets (Jun et al. 2006). Secondly, it is commonplace that most portion of lead time is spent upon either waiting in queues and transit. Actual processing time is difficult to estimate due to the dynamic manufacturing environment and uncertain disturbances. Thirdly, LTE heavily relies on the statuses of various manufacturing objects such as machines, operators and materials, whose real-time information is hardly captured. Therefore, the contingent situations deteriorate its accuracy and effectiveness.

In order to tackle the above challenges, large number of methods has been proposed to improve the precision, efficiency and effectiveness of LTE (Ozturk et al. 2006; Ruben and Mahmoodi 2000; Sudiarso and Putranto 2010; Ward 1998). However, these methods only concentrate on analytical, experimental and heuristic aspects. Real-life cases are limitedly reported and studied.

This research is motivated by a real-life automotive manufacturer who has applied RFID technology to support the real-time production on its manufacturing shop floors over 5 years. Great myriad of data has been captured, representing the typical manufacturing objects like machines, operators and materials. Due to the application of RFID technology, shop floor production has been significantly improved (Dai et al. 2012). The senior manager contemplated to explore the lead time from such massive RFID-enabled shopfloor data. Thus, a research team formed by a group of experts from collaborating universities investigated the entire company and decided to apply data mining for this purpose.

Several research questions are concerned in this paper. The first question is what aspects can largely affect the LTE and how we can examine their effects on the estimation. The second question is how we can work out the practical and precise lead time under the RFID-enabled real-time production ambience.

In order to answer the above questions, this paper proposes a data mining model for estimating the lead time from the RFID-enabled shopfloor production data. It includes four steps: data cleansing, data clustering, pattern mining and data interpreting, each of which is equipped with suitable mathematical models. The objectives of this paper are to quantitatively examine the key factors which can influence the LTE as well as to figure out the precise lead time for various product series.

33.2 Related Work

Related work can be categorized into three domains. They are lead time estimation (LTE), data mining as well as production planning and scheduling.

33.2.1 Lead Time Estimation

LTE is significant in planning shopfloor operations, thus, many research has been carried out. Three types of LTE procedures are studied so as to figure out the effectiveness shopfloor information in bottleneck-constrained production system (Ruben and Mahmoodi 2000). This work indicates the reduction of bottleneck shiftiness that is based on the excess capacity at non-bottleneck work centers. A data mining approach with regression tree was proposed for LTE in make-to-order manufacturing (Ozturk et al. 2006). This research uses a large set of attributes to work out the prediction and then compares with other methods from the literature. Another approach using a heuristic algorithm was introduced to estimate the lead time of a complex product development process (Jun et al. 2006). This paper adopts computational experiments to show the effectiveness and efficiency of the reduction of makespan of branch-merge types. Some factors influenced the LTE were examined in a make-to-order company by a mathematical models (Sudiarso and Putranto 2010). The experiment results imply the usefulness of the fuzzy approach for estimating the lead time without simulations.

33.2.2 Data Mining

The basic concepts and techniques of data mining were introduced by Han et al. (2011). Planning and data mining approach was integrated to create better planners under the background of unmanned and manned space flight (Frank 2007). This paper reviews the current work in this area and integrates some technologies for opening research issues. A RFID-enabled data mining model was demonstrated to collect the data and analyze the data for exhibition industry (Wang et al. 2009). This model integrates the exhibitor and relational customers by the data mining model when executing planning. The nature and implications of data mining techniques in manufacturing and implementations on two fields—product design and manufacturing were discussed (Wang 2007). That illustrates the methodology enabled engineers and managers to understand large amount of data by extracting useful information. A wide and comprehensive review of data mining used in manufacturing field was investigated in order to reveal the progressive applications and existing gaps (Choudhary et al. 2009).

33.2.3 Production Planning and Scheduling

Production planning and scheduling (PPS) addresses decisions on the acquisition, utilization and allocation of manufacturing resources to meet customer requirements through most efficient and effective manner (Graves 1999). In theoretical facet, a multi-period mixed integer linear programming model so as to deal with the simultaneous planning and scheduling under the back ground of single-stage multi-product continuous plants with parallel units (Erdirik-Dogan and Grossmann 2008). A bi-level algorithm is proposed to integrate MILP model and iterative approach within the upper and lower levels. An entire review on PPS was done in terms of major models, solution strategies, challenges as well as opportunities (Maravelias and Sung 2009). That reveals the new area of real-time planning and scheduling through new technologies like Auto-ID such as RFID technology.

33.3 RFID-Enabled Real-Time Shopfloor Production Environment

The RFID-enabled real-time shopfloor could be regarded as a hybrid flow-shop. There are several stages, each of which contains multiple machines with same functionality. Each stage has a job pool that arranges jobs for each machine. Two concepts are critical and detailed illustrated in our previous work (Dai et al. 2012; Huang et al. 2009).

Each machine is equipped by a RFID reader and materials are deployed by RFID tags. Machine operators carry tags as staff cards. Once deployed by RFID, they become smart objects (SOs) that can sense, reason and interact with each other. SOs dynamically generates observations associated with the timestamps and location changes, carrying significant and useful information.

The typical RFID observations include four categories: worker, machine, material and job. Worker data contains personal and operation information. Personal information is stored in a staff card. It indicates which machines and what types of work can be operated by a worker. Operation information involves a worker's critical behavior data such as processed jobs, locations, start and finish time, quality, and quantity. The information implies who did what at what time in where. Machine data includes general and behavior information. General information contains device type, technical parameters, etc. Behavior information involves its operators, processed jobs, processing time, and performance. The information represents the activities a machine performed and is significant to explore machine utilization. Material data comprises property and trajectory information. Property information includes specification, texture, etc. Trajectory information embraces location, shippers, in-time and out-time, as well as handover time. It memorizes the movements of various materials and their changes of statuses. Job data include instructions, standard operation times, times when a job enters and leaves a job pool, and priority. Job data can be updated at different stages through downloading from databases.

This company has accumulated over 5 year's data. We extracted the data from 03/2008 to 12/2010 with a size of 12.2 GB for LTE. Specifically, 16.9 million pieces of data are picked up. After data cleansing and clustering, 1.1 million effective and typical pieces are chosen. Further statistics and sampling approach has been adopted to select a suitable amount of data for specific analysis.

RFID shopfloor data have several characteristics. Firstly, these data are generated automatically and instantly, thus the volume is super large due to the daily production operations. Secondly, while the accuracy of current RFID application in shopfloor production is improving, there are still some errors such as duplicated, missing and uncompleted data. Thirdly, RFID data involve large number of information which reflects the practical situations in a RFID-enabled ubiquitous manufacturing environment. Physically, each piece of RFID data keeps the statuses of workers, machines and materials within the entire production cycle. Logically, a set of RFID data imply the production disciplines such as logistics trajectory, lead time fluctuation and their key impact factors.

33.4 A Data Mining Model for Estimating Lead Time

In order to suit the above characteristics, this section proposes a four-step data mining approach, each of which is equipped with a suitable mathematical model. The four steps are data cleaning, data clustering, pattern mining and data interpreting.

33.4.1 Data Cleaning

A piece of RFID-enabled shopfloor data is formatted and expressed as: *d* = *<BatchID, TaskID, EPC, ProcessID, StartTime, FinishTime, Quantity>*. That means a batch of materials (*BatchID*) with certain amount (*Quantity*) from a customer order (*TaskID*) is processed by an operator (*EPC*) in a machine (*ProcessID*) from *StartTime* to *FinishTime*. The lead time is the sum of all the actual processing time within all the manufacturing stages.

However, there are some noises such as incomplete, missing and duplicated data. An improved cleansing model is used in this paper which integrates the adaptive cleaning method with filter rules from (Rao et al. 2006; Jeffery et al. 2006). The purpose of this model is to detect and remove corrupt or inaccurate records from raw RFID data. The model is simplified as follows:

$$D = [d_i] \tag{33.1}$$

where

$$d_i = [B_{i1}, T_{i2}, EPC_{i3}, P_{i4}, S_{i5}, F_{i6}, Q_{i7}]$$

with filter rules formulated as a vector function:

$$Fun = \; < F_1(\alpha_{ij}), F_2(d_i, d_{i+1}), F_3(\alpha_{i5}, \alpha_{i6}), F_4(\alpha_{i7}) \; > \; 1 \le i \le n, \; 1 \le j \le 6$$

33.4.2 Data Clustering

The cleansed RFID data are clustered by using support vector machine (SVM) manner for several reasons. Firstly, SVM adopts supervised learning methods to analyze data and recognize patterns (Joachims 1999). Different categories are divided by a clear gap. That is easy to classify the RFID data which may have tinny differences. Secondly, multiclass SVM enables the classifications from several elements like product series, machines etc. Meanwhile, the bounds on error of classification could be avoided by maximizing the margin and the over-fitting could be minimized by selecting the maximal margin hyperplane in the feature space (Wang et al. 2004).

This paper uses multiclass SVM model to cluster RFID data. The purposes are to generate various data aggregations by different standards first, and second to classify the aggregations by different impact factors. The model is formulated as:

$$D' = \{(x_i, y_i) | x_i \in \vartheta^p, y_i \in \theta\}_{i=1}^n \tag{33.2}$$

33.4.3 Pattern Mining

Least square (LS) is used for establishing the patterns from a set of RFID-enabled data. LS minimizes the sum of the squares of the errors in every single equation (Geladi and Kowalski 1986). Specifically, this paper adopts least square polynomial fitting (LSPF) to work out the best fit in the least-square sense that minimizes the sum of squared residuals. Then, the models from the best fit are selected for predicting the processing time for different stages. The sum of processing of different stages is lead time for a specific product series. In addition, the eigenfunctions of key factors are obtained by LSPF with diversified degree of polynomial to examine the effect on the estimates.

The model from LSPF is

$$S^*(x) = \sum_{i=0}^{n} a_i^* \varphi_i(x) \tag{33.3}$$

$S^*(x)$ meets the constrain:

$$\|\delta\|_2^2 = \min_{S(x) \in \varphi} \sum_{i=1}^{m} [S(x_i) - y_i]^2$$

33.4.4 Data Interpreting

The above extracted models must be further interpreted for several reasons. Firstly, these models must be evaluated in a confidence interval to give the assurance that the data provided by them are correct. Polynomial interpolation and residual analysis are used for this purpose. Secondly, the raw RFID data may be normalized by different and heterogeneous methods within different steps. Data interpreting ensures that the values from the models could be understood in diversified applications. Finally, the predicted values may be used by different applications like ERP, APS with standardized format.

The data interpretation model is formulated as:

$$Y = \Phi(S^*(x)) \tag{33.4}$$

where Φ is an interpretation function that contains a set of functions in a vector to interpret the values in different applications. For example, to identify the lead time of a specific product series, Φ can be specifically expressed as:

$$y_i^* = S^*(x_i)(\alpha_1, \alpha_2, \ldots, \alpha_n)(\omega_1, \omega_2, \ldots, \omega_n)^T$$

where α_i represents an impact factor with its weight ω_i.

33.5 Experiments and Discussion

33.5.1 Experiment Design

There are several product series which are divided into categories of diesel, passenger, and racing cars etc. The experiment takes S-series used in passenger vehicles for example. S-series is determined by three key parameters: total length (TL), head diameter (HD) and stem diameter (SD). The production of such product follows batch mode. Each batch contains 180 pieces. The lead time is defined as a batch passes through all the manufacturing stages before shipping to the customer. Figure 33.1 demonstrates the S-series products with different processes and total process time. LTE has been based on the times which have been obtained from past experiences or time study. It is obtained from the sum of each process as shown in the bottom of Fig. 33.1 (S00: 330 m, S-01: 340 m and S-02: 420 m, m means minute). However, they are greatly varied and affected by some key factors when executing real case.

There are three categories in s-series. They are S-00, S-01 and S-02 with 10, 9 and 12 processes (stages). Their specifications are 100*40*8, 100*50*10 and 100*70*12 respectively. Figure 33.2 presents a statistics analysis on the three categories. The statistics data comes from the RFID-enabled real-time shop floor data within 10 months which are the peak season of this company. Each point represents the mean value of a month. The mean values of three categories are 328.7, 345.6 and 423.6 with the standard deviations are 17.6, 20.0 and 16.1. From the experiences, this company allows 60 % of the standard deviations. Therefore, the interval of lead time can be worked out with the maximum values as criteria in peak season, while, minimum values in off-season. The intervals for S-00, S-01 and S-02 in this case are [339.26, 318.14], [357.6, 333.6] and [433.26, 413.94].

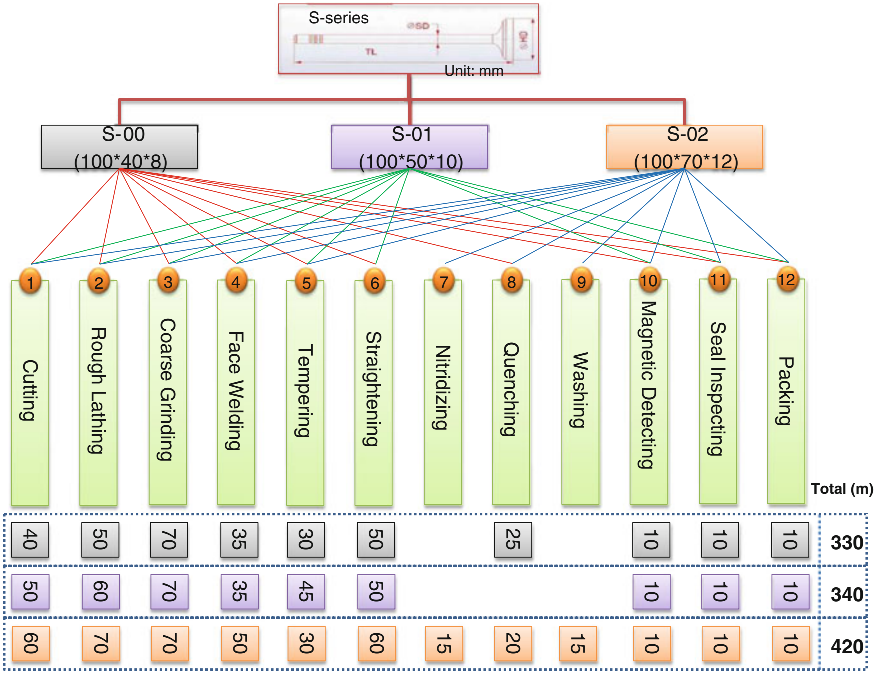

Fig. 33.1 S-series product processes with standard operation time

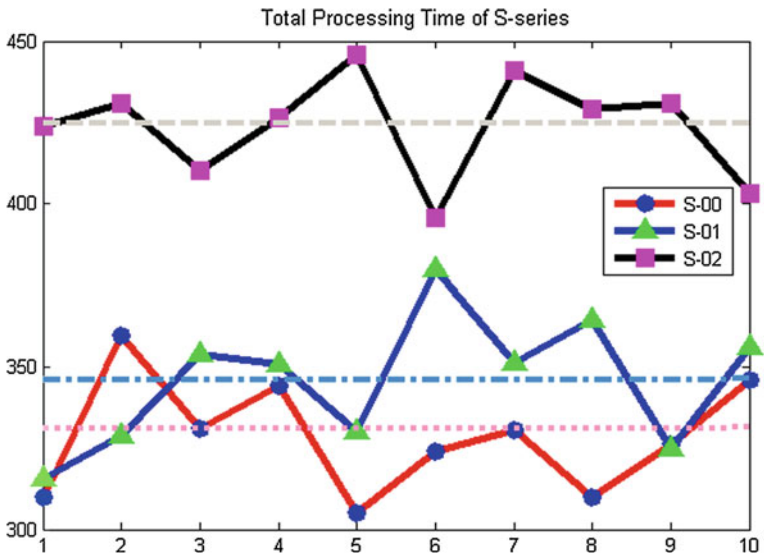

Fig. 33.2 Deviation of lead time within S-series

33.5.2 Analysis of Key Impact Factors

Lead time is commonly influenced by several factors, especially in the RFID-enabled real-time shopfloor production due to the quick data intercommunication among different manufacturing units and just-in-time (JIT) production fashion. The typical impact factors are process routine, batching strategy, scheduling rules and product specification. Figure 33.3 reports on the examinations of these impact factors and their analysis by using the proposed data mining model on RFID-enabled shopfloor data.

The process routine means a batch of material moves from the beginning of operation to the end of operating stage. Within these stages, several processes could be interchangeable. Ten groups of data from three product series with different processes routines are extracted to examine their impacts on LTE. LSPF with 2nd degree polynomial is used to figure out the characteristics curves of the process routine. The curves imply the minor impact on lead time in this case.

The batching strategy is examined by LSPF with 2nd degree polynomial. The characteristics curves of its impact on LTE are shown on the upper right diagram. With the increasing of quantity in a batch for three product categories, the lead time greatly increases with the rate of 0.29, 0.31 and 0.19 respectively. It is observed that the less quantity in a batch causes more batch amount, while, the processing time increases. But the increase rate is lower than that caused by the

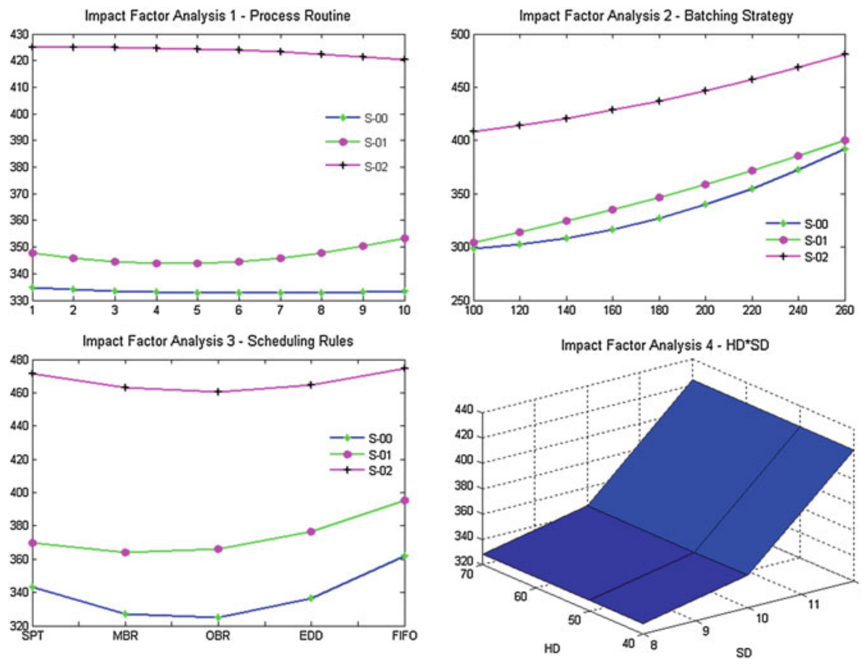

Fig. 33.3 Analysis of different impact factors

quantity increment in a batch. In order to balance the confliction, this company compromises a decent quantity—180 pieces in a batch.

Five scheduling rules are examined in this paper to evaluate their impacts on LTE. They are SPT (Shortest Processing Time), MBR (Material-based Rule), OBR (Order-based Rule), EDD (Earliest Due Date) and FIFO (First in First out). They are applied for the S-series product for generating their lead time. It is observed that they greatly influence the LTE with maximum impact rate of 0.14 and 0.13 respectively. The most suitable rules for this case are MBR and OBR which sequence jobs (batches) by material property and order information.

Two parameters of product specification are examined. They are HD and SD. The 3-D diagram in Fig. 33.3 demonstrates their impact on the LTE. The lead time slightly increases when HD $\in$ [40, 50] and SD $\in$ [8, 10]. However, when HD $\in$ (50, ∞) and SD $\in$ (10, ∞), the lead time sharply increases. It implies that these two factors largely influence the lead time when they reach a certain point (e.g. 50 and 10 mm) in this case. It is significant to instruct the estimation of processing time or lead time when the customer's requirements meet the situations.

33.6 Conclusion

This paper introduces a data mining model to analyze the lead time estimation (LTE) in RFID-enabled real-time production environment. A typical product with three categories has been examined for estimating the lead time. After that, four key factors are scrutinized to find their impacts on LTE. It is observed that, in this case, processing routine almost do not affect LTE, while, batching strategy, scheduling rules as well as head diameter and stem diameter largely influence LTE. This paper works out the intervals for predicting the lead time and optimal quantity in a batch as well as quantitative analysis of the above key factors so as to guide the LTE.

Future research will be carried out from two aspects. Firstly, case-based reasoning (CBR) will be concerned to solve new problems by using the meaningful RFID shopfloor data. Secondly, the data mining model can be extended to explore the practical processing time, setup time for real-time production planning and scheduling in the RFID-enabled real-time environment.

Acknowledgments Authors would like to acknowledge National Natural Science Foundation of China (61074146), International Collaborative Project of Guangdong (gjhz1005), Modern Information Service Fund 2009 (GDIID2009IS048), Guangdong Department of Science and Technology Fund (2010B050100023). Special acknowledgements would be given to Key Laboratory of Internet of Manufacturing Things Technology and Engineering of Development and Reform Commission of Guangdong Province.

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Chapter 34
Evaluation of Green Residence Using Integrated Structural Equation Model with Fuzzy Theory

Michael H. Hu, M. Y. Ku, C. K. Liao and P. Y. Ding

Abstract The feasibility of constructing green residential houses was investigated by analyzing questionnaires designed to collect relevant information coped with indices and design characteristics for green residential houses. The questionnaire answers were analyzed using the SPSS18.0 software to carry out descriptive statistical analyses, and the SEM with fuzzy theory to perform model suitability analyses. The objective of these analyses is to evaluate and identify the factors that practical affect the construction of green residential houses. Results of analyzing questionnaire answers reveal that as high as 80 % of the general public agrees to purchase green residential houses. The results obtained in this research indicate that these characters must be considered as important factors when developing green residential houses with qualities meeting demands of the general public so that a win–win situation can be achieved for both developer and consumers.

Keywords Fuzzy theory · Green residential houses · Residential houses · Structural equation model

34.1 Introduction

Green environmental protection is currently a topic that is concerned the most in our society. In 1996, the Administrative Yuan established the "National Sustainable Development Committee" and actively promoted the policy of developing

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E. Qi et al. (eds.), *The 19th International Conference on Industrial Engineering and Engineering Management*, DOI: 10.1007/978-3-642-38391-5_34,

green buildings as proclaimed in "Building White Paper" published earlier in the same year. Further, the Administrative Yuan approved "Project to Promote Green Buildings" on March 8, 2001 and implemented the "Green Building Logo" system (National Council for Sustainable Development Network). Although started a little late, these implementations led to obvious accomplishments; Taiwan became the fourth nation in the world that officially put certification of green buildings into practice. Therefore, the factors that affect the practicality of constructing green residential houses are studied in this research so that the difficulties that may be encountered to promote green residential houses will be identified. The results will provide valuable recommendations to be referenced by Government for future promotion of green residential houses in Taiwan.

34.2 Literature Review

In recent years, a green upsurge in construction is on the rising internationally; variations nations and relevant organizations actively promote the implementation of green products in daily applications that enable the popularity of green residential house internally. Our nation also actively promotes green buildings through rewarding and subsiding the design and construction of green buildings. However, the percentage of green residential houses on the real estate market is not as high as expected. In this research, the practicality of implementing green residential houses will be studied to identify the future trend for promoting green residential houses that is accepted by both builders and buyers.

34.2.1 Definition of Green Residential Houses

Housing is one of the basic needs to satisfy the six people's livelihood of eating, clothing, housing, transportation, education and entertainment; traditional housing simply provides sheltering. With social and economical advances, the need for quality residential houses becomes increasingly demanding. In addition to providing a safe and comfortable sheltering, green residential houses are becoming a concerned emphasis. The definition of green residential houses is discussed in this section.

a. Definition of Residence

"Residence" refers to the house that provides either a permanent or temporary shelter for the occupant to live and perform daily activities. As defined in Wikipedia (Baidu Baike 2011), a residence is an establishment where it was originally or currently being used by a host as their main place of dwelling or home. This is used as the definition of "residence" in this research.

b. Definition of Residential House

Green buildings that recently emerge in Taiwan cover a wide range of buildings. Green residential house is a part of green building. Although most scholars have proposed the definition of "green residential houses", this term has not been clearly defined. Based on literature information, the "green residential house" is defined in this research as "the residential house that is constructed based on the concept of low carbon with natural ventilation and lighting to reduce energy requirement and wastewater discharge". A green residential house is a house that can breathe by itself in some sense.

c. Characteristics of Green Residential Houses

A green residential house has the following integrated characteristics:

1. Ecological Consideration: The broad sense of this consideration was proposed in 1997 by Kuo and Kuo (1997) based on the viewpoint of ecological environment. It is based on the overall consideration to target energy source protection, climate regulation, and resource implementation for accomplishing the objective of ecological environment. A more specific definition is applying the characteristics of cultivated plants and green technology to reinforce or improve the building and foundation environment. The above statements are integrated to define the ecological consideration of green residential houses as: the combination of local environment and relevant climate to make a place for human living using natural design to reduce impacts on environment, and achieve ecological balance.
2. Energy Saving Consideration: In 1999, the Architecture and Building Research Institute, Ministry of the Interior (Taiwan) (Lin 1999), proposed four groups of green building indices; energy savings is an important index group. If a residential house meets the requirement of a green residential house, it must have the characteristics of achieving energy saving. Hence, in this research, the green residential energy saving features include facilities that lead to savings of water and energy. These features may include solar water heater, and water-saving apparatus and pipeline design to achieve conservation of water, energy and other natural resources.
3. Water Reducing Consideration (Taiwan Architecture and Building Center): For each square meter of reinforced concrete buildings constructed in Taiwan, about 1.8-kg dust is produced that seriously threatens human health. A medium-height residential building generates about 0.14 cubic meters of solid wastes during the construction period; if demolished and removed later, the building will generate 1.23 cubic meters of more solid wastes. Thus, the ultimate treatment and disposal facilities are heavily loaded by the large quantity of construction wastes (Web-site of Taiwan Architecture and Building Center). Therefore, green residential houses are constructed with natural materials that are environmentally friendly and recoverable to reduce the waste quantity so that the impact on environment can be alleviated.

4. Health Consideration: Lin (2005) proposed that the green buildings is an ecological, energy-saving, waste-reducing and healthy building indicating that promoting the health of occupants is an important characteristics of a green residential house. The quality of living environment affects to a great extent the physical and mental health of the occupants. Green residential houses apply the design of natural ventilation and external solar shed to reduce the energy consumptions on indoor artificial heating, ventilation and air conditioning as well as lighting while providing a healthy and comfortable living environment.
5. Sustainable Consideration: Kuo and Kuo (1997) proposed that during its life cycle, a building should provide the optimal and most comfortable and healthy living environment with the lowest energy consumption, most efficient management and resource application, and the least damages to environment. Hence, symbiotic existence of human, building and environment with mutual benefits can be achieved to accomplish sustainable development. In this research, the sustainable characteristics of green residential houses is based on the concept of sustainable development design to alleviate environmental damages, and to assure that future environmental development is compatible with the earth so that sustainable development of our living environment is assured.

34.2.2 Structural Equation Model

Structural Equation Modeling (SEM) is also called the "Analyses of Covariance Structure or Linear Structure Equation" that is a statistical method for analyzing case-and-effect results and examining assumptions (Chen 2007).

a. Application of Structural Equation Model (SEM)

Huang (2006) has pointed out that SEM is the most important emerging statistical method for quantifying information in modern sociology; it has been extensively applied in the various fields such as management science, psychology and economics.

b. Chartered Financial Analyst (CFA)

CFA is used for testing validity to examine the significant and structure of latent variables.

The above introduction of SEM reveals that SEM is a research and analysis method of statistical analysis technology for dealing with complicate multivariate information and data. In this research, the CFA available in SEM is used to develop factors for evaluating green residential houses so that the results are reliable and valid.

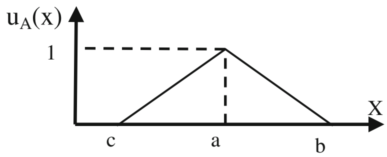

Fig. 34.1 The membership functions of a triangular fuzzy number

34.2.3 Fuzzy Theory

The Fuzzy Theory that was proposed by Prof. Zadeh in 1965 emphasizes that the concept of human thinking, inferring and cognitive ability is somewhat fuzzy for solving uncertain and fuzzy problems encounter in a real world. Chien (2009) considered that the fuzzy theory can be used for solving decisions not only for policy making but also for daily life related matters such as fuzzy control of variable frequency air conditioning unit. In recent years, the fuzzy theory has been integrated with many other methods including grey relational analyses, TOPSIS and AHP, among the many others.

Values of the fuzzy semantic variables are also called semantic values; they can be expressed by defining the base variable of a fuzzy membership function (Zimmermann 1987), or the membership function can be considered as quantified attributes of semantic values. The triangular fuzzy number A in the region of real number R indicates that any $x \in R$ is designating a number $u_A(x) \in [0, 1]$, and that:

$$u_A(x) = \begin{cases} (x-c)/(a-c), c \le x \le a \\ (x-b)/(a-b), a \le x \le b \\ 0 \end{cases} \tag{34.1}$$

The triangular fuzzy number can be expressed by A = (c, a, b) with the function value between c and b of $u_A(x)$, and the maximum membership of 1. The region between c and b refers to the possible upper and lower boundaries of the evaluation data. Regions between c and a, and between a and b reflect the fuzziness of the data as shown in Fig. 34.1.

Based on the above statements, the fuzzy theory is applied in this research for evaluating the degree of importance attached to the various factors of green residential houses. The importance of these factors is prioritized as the standards for accessing green residential houses.

34.3 Methodology

The objective of this research is to apply the combined structural equation model (SEM) and fuzzy theory for investing the possibility of developing green residential houses in Taiwan. Additionally, questionnaires are distributed to residence living in Taichung (Taiwan) region for understanding their need and degree of

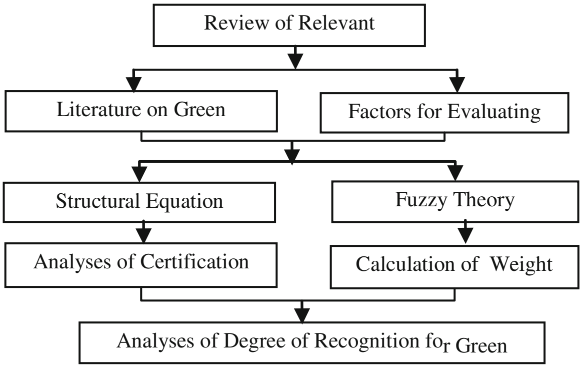

Fig. 34.2 Research structure

recognition of green residential houses, and the feasibility of developing green residential houses in Taiwan.

34.3.1 The Research Structure

Based on the viewpoint of consumers, this research is carried out for investigating the factors of green residential houses that satisfy the need of general public. Review of literature leads to the factors that influence the construction of green residential houses as included in the following research structure (Fig. 34.2):

34.3.2 Research Model

Based on the review of literature on green residential houses, the factors used in the model for evaluating green residential houses are grouped into three major dimensions: "Indoor Environment", "Energy Saving Facilities" and "Community Environment" as illustrated in the follows:

1. Indoor environment: The occupants of the green residential house enjoy a comfort and leisure life provided by appropriate residential lighting, ventilation and insulation.
2. Energy saving facilities: The objective of green residential house is achieved by providing energy saving features such as electricity saving, water saving and noise insulation.
3. Community environment: The residence of a community can enjoy the green residential houses only if the community environment and facilities are well planned such as wastewater treatment facilities, green zone, storm water drainage, and facilities to recover garbage.

34.3.3 Fuzzy Theory Procedures

The fuzzy theory that is used for solving uncertain and fuzzy problems encountered in the real world is implemented in this research using the following procedures.

Procedure 1: A fuzzy preference order matrix is established to evaluate the semantic variables expressed by K professionals and experts based on each criterion. After evaluating the m projects (Ai, i = 1,…, m) based on n criteria (Cj, j = 1,…,n) for k professionals and experts, geometric mean is used to integrate the evaluation results to yield fuzzy preference order matrix as follows:

$$\tilde{D} = \begin{bmatrix} \tilde{x}_{11} & \tilde{x}_{12} & \cdots & \tilde{x}_{1n} \\ \tilde{x}_{21} & \tilde{x}_{21} & \cdots & \tilde{x}_{21} \\ \vdots & \vdots & \ddots & \vdots \\ \tilde{x}_{m1} & \tilde{x}_{m2} & \cdots & \tilde{x}_{mn} \end{bmatrix} \forall i,j \tag{34.2}$$

where: $\tilde{x}_{ij} = \left(a_{ij}, b_{ij}, c_{ij}\right)$ is a triangular fuzz number that represents the fuzzy value of ith prospective project in the jth criterion. The following equation is used to normalize the fuzzy matrixbb $\tilde{R} = \left[\tilde{r}_{ij}\right]_{m\times n}$:

$$\begin{aligned} \tilde{\mathrm{r}}_{\mathrm{ij}} &= \left(\frac{\mathrm{a_{ij}}}{\mathrm{c_j^+}}, \frac{\mathrm{b_{ij}}}{\mathrm{c_j^+}}, \frac{\mathrm{c_{ij}}}{\mathrm{c_j^+}}\right),\ \mathrm{j} \in \mathrm{B}\ \mathrm{c_j^*} = \max_{\mathrm{i}}\ \mathrm{c_{ij}}\ \mathrm{if\,j} \in \mathrm{B} \\ \tilde{\mathrm{r}}_{\mathrm{ij}} &= \left(\frac{\mathrm{a_j^-}}{\mathrm{a_{ij}}}, \frac{\mathrm{a_j^-}}{\mathrm{b_{ij}}}, \frac{\mathrm{a_j^-}}{\mathrm{c_{ij}}}\right), \mathrm{j} \in \mathrm{C}\ \mathrm{c_j^-} = \max_{\mathrm{i}}\ \mathrm{a_{ij}}\ \mathrm{if\,i} \in \mathrm{C} \end{aligned} \tag{34.3}$$

The five classes of fuzzy semantic conversion scale proposed by Chen and Hwang (1992) are used to evaluate the importance attached to green residential houses to convert the semantic expression into fuzzy numbers as shown in Table 34.1.

Procedure 2: Weighed coefficients: The weight of each evaluation condition can be calculated; the weight of evaluation attribute is $w_i = (w_1, w_2, \ldots, w_m)$. In this research, a simpler gravity method developed by Yager (1980) is used to perform fuzzy sorting. Results of equation derivation show that the sorting of centroid fuzzy values for the fuzzy triangular function can be expressed by Eq. (34.4). The

Table 34.1 Correspondence of fuzzy semantic expressions to fuzzy number

Evaluation scale	Fuzzy semantic expression	Fuzzy number
1	Significantly not important	(0,0,0.3)
2	Not important	(0,0.25,0.5)
3	Neutral	(0.3,0.5,0.7)
4	Important	(0.5,0.75,1)
5	Significantly important	(0.7,1,1)

Source of Information (Chen and Hwang 1992) opinions expressed by experts are integrated using triangular fuzzy numbers Buckley (1984), and Eq. (34.5) is used to calculate the geometric mean of the results. The sorting of the centroid fuzzy for the integrated fuzzy triangular function is expressed as follows:

$$R(\tilde{A}) = \frac{1}{3}(l_A + m_A + u_A) \quad (34.4)$$

$$W_i = \left(\prod_{i=1}^{n} R(\tilde{A})\right)^{\left(\frac{1}{n}\right)} i = 1, 2, \ldots, n \quad (34.5)$$

Procedure 3: Preference Aggregation: The algorithm using the two triangular fuzzy numbers calculation, $\tilde{a}_1 = (a_1, a_2, a_3)$ and$\tilde{b} = (b_1, b_2, b_3)$ as proposed by Zadeh.

Procedure 4: Normalized weighted fuzzy matrix is developed:

$$\tilde{V} = \lfloor \tilde{v}_{ij} \rfloor_{\mathrm{m}\times\mathrm{n}}, \mathrm{i} = 1, 2, \ldots, \mathrm{m},\ \mathrm{j} = 1, 2, \ldots, \mathrm{n} \quad (34.6)$$

where: $\tilde{v}_{ij} = \tilde{r}_{ij} \times \tilde{W}_{ij}$ with value between [0,1]; $\tilde{W}_{ij}$ is the weighted fuzzy value of the jth criterion.

Procedure 4: Defuzzification: There are many method of defuzzification. In this research, the method proposed by Chen and Hsieh (1999) is used by assigning $A_i = (a_i, b_i, c_i)$, i = 1,2,…,m, as m triangular fuzzy numbers. R(Ai) indicates the representative value of triangular fuzzy number for the ith person being evaluated. The equation is:

$$R(A_i) = \frac{a_i + 4b_i + c_i}{6} \quad (34.7)$$

34.4 Analyses

Through reviewing literature on green residential houses, relevant residential factors are summed up. After analyzing the information collected using questionnaire and studying the sample structural analyses, confirmation factor analyses, and fuzzy theory, the factors that can be implemented and the items that the general public prefers when purchasing green residential houses can be found. The questionnaire results indicate that about 80 % of the general public has the willing to purchase green residential houses but wishes to pay not more than 10 % higher than a regular house with 5 % higher cost being the most acceptable.

34.4.1 Data Analyses

The SPSS 18.0 statistical software is used in this research for carrying out statistical analyses. The statistical methods include descriptive statistical analyses, reliability analyses and the various examinations. The overall model analyses are performed using AMOS 17.0, and finally the fuzzy theory is applied for find out the practicality of green residential houses and the order of importance for factors considered by the general public for purchasing green residential houses.

34.4.2 Factors Important to the Buyers of Green Residential Houses

The results obtained by perform the two-stage five-factor examinations are used to confirm the validity of the three assumptions proposed in this research. The explanations are provided in the following paragraphs:

1. Constructing green residential houses is an external latent variable that is reflected by the three internal latent variables, i.e. indoor environment, energy saving facilities and community environment. All coefficients obtained by conducting CFA examinations show are greater than 0.7 confirming that green residential houses can be evaluated using these three dimensions.
2. Indoor environment is an internal latent variable that is reflected by observing three variables.
3. Energy saving is an internal latent variable that is reflected by observing three variables.
4. Community environment is an internal latent variable that is reflected by observing four variables.

34.4.3 Fuzzy Theory

The fussy theory and the centroid method are used to determine relevant weighted value for investigating the factors important to constructing green residential houses in the Greater Taichung (Taiwan) region. Procedures for conducting the fuzzy theory are as follows:

Procedure 1: Standards for evaluation are established. In this research, the evaluation factor in “Dimensions for constructing green residential houses” are used to carry out the evaluation of factors affecting green residential houses as shown in Table 34.2.

Procedure 2: After the original matrix is developed, Eq. (34.5) can be used to evaluation the weight of attributes by calculating the fuzzy value of the various evaluation dimensions as shown in Table 34.3. The geometric average is then

Table 34.2 Factors for evaluating green residential house

Evaluation dimensions		Evaluation factors	
C1	Indoor environment	A1	Residential lighting
		A2	Residential ventilation
		A3	Residential insulation
C2	Energy-saving facilities	B1	Electricity saving facilities
		B2	Water saving facilities
		B3	Noise insulation
C3	Community environment	D1	Wastewater treatment facilities
		D2	Green area
		D3	Drainage
		D4	Facilities for recovering garbage

Table 34.3 Overall fuzzy evaluation results

Evaluation factors		Fuzzy number		
A1	Residential lighting	0.34	0.57	0.78
A2	Residential ventilation	0.31	0.54	0.75
A3	Residential insulation	0.30	0.53	0.74
B1	Electricity saving facilities	0.34	0.57	0.78
B2	Water saving facilities	0.36	0.59	0.79
B3	Noise insulation	0.38	0.61	0.81
D1	Wastewater treatment facilities	0.36	0.60	0.81
D2	Green area	0.29	0.52	0.73
D3	Drainage	0.32	0.55	0.76
D4	Facilities for recovering garbage	0.34	0.58	0.78

Table 34.4 Weight and ordering of green residential housing

Evaluation factors		Weight	Ordering
A1	Residential lighting	0.535	5
A2	Residential ventilation	0.500	8
A3	Residential insulation	0.490	9
B1	Electricity saving facilities	0.533	6
B2	Water saving facilities	0.550	3
B3	Noise insulation	0.571	1
D1	Wastewater treatment facilities	0.560	2
D2	Green area	0.482	10
D3	Drainage	0.513	7
D4	Facilities for recovering garbage	0.537	4

calculated to obtain the weight value and order of magnitude for various factors Table 34.4.

Procedure 3: Eq. (34.7) is used to defuzzify, calculate and sort. Order of factor important to the construction of green residential houses is shown in Table 34.5.

Table 34.5 Results of fuzzy analyses on green residential houses

Evaluation factors		Fuzzy solutions	Ordering
A1	Residential lighting	0.569	1
A2	Residential ventilation	0.537	2
A3	Residential insulation	0.527	3
B1	Electricity saving facilities	0.567	3
B2	Water saving facilities	0.583	2
B3	Noise insulation	0.604	1
D1	Wasterwater treatment facilities	0.593	1
D2	Green area	0.517	4
D3	Drainage	0.548	3
D4	Facilities for recovering garbage	0.572	2

Data in the above table reveal that the need of a green residential house with energy saving feather by the general public is relatively high. As the indoor environment is concerned, the residential lighting, which is related to energy savings, is also emphasized by the general public indicating that the general public has already acknowledged the importance of energy resources. Hence, further planning of green residential houses needs to emphasize the energy saving function in order to satisfy the need of consumers.

34.5 Conclusions

Results of investigation and analyses obtained in this research show that more than 80 % of the general public in Taiwan accepts green residential houses so that developing green residential houses is feasible. The general public also expresses that the green residential house costs less than 10 % more than a regular residential house so that 10 % cost difference is accepted. Additionally, developing green residential houses needs the cooperative efforts of government, developer and consumer. The government has to promote programs for dissimilating information on green residential houses, and encourage developers to construct more green residential houses through a rewarding system so that the general public is more willing to purchase green residential houses. Effective promotion of green residential houses will enable developer to base on specifications of green residential houses for selecting appropriate materials and methods to construct residential houses that are healthy and comfortable with low pollution and reduced energy consumption. The concept and advantages of green residential houses are dissimilated to the general public so that when purchasing residential houses, consumers consider green residential houses as the primary choice, and are willing to pay a little more for green residential houses. The idea of green residential houses can thus be implemented in Taiwan.

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Chapter 35
Evaluation of Population Age Structure Model Using Grey Clustering Theory

Bao-ping Chen

Abstract Due to the differences in economic development level and fertility policy enforcement, the population age structures are quite diverse from different regions in China. Thirty one provinces and Autonomous regions are used as clustering objects. Population from various age groups and Total dependency ratio are chosen as clustering indexes and whitening weight functions from corresponding indexes are defined. Meanwhile, clustering models of the population age structure assessment are provided and corresponding algorithms are compiled. Thirty one regions are divided into three groups by the age structure: excellent, normal, and poor. Then, sort again within each group to further analyze the reasons. The conclusion from our research provided a systematic, objective and accurate evaluation of age structure in various regions, it may has some reference value for solving China's population problems.

Keywords Cluster evaluating · Evaluation · Grey theory · Grey clustering · Whitenization weight function · Population age structure

35.1 Introduction

After several years of development, the grey system theory has centered on gray model as the core of the model system, which is built on gray equation, gray matrix, gray algebra system, etc., relying on the grey relation space analysis (Liu and Dang 2009). Grey clustering is a branch of gray system theory, which can be employed in the multivariate statistical analysis. Such method has been used to put the samples together in a multi-dimensional space and separate these samples with

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E. Qi et al. (eds.), *The 19th International Conference on Industrial Engineering and Engineering Management*, DOI: 10.1007/978-3-642-38391-5_35,

correlated measurement from each other. Edge on dealing with small sample problems, the grey clustering is one of the most applicable subjects in recent years.

The population problem is one of the key elements of China's social and economic development. Demographic statistics and the real world case reminds us that if the growth of population is out of control, the middle aged generation will make up the big foundation of pyramid-like age structure; if in the "only one child" policy, the senior generation will take place of the middle aged people with a mushroom-like age structure. After 1978, an aging population issue becomes unavoidable in China. Therefore, the age structure dilemma is not only a society problem, but a serious economic problem. The situation does not allow of any delay to deal with the current situation. There are a lot of useful researches of how age structures influence the growth of economy and CPI, and studies of different age structure among the regions (Dang et al. 2009). The examples of Liang Zhang, Elsie adjusting Leslie's Model of Population age structure (Zhang et al. 2011), Xiulin, Gen's The analysis about population age structure based on composition statistics (Gen 2011), Show ever, in all of these research papers, only few of them use grey model to demonstrate such situation.

The author apply the grey model of midpoint trigonometrical whitenization weight function to assess the composition of population age with its bring-up ratios in 2010 (all original data comes from China Statistical Yearbook 2010) and category the age structure into three regions. After the sorting, the author also analyzes which regions have the overwhelming age structure among the other two regions. The research shows that the grey model can easily assess the age structure of the population and also illustrate the aging degree of each area more objectively and accurately than other models.

35.2 Grey Clustering Theory and Model

Grey systems theory is an important ingredient in the development of information processing. Grey systems-based techniques are powerful tools in addressing those systems in which information is partially known and partially unknown. According to clustering object, Grey clustering can be divided into grey relation clustering and grey whitenization weight function clustering. Grey relation clustering is mainly used for the same incorporated factors to make complex system simplified. Gray whitenization weight function clustering is established through the grey Numbers whitenization weight function, which gets together all the different clustering objects to sort each other with same whitenization weight and finally judge which type those clustering are (Zhang G-h et al. 2011; Wang et al. 2011).

Gray whitenization weight function is a function which uses a quantitative description method to formulate the degree of grey of the grey cluster and then decide which type those clustering are. Whitenization weight function can be assured in real situation. When dealing with the real world cases, it can be either determined by the involved objects or obtained through the whole picture to determine all the similar sample objects of whitenization weight function. According to the Chinese age data, the author chose center point trigonometrical whitenization weight function of the grey evaluation model to make it a reasonable classification.

35.2.1 Center Point Triangle Whitenization Weight Function of Gray Evaluation Model

Assume there are N objects, m assessment index, s different gray clusters, for object I of index J sample observation value is X_{ij}, i = 1,2,3,…, n, j = 1,2,3,…, m, please make diagonal assessment according to the X_{ij} value for the corresponding object I. During sorting different grey cluster, we will determine the maximum of grey level as "gray center point". The following is the process of calculation:

Step1: Accordance with the evaluation requirements of grey number s, I define each grey cluster as 1,2,…, s, each of their center point as $\lambda_1, \lambda_2, \ldots \lambda_s$, in which of them maybe any kind of the target grey central point (not the center point necessarily). I also define the domain of each index as S correspondingly, which are $\lambda_1, \lambda_2, \ldots \lambda_s$.

Step2: Make connection $(\lambda_k,1)$correspondingly with$(\lambda_{k-1},0)(\lambda_{k+1},0)$ and get K gray triangle whitenization weight function to index J :$f_j^k(X_{ij})$ $(j = 1, 2, \ldots, m, k = 1, 2, \ldots, s)$. As the measured value X of index J, can be calculated each grey type (k = 1, 2,…, s) and its grey level $f_j^k(X_{ij})$ through the following function:

$$f_j^k(x) = \begin{cases} 0, x \notin [\lambda_{k-1}, \lambda_{k+1}] \\ \dfrac{x - \lambda_{k-1}}{\lambda_k - \lambda_{k-1}}, x \in (\lambda_{k-1}, \lambda_k) \\ \dfrac{\lambda_{k+1} - x}{\lambda_{k+1} - \lambda_k}, x \in (\lambda_k, \lambda_{k+1}) \end{cases} \tag{35.1}$$

Step3: Calculate the comprehensive clustering coefficient σ_i^k (i = 1,2,…,m; k = 1,2,…,s) from the objects I of their grey cluster K.

$$\sigma_i^k = \sum_{j=1}^{m} f_j^k(X_{ij}) \times \eta_j \tag{35.2}$$

Note: $f_j^k(X_{ij})$ is the subclass of Whitenization weight function of index J and η_j (j = 1,2,3,……,n) is the weight of Comprehensive clustering of index J.

Step4: Determine the level of the target sample object. If max $\{\sigma_j^k\} = \sigma_j^{k^*}$, and then we can reckons that objects I belongs to K*, we can get the further results of the class of each objects and order according to their corresponding comprehensive clustering coefficient value.

35.2.2 Advantages of Center Point Triangle Whitenization Weight Function

Comparing with other grey clustering methods, the center point triangle whitenization weight function is based on the most likely point λ_k as the center point of the level, so such kind of method can easily calculate center point triangle whitenization weight function of each grey clustering through $\lambda_0, \lambda_1, \lambda_2, \ldots \lambda_s, \lambda_{s+1}$. People can be more familiar with how to accurately get the center point of grey cluster than that of the intervals, therefore, any research conclusion based on such method might be more reliable and accessible.

35.3 Assessment of Real Case

When UN do population census, they usually begin with the age of 65. Generally, there are three categories by age: below 14, 14–65, 65 above (65 inclusive) (Zhang and Lei 2011). There is a fact we cannot ignore that china is a large country, so there are total different economic development among area, especially the east and west part of China (Bao 2012; Kang 2009; Ding 2012). Each area, which of the age structure is changing from middle adult to senior citizen and this gap expends gradually. The following is that the author applied the grey model of midpoint trigonometrically whitenization weight function to according to assess the composition of population age with its bring-up ratios in 2010 and category the age structure into three regions, all the data come from China Statistics Yearbook 2010.

35.3.1 Evaluation Model

Considering the different economic development among each area in China and the research result more reliable, the author will divide the 31 provinces, cities and autonomous regions into three parts: east, middle and West. East: Beijing, Tianjin, Hebei, Liaoning, shanghai, Jiangsu, Zhejiang, Fujian, Shandong and Hainan; Middle: Shanxi, NMG, Jilin, Heilongjiang, Anhui, Jiangxi, Henan, Hubei and Hunan; West: Sichuan, Guizhou, Yunnan, Guangxi, Shanxi, Gansu, Qinghai, Ningxia and Xinjiang. Age Data collected from all regions is below 14, 15–64 and 65 above (65 inclusive) and the number of population in each area. In addition, the author also adds young dependency rate and old dependency rate of each part of China. We can get the weight of age of below 14 years old through dividing the total amount of population of age below 14 years old by the total sample amount of population; similarly, we also get each weight of the age 15–64 and 65 above using the same method. Table 35.1 shows each weight of the three different age group, young dependency ratio and senior dependency ratio of the 31 cities.

The following is the process of evaluation:

Step1: as the sample matrix X:31 areas are the clustering objects ($i = 1,2,\ldots,31$), each age group weight from each region, as well as their dependency ratio correspondingly of each clustering index as J ($j = 1,2,3,4,5$).

Step2: divided each region into three categories: excellent, normal, poor, which means grey number S is 3, calculate each gray center point based on its mean, maximum and minimum value. For example, the age group of below 14 year old, its level center point of excellent level is 20, medium level is 15, and poor level is seven.

Table 35.1 The population structure parameters in 31 regions

City	The ratio of 0–14	The ratio of 15–64	The ratio of 65	Young dependency ratio	Senior dependency ratio
Beijing	8.62	82.66	8.72	10.41	10.54
Tianjin	9.81	81.68	8.50	11.99	10.43
Hebei	16.83	74.93	8.24	22.46	10.99
Shanxi	17.11	75.30	7.59	22.70	10.06
Neimenggu	14.08	78.35	7.57	17.99	9.65
Liaoning	11.43	78.26	10.31	14.59	13.17
Jilin	11.98	79.64	8.38	15.06	10.53
Heilongjiang	11.96	79.72	8.33	15.00	10.44
Shanghai	8.64	81.23	10.12	10.62	12.46
Jiangsu	13.01	76.10	10.89	17.09	14.31
Zhejiang	13.21	77.46	9.33	17.05	12.05
Anhui	17.98	71.83	10.18	25.03	14.17
Fujian	15.48	76.63	7.89	20.18	10.30
Jiangxi	21.88	70.52	7.61	31.02	10.77
Shandong	15.73	74.42	9.84	21.15	13.23
Henan	21.01	70.63	8.36	29.73	11.83
Hubei	13.91	77.01	9.08	18.07	11.81
Hunan	17.62	72.61	9.77	24.27	13.47
Guangdong	16.89	76.36	6.75	22.12	8.84
Guangxi	21.70	69.06	9.23	31.44	13.38
Hainan	19.95	72.20	7.84	27.71	10.80
Chongqing	16.98	71.47	11.54	23.76	16.17
Sichuan	16.96	72.08	10.95	23.54	15.19
Guizhou	25.21	66.22	8.58	38.10	12.94
Yunnan	20.73	71.63	7.64	28.93	10.65
Xizang	24.33	70.67	5.00	34.55	7.22
Shanxi	14.71	76.77	8.52	19.16	11.11
Gansu	18.14	73.61	8.25	24.67	11.19
Qinghai	20.96	72.82	6.22	28.75	8.66
Ningxia	21.43	72.22	6.35	29.79	8.89
Xinjiang	20.77	73.04	6.19	28.44	8.47

Step3: set up each whitenization weight function respectively in excellent, normal and poor level

as $f_j^k(X_{ij})$ (j = 1, 2, ⋯, m, k = 1, 2, ⋯, s) :

$$
\begin{array}{lll}
f_1^1[20,\ 26,\ -,\ 100], & f_1^2[15,\ 20,\ -,\ 26], & f_1^3[5,\ 15,\ -,\ -] \\
f_2^1[78,\ 83,\ -,\ 100], & f_2^2[73,\ 78,\ -,\ 83], & f_2^3[50,\ 73,\ -,\ 78] \\
f_3^1[-,\ -,\ 5,\ 7], & f_3^2[-,\ -,\ 7,\ 9], & f_3^3[-,\ -,\ 9,\ 14] \\
f_4^1[25,\ 39,\ -,\ 100], & f_4^2[21,\ 25,\ -,\ 39], & f_4^3[6,\ 21,\ -,\ 25] \\
f_5^1[-,\ -,\ 7,\ 10], & f_5^2[-,\ -,\ 10,\ 13], & f_5^3[-,\ -,\ 13,\ 17]
\end{array}
$$

Step4: calculate the comprehensive clustering coefficient σ_j^k from the objects i(i = 1, 2, …, 31) of their grey cluster k(k = 1, 2, 3). For example: σ_j^k of Beijing = {0.0937, 0.3728, 0.0000, 0.1137, 0.1313}.

Step5: Calculate grey cluster of each region using max $\{\sigma_j^k\} = \sigma_j^{k^*}$.

For example: max $\{\sigma_j^k\}$ of Beijing = max{0.0937, 0.3728, 0.0000, 0.1137, 0.1313} = 0.3728

Step6: Based on the value of $\sigma_j^{k^*}$ of each region and get the further sorting of each grey type, we can drive the conclusions as follows:

35.3.2 Analysis of the Results

From the 1970s, China has implemented the one-child policy, but the enforcement of this policy differs regionally. Due to the less developed economy and lack of prospection in central and western parts of the country, this policy is not strictly carried out, especially in the western parts of China, which results in high birth rate there because of relatively more tolerant policy environment, This situation result in the varying degree of aging in different part of China. During the research, the author found the assessment result was same as the real world case: Age structure in Sichuan, Guizhou, Yunnan, Tibet, Shaanxi, Gansu, Qinghai, Ningxia and Xinjiang have changed slowly, so these provinces haven't been in the stage of aging yet and have relatively more reasonable demographic structure than any other area. Some metropolis like Beijing, Tianjin and Shanghai, there is a large number of Talent Introduction under the age of 65, the demographic structure is still at a rational level in spite of some difference from Sichuan province. But in Liaoning, Heilongjiang, Shandong, Guangdong Province, and some parts of the western area, there are larger elderly population cardinal number and more speedy of aging, therefore, they have most prominent Irrationality in demography Table 35.2.

Table 35.2 The population structure clustering results in 31 regions

Sorting results	Provinces or cities(from excellent to poor)
Excellent	Hainan, Chongqing, Sichuan, Guizhou, Yunnan, Xizang, Shanxi, Gansu, Qinghai, Ningxia, Xinjiang
Normal	Beijing, Tianjin, Hebei, Shanxi, Shanghai
Poor	Neimemggu, Liaoning, Jilin, Heilongjiang, Jiangsu, Zhejiang, Anhui, Fujian, Jiangxi, Shandong, Henan, Hubei, Hunan, Guangdong, Guangxi

35.4 Discussion

As an appraisal and decision approach for Uncertainty Problem, grey clustering method is widely used in different area (Yuan and Liu 2007). We defined the Whitening weight function of Corresponding indicators based on the data from China Statistical Yearbook 2010, and build the Grey Clustering Model of the population age structure. As the result of the evaluation, it combined all the impacts from each of the sample data, much more close to the original properties of the subject being evaluated. For a country or a region, structure and changes of population age are the performance of the quality of the total population. It's not only related to the development of the population, but also the development of society and economy. Demographic theory reveals the age structure of the different types of the population and indicates different population reproduction scale, speed and development trend, which highlights various social economics and population problem. Just because of this, people pay much more attention of the population statistics and the composition of age structure of population. This paper strives to achieve objectivity and accuracy to evaluate of the age structure of each area of China and try to overcome any kind of human factors. This paper also is very helpful to be provided as a scientific reference to any interested scholars and researchers to solve the population problem.

Acknowledgments Project supported by the Science Research Projects of the Colleges and Universities in Inner Mongolia (NO.NJZY11106) and the Natural Science Foundation Project in Inner Mongolia (NO.2010 MS1007).

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Chapter 36
Evaluation of Recycle Level of Qaidam Salt Lake Circular Economy with Intuitionistic Fuzzy Entropy Measures

Fei Feng, Yu Liu, Jian Zhang, Nan Wang and Xiao-hui Xing

Abstract The purpose of this paper is to build the evaluation index system of Qaidam salt lake circular economy and sorting the programs according to the weights with the intuitionistic fuzzy sets conception. Intuitionistic fuzzy sets conception takes into account the objective and subjective weights comprehensive to determine weight, and then get the more accurately weight. This paper plays a referenced role for assessing the circular level of circulation in the Qaidam region.

Keywords Circular economy · Evaluation index system · Intuitionistic fuzzy entropy · Qaidam salt lake

36.1 Introduction

Circular economy is a completely new kind of ecological economy about human development raised by western countries. It is the economic model based on the reducing, reusing and recycling principles (known as the 3R principle) (Huang 2004). The real terms to develop circular economy is minimal resource consumption and the smallest environmental costs, to get maximize the development benefits, so as to unify economic, environmental and social benefits, and achieve the goal of sustainable development (Xiao 2007). Germany put forward the recycle economic Law in October 1996, and have done quite well in this regard.

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E. Qi et al. (eds.), *The 19th International Conference on Industrial Engineering and Engineering Management*, DOI: 10.1007/978-3-642-38391-5_36,

China was first reported circular economy in 1997 (Min 1997), it shows that Chinese late start in the circular economy.

Zhong et al. (2006) summed up in the present on recycle economic, China's mainly research recycle economic is concentrated in the following areas: firstly, the connotation and principle of recycle economics; Secondly, the role of the recycling economy and the impact on socio-economic; Thirdly, the discussion of the pattern of the recycle economic; Fourthly, the supporting conditions to achieve recycle economic. So, in the circulating levels of evaluation have not done enough, and some of them based steel. For example, Wenjie and Ma (2007) build a set of index system about ecological steel industry, include positive benefit and negative benefits, and use them evaluate the Chinese level of ecological steel industry in 2003; Cui et al. (2008) base on the present index system of circular economy and the evaluation index system of steel and iron industry clean production, and build evaluation index system of steel and iron industry based on circular economy. Ma et al. (2007) build index system and evaluation system of steel and iron industry by green manufacturing, and use DEA evaluate the green degree of Chinese eighteen steel and iron companies. But, now there is few people evaluate the level of salt lake circular economy, and it mainly still locate theory research phase. This paper analysis present salt lake resource situation and reference to the index system of steel and iron circular economy and Chinese index and evaluation system, and combine the feature of salt lake to build index and evaluation system, then use the intuitionistic fuzzy(IF) sets and empower weight algorithm to evaluation.

36.2 The Theory of Intuitionistic Fuzzy Sets and Aggregation Operators

Zhang (2006) pointed that there is gap of data in index system of recycle economic, so some index are fuzzy when statistical investigation. Hong and Choi (2000) and Li (2005) used to do useful exploration of decision problems based on the intuitionistic fuzzy sets. And intuitionistic fuzzy sets is characterized by taking into account the element of non-empty set degree of membership and non-membership information, and which makes the ability to express, more flexible, and more suitable to deal with the reality of the practical problems (Wang and Yang 2010).

36.2.1 Intuitionistic Fuzzy Sets

Intuitionistic fuzzy sets constitute a generalization of the notion of a fuzzy set and were introduced by Atanassov in 1983 (Atanassov 1986).

Definition Set X is a not empty classic set, and an intuitionistic fuzzy set A in a universe X is an object of the form $A = \{<x, \mu_A(x), v_A(x)> | x \in X\}$, where, for all $x \in X$, $\mu_A(x) \in [0,1]$ and $v_A(x) \in [0,1]$ are called the membership degree and the non-membership degree, respectively, of x in A, and furthermore satisfy $0 \leq \mu_A(x) + v_A(x) \leq 1$ (Xu 2008). For example, $[\mu_A(x), v_A(x)] = [0.5, 0.3]$ in voting model meaning that 10 people, including five members in favor, three against and two abstained. The class of intuitionistic fuzzy sets in X is denoted by IFS[X]. For each A-IFS in, if $\pi_A(x) = 1 - \mu_A(x) - v_A(x)$, then $\pi_A(x)$ is called the degree of indeterminacy of x to A.

36.2.2 Intuitionistic Fuzzy Weighted Averaging (IFWA) Operator

In generally multi-attribute decision-making (MADM) program need be empowered weight, the weight reflect the relative importance of each attribute. The method to determine weight usually divide into two types: the one is subjective method, weight is determined by the decision makers' preferences and experience, the common methods are expert scoring method and Analytic Hierarchy Process (AHP), the shortcomings of such methods have greater subjective arbitrariness in the decision-making. Another is objective method, it basis for attributive information and using the mathematical theory to empower, so it avoid subjective and arbitrary, but the disadvantage is to ignore the preferences of decision makers'. Therefore, this paper used intuitionistic fuzzy intuitionistic fuzzy sets in dealing with uncertainty information than the traditional fuzzy sets have stronger entropy to determine the weights, and then based on expert scoring to correct weights, and to determine the weight integrated.

Set $Y = (y_1, y_2, y_3, \ldots, y_m)$ is sets for the evaluation programs, set $G = (g_1, g_2, g_3, \ldots, g_n)$ is set for attribution, $\lambda = (\lambda_1, \lambda_2, \lambda_3, \ldots, \lambda_n)$ is decision makers' preference for all of attribution, and $\sum_{j=1}^{n} \lambda j = 1$. So, the formula of Y about decision information of G is as follows:

$$E_{Gj} = \frac{1}{2m} \sum\nolimits_{i=1}^{m} \left(\pi_{ij} + \theta_{ij}\right) \quad (36.1)$$

The E_{Gj} reflect the program sets based on the decision-making information of attribution G_j ambiguity and uncertainty, and the higher values indicate that the degree of fuzzy and degree of uncertainty higher,and it meaning that the degree it rely on attribution G_j less. Let D_{Gj} is the degree of deviation of decision-making information of attribution G_j, where, $D_{Gj} = 1 - E_{Gj}$, j = 1,2,…,n. Then the formula of subjective weights of attribution G_j is as follows:

$$r_j = \frac{DG_j}{\sum_{i=1}^{n} DG_j}, \ j = 1, 2, 3, \ldots, n \quad (36.2)$$

Moreover, taking into account the decision makers' preferences and experiences, we according to the subjective weights $\lambda = (\lambda_1, \lambda_2, \lambda_3, \ldots, \lambda_n)$ for correction, the formula is as follows:

$$w_j = \frac{\lambda_j r_j}{\sum_{i=1}^{n} \lambda_j r_j} \quad (36.3)$$

The weighted averaging operator is a common operator in multi-attribute decision making with integrating data and information.

Definition Let WA: Rn → R, if

$$\mathrm{WA}_\omega = \omega 1\, \alpha 1 \oplus \omega 2\, \alpha 2 \oplus \cdots \oplus \omega_n\, \alpha_n. \quad (36.4)$$

Then WA is called a weighted averaging operator, where $\omega = (\omega_1,\omega_2,\omega_3,\ldots,\omega_n)^T$ is the weight vector of $\alpha_j (j = 1,2,3,\ldots,n)$, with $\omega_j \in [0,1]$ and $\sum_{j=1}^{n} \omega_j = 1$, R is the set of all real numbers, and "⊕" is the symbol for the addition of intuitionistic fuzzy sets (Harsanyi 1955).

Amended weights apply to formula (36.4) can get each attributive information about sets of programs Y_i (i = 1,2,…,m), then use the formula of intuitionistic fuzzy weighted averaging (IFWA) operator, it is as follows (Qin 2012):

$$\mathrm{IFWA}(Y_i) = \left(1 - \prod_{j=1}^{n} \left(1 - \mu_{ij}\right)^{wj}, \prod_{j=1}^{n} v_{ij}^{wj}\right), \mathrm{i} = 1, 2, \ldots, \mathrm{m} \quad (36.5)$$

Then we can get the value of decision-making programs Y_i (i = 1,2,…m) based on the sets of attribution G_j. Finally, we use formula (36.6) sort based on S (IFWA (Y_i)) and select the maximum score value for the optimal solution. The formula (36.6) is as follows:

$$\mathrm{S}(\mathrm{IFWA}(Y_i)) = 1 - \prod_{j=1}^{n} \left(1 - \mu_{ij}\right)^{wj} - \prod_{j=1}^{n} v_{ij}^{wj}, \mathrm{i} = 1, 2, \ldots, \mathrm{m} \quad (36.6)$$

36.3 Building Evaluation System of Qaidam Salt Lake Circular Economy

36.3.1 The Resource of Qaidam Salt Lake Recycle Economic Development and Situation

There are 33 salt lakes in Qaidam, and the salt lake resources are the unique advantaged resources, and it play an important position and role in Chinese national economic construction, moreover, the lithium mine, and chemical fertilizer and asbestos are ranking first in China, in Table 36.1.

At present, the main developed salt lake includes the Chaka, Keke Lake, Chaerhan Lake, and small Qaidam Lake. The main production includes salt, potassium salt, magnesium salt and boron salt (Yu and Tan 2000). However, the development of Qinghai salt lake resources, in the past 50 years, always had been based on potassium resource development as the main product. The associated or

Table 36.1 The main miner of the qaidam basin

Minerals	Main ingredients	Maintain reserves (10^3 t)	Potential value (10^2 million)	Province's ratio (%)	Domestic position	Mining area number
Lithium mineral	LiCl	1388.6	3611.7	100	1	10
Sr deposits	Celestite	1589.5	79.6	100	1	3
Salt mineral	NaCl	32626.0	122349.7	100	1	24
Magnesium salt	MgCl	311866.6	9000.0	100	1	21
	$MgSO_4$	167339.7	2174.4			
Potassium salt	KCl	44299.5	2215.0	100	1	22
Mirabilite	K_2SO_4	668516.4	19246.9	100	1	9
Boron mineral	B_2O_3	1152.5	38.4	100	2	12

[a] The material comes from the tenth five-year plan of Qaidam basin mineral resources comprehensive development and utilization

symbiotic resources, like lithium, boron, magnesium, rubidium, bromine and other active ingredients do not use effectively, and most of them as the waste emissions, and formed a one-way linear process of "resources—products—waste". This unidirectional extensive irrational development, on the one hand lead to tremendous waste of the salt lake resources, and exacerbated destruction of resources; the other hand, this mode of production resulting in high production costs and affecting the economic efficiency of enterprises and the competitiveness of products in the market, and weak ability to withstand market risks (2005). Therefore, the route of development of circular economy is a priority, and effectively evaluate the circulatory levels of ability is the most important.

36.3.2 The Principle to Build Qaidam Salt Lake Recycle Economic Evaluation and Index System

The principle to build salt lake recycle economic evaluation and index system should be based on the "reducing, reusing, recycling" (3R) as the main criteria and should take into consideration the levels of corporate, regional and social at the same time. Wang and Chen (2003) proposed the five principles to build index of the salt lake resources for evaluating sustainable development: systematic principle, scientific principle, operability principle, regional principle and dynamic principle.

36.3.3 Determining the Index and Evaluation System of Qaidam Salt Lake Circular Economy

Salt lake recycle economic evaluation index system is still in the exploratory stage, and it is still not reached a uniform, accepted standard. Based on the above principles of constructing, and relying on the instructions on the "recycle economic evaluation index system" in China and the existing statistical system of the National Bureau of Statistics proposed the output indicator of resources, the consumption indicator of resources, comprehensive utilization of resources indicator, waste disposal volume indicator. Besides, Wang and Chen (2003) based on the method of problematic focus (Yang and Hong 2001) determined index system which contains sustainable utilization of salt lake resources, the impact on the environment of exploiting and using salt lake resources, and sustainable development of the salt lake industries for themselves. Wang and Feng (2012) considered the unique characteristics of the object in the circular economy innovation evaluation, and combined with the phase characteristics of the economic and social development propose the evaluation index of the recycle economic innovation situation and effects to evaluate the capability of innovation. Then, this paper consider these evaluation index comprehensively and provide the evaluation index system with six first-grade indexes and twenty-two second-grade indexes, in the Table 36.2.

Table 36.2 The evaluation index system of the salt lake circular economy

Target layer	Criterion level layer	Index layer
The evaluation index system of the salt lake circular economy	The output indicator of resources	The main mineral resources output rate
		The energy output rate
		Water resources output rate
	The consumption indicator of resources	Water consumption per unit of GDP
		Unit GDP energy consumption
		Ten thousand production value of "three wastes" emissions
	The comprehensive utilization indicator of resources	Industrial waste gas comprehensive utilization rate
		Industrial solid waste comprehensive utilization rate
		Industrial water reuse rate
		The proportion of industrial "three wastes" comprehensive utilization output value of the production in GDP
	The waste disposal volume indicator	Waste recycling rate
		Industrial solid waste disposal quantity
		Industrial waste water emissions
		Sulfur dioxide emissions
		COD emissions
	The impact on the environment of exploiting and using salt lake resources indicator	The capability of resource consumption
		The capability of environmental bearing
		The capability of ecological system bearing
		The capability of resources environmental protection
	Recycle economic innovation situation evaluation indicator	The proportion of research funds in GDP
		The proportion of circular economy research funds in scientific and technological activities funds
		The number of patents

36.3.4 The Steps and Result Analysis for Evaluation of Qaidam Salt Lake Circular Economy

Based on the formulas of intuitionistic fuzzy sets, and then use the intuitionistic fuzzy weighted averaging (IFWA) operator to evaluate salt lake recycle economic index system. The mainly steps are as follows:

Firstly, based on the formula (36.1) to calculate the every attributive intuition fuzzy entropy, and we can get six value, that is E_{G1}, E_{G2}, E_{G3}, E_{G4}, E_{G5}, E_{G6} Secondly, based on the formula (36.2) to calculate the every attributive objective weight; Thirdly, use the formula (36.3) correct weight with the subject weights, where, the subject weights could come from experts scoring; Fourthly, use the formula (36.4) we can get the value of IFWA based on sets of programs; Finally, based on the formula (36.5) we can get the value of the S (IFWA (Y_i)) and select the maximum score value for the optimal solution.

36.4 Conclusion

With the continuous development of circular economy, the effective index system is conducive to better monitoring and evaluation for circulating levels, and realize the minimum consumption to get the maximize development benefits. This paper try to propose the evaluation index system of the salt lake circular economy, and use the intuitionistic fuzzy sets and intuitionistic fuzzy weighted averaging (IFWA) operator algorithms, and take into account the objective and subjective weights comprehensive to determining weight, then get the more accurately weight, and evaluation of the program can achieve eventually.

Acknowledgments This paper was supported by 'The National Key Technology R&D Program' (Grant No.2012BAH10F01, 2011BAC04B02), 'Education program for New Century Excellent talents' (Grant No.NCET-11-0893), 'Beijing municipal talents supporting plan for enhancing education' (Grant No.PHR20110514), 'science and technology innovation platform of university in Beijing' and 'Beijing knowledge management research base program'.

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Chapter 37
Evolution Analysis of Standardization Production Behavior in GI Agricultural Product Enterprise Cluster

Zhi-fang Li and Tong Chen

Abstract GI agricultural products, as the typical representative of quality agricultural products, play an important role in promoting the development of rural economy. However, in recent years, some GI agricultural products enterprises did not process agricultural products according to the standards, so the accidents occurred frequently. Based on the problems, with the premise of sharing the collective revenue, this paper uses the evolutionary game theory to analyze the behaviors of standardization strategy of GI agricultural product enterprise cluster. The research shows that it must be properly introduced the supervision of the local government and the association and the construction of the mechanism of punishment, which can promote the development of GI agricultural product enterprises cluster.

Keywords Enterprise cluster · Evolutionary game · GI agricultural product · Standardized production

37.1 Introduction

In terms of the definition in "Trade related intellectual property rights agreement" (TRIPS), Geographical indications(GI) refers to the commodities in the origin, which has specific quality, reputation or other characteristics, are determined by the natural or cultural factors in the region. According to the definition of geographical indications, geographical indication of agricultural products is identification marking of agricultural products, which is naive to a particular country, region or in a particular place, the quality characteristics, flavor and reputation of

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E. Qi et al. (eds.), *The 19th International Conference on Industrial Engineering and Engineering Management*, DOI: 10.1007/978-3-642-38391-5_37,

agricultural product completely or mainly depends on the geographic environment, natural conditions, human factors and so on in this area (Ren and Huang 2007). Based on the protection of geographical indications of the agricultural products, it is conducive to the development of the local leading industry, regional brand; but also can improve the added value of agricultural products, increase the income of the farmers, and promote rural economic development (He 2010).

According to "Geographical indications products protection regulations" in China, in the registration process, there must be detailed plant (production, cultivation) specification, local and national standards, which is to ensure that the quality characteristics of GI agricultural products, but also to make the sustainable development (Wang and Du 2011). But in recent years, geographical indications agricultural products appeared more malignant events, such as 2010, "consumer advocate" in CCTV reported the massive fraud of Heilongjiang Wuchang rice, the reason mainly lies in the adulteration of Wuchang rice processing enterprises in origin. These events seriously disturbed the stability of agricultural product market and violated consumer rights. The fundamental reason lies in the "free riding" behaviors under sharing collective reputation, processing businesses, which belongs to small and medium enterprises, do not strictly enforce the standards of production and processing (Sun 2012).

From production to processing, to enter the market, GI agricultural products involve multiple bodies. At the same time, processing as the most important link, multiple small and medium-sized processing enterprises distribute in the origin, which is consisted of a fully competitive market (Wang and Liu 2008). Therefore, in view of the current literature on the standardized production of GI agricultural products being not studied, this paper uses evolutionary game theory and method, under the premise of the collective revenue sharing, builds behavior evolution model on using standardized strategy in the processing of GI agricultural products enterprise clusters in the processing link, analyzes the stability of evolution process and identifies the key factors to adopt standardized strategy, in order to provide decision-making references on promoting the GI agricultural product standardization production.

37.2 Methodology

Evolutionary game theory takes the group behavior as the research object, from the bounded rational individual as the starting point, thinks that individual decision-making behavior is not always optimal, it is often not possible to find the optimal strategy in the beginning. Individual decision-making is through individual mutual imitation, learning in dynamic process to achieve, stepwise finds the better strategy (Sun et al. 2003; Wu et al. 2004).

One of the most important dynamic behavior analysis models in evolutionary game theory is replicator dynamic model. Replicator dynamics is a dynamic differential equation which describes adopted frequency of a particular strategy (behavior) in a group. It can well describe the change trend of bounded rational individual in groups and predict individual behavior in groups. Replicator dynamic model can be expressed as:

$$dx(t)/_{dt} = x(t) * \left[u_t(\alpha) - \bar{u}_t(g)\right],$$

where $x(t)$ is the proportion of the involved members in the groups who adopt pure strategy α during the time t involved in groups; $u_t(\alpha)$ is the expected utility of the involved members who use the pure strategy α in the period t; $\bar{u}_t(g)$ is the group's average expected utility (Friedman 1991; Taylor and Jonker 1978; Friedman 1998). Evolutionary game theory provides good analysis methods and tools for analyzing the mutual game behavior of cluster members in GI agricultural product cluster enterprises who adopt standardization strategy (Hu 2010).

37.3 Results

37.3.1 Model Building

GI agricultural products processing enterprises are the core bodies who can add the value of agricultural products, the process of adopting standardized production is directly related to the GI agricultural product reputation and the economic interest of relevant interest persons. In the processing link of GI agricultural products, this paper takes adopting standardized production behavior in GI agricultural products processing enterprise cluster as an example, analyzes the dynamic behavior evolution (Zhang 2011).

Hypothesis 1 GI agricultural product enterprise cluster has n similar enterprises in scale. At one time t, each enterprise in clusters is faced with the same set of strategies $S_i = \{s_1, s_2\}$, where is named {adopting the standards, not adopting the standards}. Thus, it assumes that in the period t, the percentage of adopting standards in cluster is $x(t)$, so the percentage of not adopting standards is $1 - x(t)$.

Hypothesis 2 The amount of resources which each enterprise has is 1, the amount of resources which can be put into the standardized production is ε.

Hypothesis 3 R is the benefit of standardization production in GI agricultural product enterprises cluster, which is a regional sharing, for all enterprises sharing. Here, it assumes that $R(\varepsilon, n, x(t)) = (\varepsilon n x(t))^{1/\alpha}$, here $0 \le \varepsilon \le 1$, $\alpha \ge 0$. In the above formula, the benefit R is decided by the numbers $nx_t(t)$ of enterprises who adopt standardization strategy in cluster and the amount ε of resource which is put into the standardized production, and both size is proportional to R; where α is the productivity parameters of the standardized production, in this article α is assumed to be valued 2.

Hypothesis 4 The income π^c of the enterprises who adopt standardized strategy is composed of two parts, one part $1 - \varepsilon$ is devoted by the profits of other agricultural products, another part is the benefit of the standardized production, $R(\varepsilon, n, x(t))$. Therefore,

$$\pi^c = 1 - \varepsilon + R(\varepsilon, n, x(t)).$$

Hypothesis 5 The income π^b of the enterprises who do not adopt standardized strategy is composed of two parts, one part is the original resource 1, another part is the overflow profit of the enterprises who use standardized production, overflow value coefficient is λ, so $\pi^b = 1 + \lambda R(\varepsilon, n, x(t))$.

Taking into account all enterprises using the standardization production being randomly paired into the game, at a time t, it can establish the following 2×2 asymmetric game model, as shown in Fig. 37.1 (Shen and Wang 2011).

37.3.2 Model Solution

Assume that in a certain period t, u_c is the expect profit of the enterprises which use standardized strategy, u_b is the expect profit of the enterprises which do not use standardized strategy, $\bar{u}$ is the average expected returns of GI agricultural product enterprises cluster. According to Fig. 37.1, it can concluded that

$$\begin{aligned} u_c &= x(t)[1 - \varepsilon + R(\varepsilon, n, x(t))] \\ &\quad + (1 - x(t))[1 - \varepsilon + R(\varepsilon, n, x(t))] \\ &= 1 - \varepsilon + R(\varepsilon, n, x(t)) \end{aligned} \tag{37.1}$$

Enterprise 2 \ Enterprise 1	**adopting the standards**	**not adopting the standards**
adopting the standards	$1-\varepsilon+R(\varepsilon,n,x(t))$, $1-\varepsilon+R(\varepsilon,n,x(t))$	$1-\varepsilon+R(\varepsilon,n,x(t))$, $1+\lambda R(\varepsilon,n,x(t))$
not adopting the standards	$1+\lambda R(\varepsilon,n,x(t))$, $1-\varepsilon+R(\varepsilon,n,x(t))$	$1+\lambda R(\varepsilon,n,x(t))$, $1+\lambda R(\varepsilon,n,x(t))$

Fig. 37.1 The 2×2 asymmetric game model of the standardization production in GI agricultural products cluster

$$\begin{aligned} u_b &= x(t)[1 + \lambda R(\varepsilon, n, x(t))] \\ &\quad + (1 - x(t)) \times [1 + \lambda R(\varepsilon, n, x(t))] \\ &= 1 + \lambda R(\varepsilon, n, x(t)) \end{aligned} \tag{37.2}$$

$$\begin{aligned} \bar{u} &= x(t)u_c + (1 - x(t))u_b \\ &= x(t)[1 - \varepsilon + R(\varepsilon, n, x(t))] \\ &\quad + (1 - x(t))[1 + \lambda R(\varepsilon, n, x(t))] \end{aligned} \tag{37.3}$$

Therefore, according to the references (Rosenberg 1983), the changed proportion of choosing standardization strategy in cluster enterprises every period can be used to describe by the following discrete dynamical system:

$$x(t+1) = \frac{x(t)u_c}{x(t)u_c + (1 - x(t))u_b} \tag{37.4}$$

The equation shows that if the profits of using standardized strategy is greater than the average expected return of GI agricultural product enterprise cluster, then it will increase the probability of using standardized strategy in the next period; otherwise, the cluster will reduce the proportion of using standardized strategy in the next period.

Subtracting $x(t)$ from the Formula (37.4) in both sides, then, introducing the Formulae (37.1), (37.2, (37.3) into the Formula (37.4), it can be obtained as follows a discrete dynamical system:

$$\begin{aligned} x(t+1) &= x(t) + \frac{x(t)(1 - x(t))(u_c - u_b)}{x(t)u_c + (1 - x(t))u_b} \\ &= x(t) + \frac{x(t)(1 - x(t))\left((1 - \lambda)(n\varepsilon x(t))^{\frac{1}{2}} - \varepsilon\right)}{1 - \varepsilon x(t) + x(t)(n\varepsilon x(t))^{\frac{1}{2}} + \lambda(1 - x(t))(n\varepsilon x(t))^{\frac{1}{2}}} \end{aligned} \tag{37.5}$$

Commanding $x(t+1) = x(t)$, when $0 < \lambda < 1$, there are three equilibrium points in the discrete system, respectively 0,1, $\frac{\varepsilon}{n(1-\lambda)^2}$; when $\lambda = 1$, the Formula (37.5) changes into $x(t+1) = \frac{x(t)(1-\varepsilon)}{1 + x(t)(1-\varepsilon)}$, there are two equilibrium points, respectively 0,1.

37.3.3 Stability Analysis

According to the discrete dynamic system theory, it can get the following conclusion:

Conclusion 1 when $0 < \lambda < 1$, the Formula (37.5) can change into (Shen and Wang 2011)

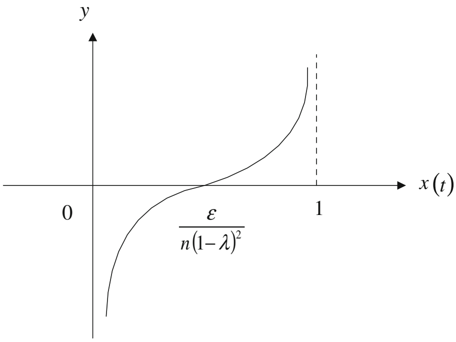

Fig. 37.2 The behavior evolution of the standardization production in GI agricultural products cluster

$$\begin{aligned} y &= \frac{dx(t)}{dt} = \frac{x(t+1) - x(t)}{x(t)} \\ &= \frac{(1 - x(t))(u_c - u_b)}{x(t)u_c + (1 - x(t))u_b} \\ &= \frac{(1 - x(t))\left((1-\lambda)(n\varepsilon x(t))^{\frac{1}{2}} - \varepsilon\right)}{1 - \varepsilon x(t) + x(t)(n\varepsilon x(t))^{\frac{1}{2}} + \lambda(1 - x(t))(n\varepsilon x(t))^{\frac{1}{2}}} \end{aligned} \tag{37.6}$$

As shown in Fig. 37.2, when $0 \le x(t) < \frac{\varepsilon}{n(1-\lambda)^2}$, which meets $u_c < u_b$, at this time, GI agricultural product enterprises are all not using standardized strategy; when $\frac{\varepsilon}{n(1-\lambda)^2} \le x(t) \le 1$, which meets $u_c > u_b$, at this time, GI agricultural product enterprises are all using standard strategy; $x^*(t) = \frac{\varepsilon}{n(1-\lambda)^2}$, it means that said the proportion, $\frac{\varepsilon}{n(1-\lambda)^2}$, of GI agricultural product enterprises in the period is using standardized strategy, which is a non steady state (Shen 2008).

Conclusion 2 When $\frac{\varepsilon}{n(1-\lambda)^2} \le x(t) \le 1$, the probability of using standardized strategy decreases (increases) as the amount of resources required increases (decreases), as the spillover coefficient of adopting standardized strategy increases (decreases), as the cluster size increases (decreases).

Conclusion 3 When $\lambda = 1$, $x^*(t) = 0$, no GI agricultural product enterprise in the period uses standardized strategy, which is a pure strategy equilibrium; $x^*(t) = 1$, all GI agricultural product enterprises in the period have adopted standardized strategy, which is a pure strategy equilibrium.

37.4 Discussion

According to the above, it can be known that the initial state of the GI agricultural product enterprise clusters, the amount of resource of the enterprise using standardized strategy, the spillover coefficient of standardization strategy, the efficiency of standardized strategy and the size of GI agricultural product enterprise cluster and other factors play important roles on the formation, evolution and stability of GI agricultural product enterprise cluster.

(1) The amount of resource of the enterprise using standardized strategy ε. On the condition that a certain amount of resources needed by standardized strategy, the less the enterprises using standardized strategy, the more resources invested by every enterprise. In addition, the more the resource required to invest, the higher the ratio threshold of using standardized strategy by GI agricultural product enterprise clusters is. Therefore, reducing ε through the construction of government subsidies mechanism, improving the agricultural science and technology extension system and other measures are contribute to the evolution and stability of adopting standardized strategy of the GI agricultural product enterprise clusters generally.
(2) The spillover coefficient λ. When λ closes to 1, spillover effect is obvious, which will lead to more "free-riding" behaviors, so it leads to a decrease in the quality of agricultural products, and even endanger the collective reputation. So, only by cluster internal or local government to improve the punishment system, the "free-riding" acts will be reduced.
(3) The efficiency α. The size of α directly affects the threshold of using standardized strategy in GI agricultural product enterprise clusters. Thus, in reality, planning the industrial structure and the coordination of organizational settings and designing management mechanism can effectively influence the standardized popularization efficiency.
(4) The scale n. From the Fig. 37.2, when the initial area is in $\frac{\varepsilon}{n(1-\lambda)^2} \le x(t) \le 1$, the smaller clusters, the popularization rate of using standardized strategy is higher, thus more stable. It means that, in reality, it should control the number of enterprises, ensure the effective supervision and management, being combined with the above measures at the same time.

37.5 Conclusion

This paper constructs the evolutionary game model of using standardized strategy in GI agricultural product enterprise clusters, and focuses on the analysis of behavior evolution of cluster members in different conditions. The results show that using standardized strategy may be influenced by a variety of key factors, so local government, industry associations and other coordination organization which are used to control these factors should play an important role. Establishing the supervision and punishment mechanism of standardized strategy implementation, through the improvement of the initial state, reducing the burden of cluster members, thereby improving the popularity efficiency of standardization, reducing the exterior effect of standardized popularization, making standardization to carry out effectively, safeguarding the characteristics and market competitive advantage of GI agricultural product.

Acknowledgments This paper is supported by the Humanities and Social Sciences Program of the Ministry of Education of China (10YAJ630014).

The authors thank the editor and the anonymous referees for their comments and suggestions.

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Chapter 38
Forecasting of Vehicle Capacity Based on BP Neural Network

Ya-qin An, Ya-jun Wang and Wen-wei Gao

Abstract According to the theory of neural network, a forecasting model of BP neural network is set up on the basis of studying the influencing factors of vehicle population. The forecasting accuracy is improved greatly compared with the gray forecasting model. It is valuable to enact reasonably the resource management policies and establish expropriation counterplan for freight capacity.

Keywords BP neural network · Forecasting · Influencing factors · Vehicle population

38.1 Introduction

The civilian vehicle capacity resource is an important component of national defense reserve forces, it is a basic way to enlarge military traffic transportation strength and enhance the continued support capacity of military traffic transportation during wartime. Because of the sudden and uncertainty characteristics of future war, we must prepare for the vehicle capacity mobilization in advance in order to meet the sharply increased requirements of military transportation. On the basis of existing statistical data, therefore, it is important to analyze and forecast exactly the distribution and trend of vehicle capacity resource of each war area according to the objective law of vehicle capacity development, which can also help us enact some policies of capacity resource management and establish the capacity expropriation counter plans.

We must forecast the vehicle population exactly before confirming civilian vehicle capacity. There are three ways to forecast the vehicle population at present

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E. Qi et al. (eds.), *The 19th International Conference on Industrial Engineering and Engineering Management*, DOI: 10.1007/978-3-642-38391-5_38,

(Cheng and Su 2005; Deng and Hu 2010; Zhu 2011; Zhou et al. 2011; Ren et al. 2011; Zhu et al. 2011; Wen 2000; Hu 2003; Yuan 1999; National Bureau of Statistics 2010; Wu et al. 2006; Guo et al. 2006; Cheng 1997; Zhang and Xue 2008; Ye 2004). The first one is extrapolation method which forecasts the future status using the past data, for example, the time series method is used frequently; The second one is cause and effect method which forecasts the future status by finding out the relationship between the forecasting variables and correlated variables according to the past data, for example, regression analysis method; The last one is judgment analytical method which forecasts the future status depending on the experience and comprehensively analytical ability of forecast experts. Because of the correlation among the forecast factors of vehicle population is anfractuosities, the primary and secondary relation is uncertain and the quantity relation is difficult to pick up, all above methods have some flaws at different level simultaneously.

Neural network is an important artificial intelligence technology developed in recent years (Wen 2000; Hu 2003; Yuan 1999). Because of its characteristics such as parallel distributed processing, self-organization, self-adaption, self-learning, associative memory, stronger fault tolerance and so on, it is applied successively in many areas. Moreover, it is used widely to forecast the multi-factor, uncertain and nonlinear problems (Zhu et al. 2011). This type of forecasting method similar to a black box can overcome the shortages of traditional forecasting methods well. Moreover, it can combine well with some traditional forecasting methods (Deng and Hu 2010). In this paper, BP neural network is used to forecast the vehicle population, and a forecast model based on BP neural network is discussed.

38.2 BP Neural Network

The structure of Backpropagation (for short BP) Neural Network model is shown in Fig. 38.1. The main ideas of BP algorithm is dividing the leaning or training processes into two stages. The first stage is forward-propagation process which performs according to an order of inputting the initial input vector, entering into the input layer, going though the hidden layer and arriving at the output layer by dealing with every layer and calculating the actual output value of each unit; the second stage is called counter-propagation process. When the desired output result is not gotten at the output layer, D-value (namely error) between actual output result and desired output result is calculated recursively layer by layer. In order to reduce the error, then, the weights of corresponding joints in different layers are adjusted according to the D-value. The two processes are applied repeatedly and the learning process is over until the error signal drops off and meets the reasonable demand.

The neural network trained by learning process extracted the nonlinear mapping relation contained in the specimens, and stored the values of weights in the network. During the operational stage, when a new example is inputted into the

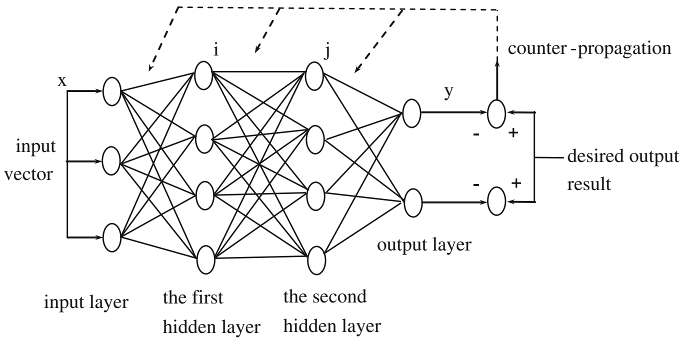

Fig. 38.1 Model of BP neural network

established neural network, it can build up the arbitrary nonlinear mappings from n-dimensional input space to m-dimensional output space. Finally, it can exactly describe the laws of specimens which are hard to describe using some mathematical equations.

In this paper, the model of BP neural network including three layers, namely, input layer, one hidden layer and output layer was built and discussed.

38.2.1 Confirming the Network Joint Number of Input Layer

There are many relevant factors influencing the vehicle population. For example, gross industrial output value is the foundation of national economy, it influences the vehicle market remarkably; Traffic volume reflects the objective demand to the transport facilities and can promote the development of vehicle market. So passenger and freight volume is an important factor influencing the vehicle population; furthermore, highway total mileage is also a key factor determining the vehicle population. Thus, the joint number of input layer is identified as three, they are total product of society, road traffic volume and highway total mileage.

38.2.2 Confirming the Network Joint Number of Hidden Layer and Output Layer

Because of shortage of strict theory or basis, choosing joint number of hidden layer is a complex question. Normally it is determined in accordance with the experience. If the hidden units are less, network may not be trained; however, more hidden units make the learning time to prolong and the error may increase. In general, when more hidden units are used, the possibility of forming local minimum decreases; conversely, a platform phenomenon caused by the slowly descending learning error function value forms easily. So the network joint number of hidden layer should be considered synthetically combining accuracy and generality. In this paper, the joint number of hidden layer is confirmed as five finally by calculating repeatedly and considering the computational accuracy and speed synthetically.

The network joint of output layer is object variable, namely vehicle population.

38.3 Forecasting Vehicle Population

38.3.1 Demand Analysis of Civilian Vehicle Capacity

According to the tasks and characteristics of military transportation guarantee in the future warfare, the necessary vehicle types mainly include passenger service vehicle, motortruck, birdyback, special purpose motor vehicle and so on. For example, the common trucks and special vehicles such as dump trucks, tank trucks, vans trucks, etc. with excellent properties and more than 4 ton payload can meet the requirement of military transportation. These vehicles can be used for transportation guarantee such as troop maneuvering, transporting to the frontline of the warstate organs and important factories, goods and materials transportation under special circumstances such as emergency and armed conflict, and urgency transport when grave natural calamities are happened. According to Chinese statistical yearbook, the heavy motortruck populations from 1989 to 2005 and their main influence factors are listed in Table 38.1.

Table 38.1 National motortruck population and its main influence factors

Years	Motortruck population (ten thousand)	Gross product of society (hundred million Chinese Yuan)	Road freight volume (ten thousand ton/km)	Highway total mileage (km)
1989	346.37	16909.2	733781	101.43
1990	368.48	18547.9	724040	102.83
1991	398.62	21617.8	733907	104.11
1992	441.45	26638.1	780941	105.67
1993	501.00	34634.4	840256	108.35
1994	560.33	46759.4	894914	111.78
1995	585.43	58478.1	940387	115.70
1996	575.03	67884.6	983860	118.58
1997	601.23	74462.6	976536	122.64
1998	627.89	78345.2	976004	127.85
1999	676.95	82067.5	990444	135.17
2000	716.32	89468.1	1038813	140.27
2001	765.24	97314.8	1056312	169.80
2002	812.22	105172.3	1116324	176.52
2003	853.51	117251.9	1159957	180.98
2004	893.00	136875.9	1244990	187.07
2005	955.50	182320.6	1341778	193.05

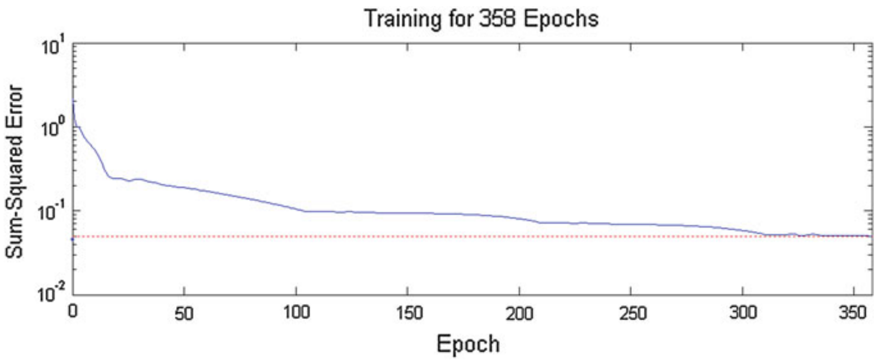

Fig. 38.2 Deviation curve of BP neural network training process

38.3.2 Network Training and Forecasting

According to the BP network established in above section, we choose the national motortruck population from 1989 to 2005 and main influence factors as an example. Visual Basic language was used to design an application program for above BP network; MATLAB program was used to train the specimens and forecast the result. The data from 1989 to 2002 were used as learning specimens, and the data from 2003 to 2005 are used as samples for forecasting. Square sum error of network output is designed as 0.05, learning rate is designed as 0.02, and the maximum training number is designed as 10,000.

The network meets the requirement after training 368 times, and the network error curve after training is shown in Fig. 38.2; the forecasting result is shown in Table 38.2.

In order to avoid data overflow and decrease learning rate, the specimen data must be normalized before forecasting, then each variable has the same normalization scale. In this paper, the data of training specimens and forecasting samples are calculated following (40.1), which makes the data to limit in the scope of [−1, +1].

$$X_n = \frac{2(x - x_{\min})}{x_{\max} - x_{\min}} - 1 \tag{40.1}$$

Here, x is a variable to be determined; $x_{\min}$ is the minimum of x; $x_{\max}$ is the maximum of x; X_n is the normalized value of x.

Table 38.2 Forecasting results and data error analysis from 2003 to 2005

Years	2003	2004	2005
Actual value	853.51	893.00	955.50
Forecasting value	818.55	849.93	937.92
Relative error	4.10 %	4.82 %	1.84 %
Mean error	3.59 %		

Table 38.3 Forecasting results of vehicle populations in 2015, 2020 and 2025

Years	Motortruck population (ten thousand)	Gross product of society (hundred million Chinese Yuan)	Road freight volume (ten thousand ton/km)	Highway total mileage (km)
2015	1968.58	587314.8	3316312	479.80
2020	2601.22	785172.3	4506324	555.52
2025	3523.51	977251.9	5729957	648.98

Cheng and Su (2005) forecasted the data from 1999 to 2001 using gray forecast method and the average forecast error was 20.94 %. So the application of BP neural network method makes the mean error to decrease from 20.94 to 3.59 %. It means that the forecasting accuracy is improved greatly by using the BP neural network method.

38.3.3 Forecasting Vehicle Population

If the forecasting value is input to the network model again as a new input value, the vehicle population in arbitrary future year can be forecasted. The influence factors of vehicle populations in 2015, 2020 and 2025 are forecasted separately using time series method, which are shown in Table 38.3.

38.4 Summary

BP neural network model sets up in this paper is 3-5-1-type, which fits the raw data accurately and gets higher forecasting precision. This type of method has an unparalleled advantage compared with other methods, especially it is a more important and better method to forecast vehicle population, enact capacity resource management policies and establish capacity expropriation counterplan. However, BP Neural Network still has some flaws such as slow training rate, easily plunging into local minimum. And its forecasting accuracy can be further improved.

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Chapter 39
Fuzzy Data Mining with TOPSIS for Fuzzy Multiple Criteria Decision Making Problems

Chin-yao Low and Sung-nung Lin

Abstract In this study, we purpose a common fuzzy multiple criteria decision making model. Different with formerly studies, a new concept—fuzzy data mining scheme is adopted for considering in the model to establish a fuzzy multiple criteria decision making with time weight (FMCDMTW) model. In this study, a real case of fuzzy multiple criteria decision making (FMCDM) problem to be considering. The problem under investigated is a FMCDM problem with multiple appraisers, and the data considered is combined with historic data and recent data. Since the evaluated criteria proposed in the literature cannot be defined precisely and numerically, fuzzy linguistic terms can be used to aggregate them numerically. It not only conforms to human cognition but also benefits interpretation. Furthermore, notice that the data considered contains certain amount of historic data. As a result, fuzzy time weighted technique is adopted to resolve this issue.

Keywords Auction website · FMCDM · Fuzzy data mining · Fuzzy time weighted · TOPSIS

39.1 Introduction

According to the development of the internet network, consumer behavior had been changed. E-commerce becomes one of the main shopping ways. E-commerce is a way engaged in the business activity through the internet, and its target and range include inside/outside enterprises and individual consumer. Its business activity's content includes goods, service trade, network auction, financial

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E. Qi et al. (eds.), *The 19th International Conference on Industrial Engineering and Engineering Management*, DOI: 10.1007/978-3-642-38391-5_39,

exchange, network advertisement, etc. Among them, the auction website has taken the majority of e-commerce, and is growing up continuously constantly.

The development of the auction website has not only changed people's life but also changed its consumption habit. Consumers don't need to go out and can stay at home and surf the Net and buy the goods needed. And utilize the auction website to have several advantages to buy the goods, price flexible, goods various in style, rate of exchange easy, 24-h marketing and have no regional constraint etc. The factors which the auction website could operating continuously, totally depend on users, whether would like to continue using and trading the platform and doing a deal. In other words, the service performance of the auction website has determined whether this website can manage continuously. Therefore, how to measure the auction website effectively to manage and serve performance, not only the subject that website's operator cares about, but also an important reference indicator while choosing the trade platform of consumer.

The first job of setting up the performance assessing method is to propose the effective assessment criterion. There is no standard measure criterion for auction website. Therefore, it is quite difficult to set up the effective assessment criterion accorded with subject of assessing. Especially when assess and plan executors have no professional knowledge set up of the criterion; the setting-up of the criterion must gather the relevant specialty personage's opinion. However, it is obtained face to face that the professional personage's opinion is difficult, or need to spend a lot of cost and time. For overcome this difficulty, this research propose one utilize literature review to replace expert opinion probe into method—'fuzzy time weighted' effectively originally.

Assess the criterion in performance about the auction website; quite a lot of literatures propose different assessment criteria. In order to choose the really important assessment criterion objectively and effectively, give consideration to the applicability of gradual progress with time of the criterion at the same time. This research is summing up the assessment criterion that relevant literature, arrange in an order and select the assessment criterion that the research institute need by way of fuzzy time weight (Hoffman and Novak 1996; Hung et al. 2003).

To consider the criterion of auction website service performance, will often be influenced by the appraiser experience subjectively, course the result indistinct and uncertainty, in addition, the assessment of auction website service performance are not assess the criterion singly can be satisfied, must consider a lot of assessment criteria at the same time. So, after the ones that finish assessing criterion, this research continues utilizing the criterion of assessing to set up the auction website to deal in the performance questionnaire. What the questionnaire topic made use of linguistic variable in the fuzzy method to express appraiser's linguistic variable is fuzzy, the ones that assessed the criterion after building and constructing, then appraised to the behavior in assessing the criterion of website by the user of auction website. Finally, serve to apply fuzzy theory and combine multiple criterion decision method tool TOPSIS come assessment opinion to combine persons who assess while being arithmetical performance, thus build and construct the assessment result that an auction website serves performance. The performance and competitive ability that this method can not merely offer service of understanding the one's own one in the auction website, can still offer consumers to choose the best auction website of a service performance (Troy and Shaw 1997; Zadeh 1965, 1975).

39.2 Methodology

39.2.1 Fuzzy Theory

The fuzzy theory had been proposed by Professor Zadeh. He viewed its human cognitive process (mainly in order to think deeply and deduce). Uncertainly, it come by the way of mathematics expression, and mathematics that is traditional is from having only 'True' and 'False's two value logics (Binary logic). Expand to the continuous n-value (Continuous multi-value) with gray area Logic. And the fuzzy theory utilizes under the jurisdiction of the function (Membership Function). Value come, describe one speciality of concept, come, shows from 0 to 1 element which belong to a certain concept of intensities with 1 number value that asks also, the ones that call this element to assembling in this value are under the jurisdiction of degree (Membership grade). Expect that discourse domain

$$U = \{x_1, x_{2,}\ldots, x_n\},$$

and the fuzzy set of discourse domain U, $\widetilde{A}$ present as

$$\left\{\left(x_1, u_{\widetilde{A}}(x_1)\right), \left(x_2, u_{\widetilde{A}}(x_2)\right), \ldots, \left(x_n, u_{\widetilde{A}}(x_n)\right)\right\}$$

$u_{\widetilde{A}}(x_i)$ means the degree of membership of x_i in set $\widetilde{A}$.

The linguistic variable is in the appointed fuzzy set that is used for describing the natural language under the land, can turn into narration of natural language with logic person who infer logic narrate, and the linguistic variable regards word or sentence in the natural language as the parameter that is worth instead of the regarding counting as value. For example the persons who assess experience the appraisal which the network shop service performance, can utilize 'very unsatisfied', unsatisfied, 'ordinary', 'satisfied', 'very satisfied' the sentences of five kinds of yardstick express and serve the quality intensity of the performance, and can turn into number value for language purpose via the expert, change into relevant fuzzy numbers (Hsu and Chen 1996; Kaufmann and Gupta 1991; Klir and Yuan 1995; Langari and Zadeh 1995; Mendel 1995; Zadeh 1965, 1975).

39.2.2 Multiple Criterion Decision Methods

In true world, most decision questions have a lot of assessment criteria, it was not the single indicator that be weighed, but each criterion cannot turn into the same unit to compare, so utilize many criterion decision technology carry on decision of assessment method to born because of answering. Common many criteria decision method as if the analytic approach of the level (AHP), For example: Bi (Chow et al. 1994) AHP and apply the research that is assessed to supplier's performance; In addition SMART analytic approach and TOPSIS. And TOPSIS is by Hwang and Yoon (Van Heck and Ribbers 1997) Multi Criteria Analysis Model. The method, this theoretical foundation supposes promptly every assessment indicator all has a dull characteristic that increases progressively or decreases progressively, it is solved and so-called ideal solution (Grant and Schlesinger 1995; Hung et al. 2003). It is all criterion optimum value that make up (the greatest one of attribute value of the interests; the minimum one of attribute value of the cost). Shoulder the ideal to solve on the contrary (Negative-ideal Solution). It is all criteria difference make up the most (the minimum one of attribute value of the interests; the largest one of attribute value of the cost). Evaluate for select scheme calculate with Euclid Distance, in order to assess indicator comparing to degree of approximation that ideal solve, the scheme chosen answers and the ideal distance that is solving is being shortest, it is farthest and shoulder the distance that the ideal is being solved. TOPSIS has assessed the law and has already been accepted and employed the order of all kinds of trades to compare and assess extensively in the educational circles. For example: Wang, Xu (The National Library 2011), employ research of assessing operation performance of listed company of TOPSIS method; Wang, Chen (The National Library 2011), assess the listed company of the computer and manage the performance with the financial indicator.

According to motive and purpose of this research, we carry on collection and arrangement of literature and relevant materials, added in more than 20 foreign research quoted in the thesis by 105 theses and dissertation, by fuzzy time weight method, according to assess criterion occurrence number, relevance and time weight remit, appear 5 indices, total 25 items auction website serve assessment criterion of performance mainly exactly, and assess the criterion of these to make into the questionnaire, regard user of the auction website as testees and carry on questionnaire investigation. And then assess two big auction websites (Yahoo & Return) at present service performance. The questionnaire one is mainly divided into two major parts. First, it is importance degree comparing and assessing the performance of serving and assessing the criterion. Second and assess the satisfaction of assessing the criterion; And via the questionnaire retrieving, the rated value to two major auction websites that utilize the fuzzy theory and evaluate the weight of the service criterion project of network shop and person who assesses integration, utilize the decision method TOPSIS method of many criteria finally, get rank order and good and bad detail that two auction websites serve performance (Lambert and Sharma 1990; Parasuraman et al. 1985).

39.2.3 Assesses and Service Performance Criterion Appraise

The research of the auction website belongs to quite young subject, but numerous relevant research issues. This research analyzes and quotes use to extract out the measure criterion of managing performance of auction website which this research institute needs to relevant literature. The main facts are involved in 105 theses (The National Library 2011).

First, in order to overcome the difficulty that the expert opinion has, reduce the relevant cost which assesses the necessary expenditure of the homework at the same time. This research uses the way in which the literature probes into to produce the criterion of assessing, look at every literature the same expert, analyze and combine assessment performance relevant components of managing the performance in each literature with the auction website, use to extract the important assessment criterion.

Network auction has been just the trade form coming out in development in recent ten years; the user is at the stage of break-into this kind of transaction formally. So, with the progress of relevant science and technology and gradual progress of time, the user, to the performance that the auction website shows, concerned angle and proportion are being produced and changed constantly. Because performance of user's service for auction website varies with gradual progress of time greatly; the turnover auctioned adds a new line of consumer's consciousness with all increasing on day too. While the literature is put in order, we find though the time block that relevant literature are issued is not big, but service performance that consumers mind has some changes every year (Bellman and Zadeh 1970; Chen and Hwang 1992; Day 1984).

In order to further assess and consider objectively because the time array produced and assessed the criterion change, this research is during the process of putting the literature in order, the assessment criterion of putting forward various years is entrusted to different weights respectively. The assessment criterion after gathering together wholly is according to issuing number of times and relevance, it issues times fuzzy weight on taking advantage of, in order to get the real weight of the criterion. Analyzing the domestic master's thesis quoted will issue times and all lie between in 1998 to 2010 because of this research institute, and foreign most literature definitely also and. So, we build the fuzzy time weight of setting up and belong to one degree of functions as shown in Fig. 39.1.

This research is set out by the user view, through the collection and gathering together wholly of the literature, by weight method of fuzzy time, calculate according to assessing the occurrence number of the criterion and time weight, score according to criterion weight order elect 5 construct surface, total 25 items auction website serve assessment criterion of performance mainly (The National Library 2011; Angehrn 1997; Athanassopoulos 2000; Beam 1999; Bellman and Zadeh 1970; Cheng 1994; Fornell 1992; O'Connor and O'Keefe 1997; Kim and Stoel 2004; Nielsen and Tahir 2005; Parasuraman et al. 1988; Paul 1996; Simon 2001).

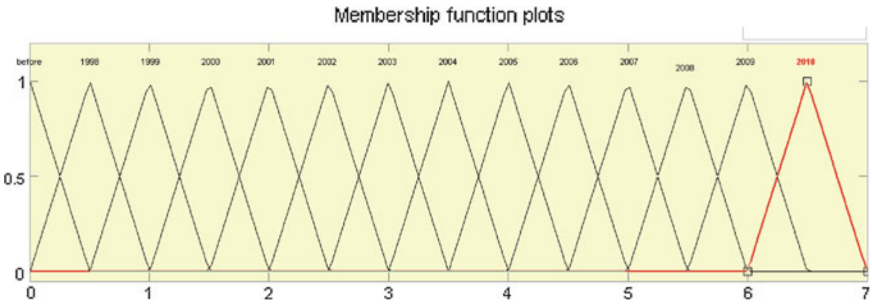

Fig. 39.1 Ownership function that assess the weight of criterion

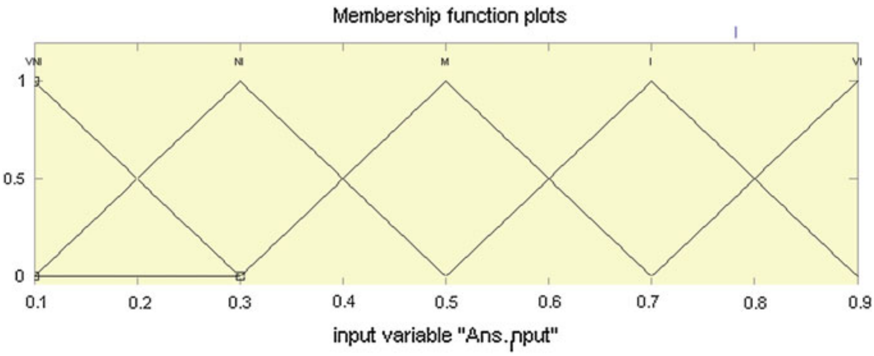

Fig. 39.2 Assess the ownership function of the criterion 'importance'

39.2.4 Assess and Serve the Criterion Weight of the Performance

After receiving the criterion of assessing, we entrust the criterion to the weight of different levels through the fuzzy way to define with justice, make by favorable follow-up study and questionnaire. Assess the detail as follows:

Step1: Determine to assess the semantic parameter of the criterion importance and count fuzzily

It is because in design of questionnaire utilize by Likert scale with five grade scale, can utilize person who assesses each person by different linguistic variable. To expresses the important measurement value of degree of each assessment criterion of persons who assess, as shown in Fig. 39.2.

Step2: Calculate every fuzzy weight of assessing the criterion

$$\begin{aligned} \widetilde{w}_j &= \left(l_j, m_j, u_j\right), \quad j = 1, 2, \ldots, n \\ l_j &= \underset{i}{Min}\left\{l_{ij}\right\}, \quad i = 1, 2, \ldots m \end{aligned} \tag{39.1}$$

$$m_j = \left(\prod_{i=1}^{m} m_{ij} \right)^{1/m}, \quad i = 1, 2, \ldots, m$$
$$u_j = \underset{i}{Max}\{u_{ij}\}, \quad i = 1, 2, \ldots, m \tag{39.2}$$

Step3: Each assess the solving and melting fuzzily of fuzzy weight of the criterion

Its main purpose is to change the fuzzy weight of 25 assessment criteria into a clear single number value (Ofj), Can learn importance degree and priority of each assessment criterion, and often the fuzzy method to melt of the opinion includes 'the maxima–minimum set method', 'the greatest average law' and 'center law', among them it is the simple and most easy method to calculate too that it is the most general that center law is and is adopted, so, this research utilizes center law to change the fuzzy weight of n assessment criteria, the conversion method is as follows:

$$of_j = \frac{l_j + m_j + u_j}{3}, \quad j = 1, 2, \ldots, n \tag{39.3}$$

39.2.5 Combines the Rated Value to the Auction Website of Persons Who Assess

Utilize questionnaire that retrieve, serve the measurement of the performance. Serving the measurement step of the performance about the network shop proves as follows:

Step1: Determine to assess the semantic parameter of criterion satisfaction and count fuzzily

Utilize the special five grade yardstick scale too, come, weigh person who assess to each assessment criterion satisfaction, utilize different and fuzzy language purpose parameters (very unsatisfied, is unsatisfied, ordinary, satisfied, very satisfied) To express the measurement value of each assessment criterion satisfaction, as shown in Fig. 39.3.

Step2: Combine every indicator of assessing in the assessment value of satisfaction of auction website

$$\widetilde{X}_{tj} = \left(l_{tj}, m_{tj}, u_{tj}\right)$$
$$l_{tj} = \underset{i}{Min}\left\{l^{i}_{tj}\right\}, \quad i = 1, 2, \ldots m \tag{39.4}$$

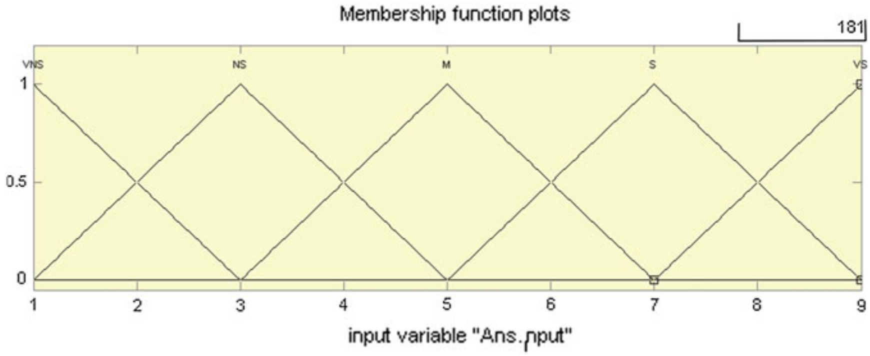

Fig. 39.3 Assess the ownership function of the criterion 'satisfaction'

$$m_{tj} = \left(\prod_{i=1}^{m} m_{tj}^{i}\right)^{1/m}, \quad i = 1, 2, \ldots, m$$
$$u_{tj} = \underset{i}{Max}\left\{u_{tj}^{i}\right\}, \quad i = 1, 2, \ldots, m \tag{39.5}$$

39.2.6 Utilizes Service Performance of Every Network Shop of Commenting Amount of TOPSIS Method

Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) proposed Hwang and Yoon in 1981 were mainly used for solving the decision problem of many criteria; its basic idea lies in defining and solving positive ideal solution and negative ideal solution. First, so-called and ideal to solve, mean, and take the place of select scheme benefit most heavy or cost minimum criterion value. On the contrary, shoulder ideal solving minimally for benefit or heaviest criterion value of cost, that is to say this method purpose lies in looking for a best scheme, and scheme this distance 'positive ideal solution' to close most, from 'negative ideal solution' most far.

According to the concept of TOPSIS, we can be defining out and solving and shouldering the ideal to solve fuzzily ideally fuzzily, utilize fuzzy decision matrix to calculate the fuzzy distance that counts of trigonometry, get each auction website to solving and is being defeated by the distance that the ideal is being solved ideally, utilize the common performance indicator (OPI) finally Value is come to arrange in an order, find out and serve the best auction website of the performance. The operation step is as follows:

Step1: Set up and assess matrix and weight matrix fuzzily

$$\widetilde{D} = \left[x_{tj}\right]_{k \times n}, \quad t = 1, 2, \ldots, k, \quad j = 1, 2, \ldots, n \tag{39.6}$$

$$\widetilde{W} = [w_j]_{1\times n}, \quad j = 1, 2, \ldots, n \tag{39.7}$$

$\widetilde{x}_{tj}$ and $\widetilde{\mathrm{w}}_{\mathrm{j}}$ are calculate assess fuzzy weight of criterion with assess merger fuzzy service performance value of criterion each under the auction website in t websites each in Sects. 39.3.1 and 39.3.2.

Step2: Assess the matrix regularization fuzzily

$$\widetilde{r}_{tj} = \left(\frac{l_{tj}}{u_j^+}, \frac{m_{tj}}{u_j^+}, \frac{u_{tj}}{u_j^+}\right), \quad j \in B \tag{39.8}$$

$$u_j^+ = \max_t u_{tj} \quad if\ j \in B$$

Step3: Build and construct the fuzzy decision weight matrix of the regularization

$$\widetilde{V} = [\widetilde{v}_{tj}]_{k\times n}, \quad t = 1, 2, \ldots, k, \quad j = 1, 2, \ldots, n \tag{39.9}$$

where

$$\widetilde{v}_{tj} = \widetilde{r}_{tj} \otimes \widetilde{w}_j \tag{39.10}$$

Step4: Determine to be shouldering the ideal to solve

$$\widetilde{v}_j^+ = \sigma_{\min d\left(\widetilde{v}_{tj}, \widetilde{v}_j^{+*}\right)} \left\{\widetilde{v}_{tj}, \quad t = 1, 2, \ldots k\right\}, \quad j = 1, 2, \ldots n \tag{39.11}$$

$$\widetilde{v}_j^- = \sigma_{\min d\left(\widetilde{v}_{tj}, \widetilde{v}_j^{-*}\right)} \left\{\widetilde{v}_{tj}, \quad t = 1, 2, \ldots k\right\}, \quad j = 1, 2, \ldots n \tag{39.12}$$

where the absolutely positive solution $\widetilde{v}_j^{+*}$ and negative solution $\widetilde{v}_j^{-*}$ is:

$$\widetilde{v}_j^{+*} = (1, 1, 1)$$
$$\widetilde{v}_j^{-*} = (0, 0, 0)$$

Step5: Calculate that is shouldering the ideal and solving the distance

Calculate method as follows:

$$d_t^+ = \sum_{j=1}^{n} d\left(\widetilde{v}_{tj}, v_j^+\right), \quad t = 1, 2, \ldots k \tag{39.13}$$

$$d_t^- = \sum_{j=1}^{n} d\left(\widetilde{v}_{tj}, v_j^-\right), \quad t = 1, 2, \ldots k \tag{39.14}$$

Step6: Calculate every auction website service performance indicator (OPI) with arranging in an order

The movements arranged in an order finally, the good and bad order of performances of the service that the result arranged in an order offers for every auction website.

$$OPI_t = \frac{d_t^-}{d_t^+ + d_t^-} \quad t = 1, 2, \ldots, k \tag{39.15}$$

39.3 Results

39.3.1 Process

This research gathers together and exactly appears 5 and mainly indices via collection and arrangement of literature and relevant materials, total 25 assessment criteria that service performance of auction website, and assess the criterion of these to design into a questionnaire, the sample is the website user who often use the auction website (Yahoo and Return). Testee send out it questionnaire by investigation of carrying on, last questionnaire of 60 copies together this research, retrieve 59 part questionnaires, the effective questionnaire 57 part among them, the effective questionnaire rate is 95 %. 57 persons who assess evaluate 25 service performances that two major auction websites include to assess importance degree of the criterion, appraise to the satisfaction of this criterion while using this website actually to the persons who assess, then we utilize the fuzzy theory and TOPSIS method, calculate the common performance indicators of two major auction websites, ask the good and bad level of service performance of two major auction websites.

39.3.2 Results

According to the analysis described above, the good and bad orders of the service performances of two domestic auction websites are: Yahoo is expressively better than Return, found finally the buyer presented the obvious difference to two major domestic service satisfaction of auction website as in Tables 39.1 and 39.2.

Table 39.1 Each assess shouldering the distance that the ideal is being solved of the criterion

Auction website	d_i^+	d_i^-
Yahoo	0	1.4718
Return	1.4718	0

Table 39.2 Service performance indicator of OPI value with arranging in an order

Auction website	OPI	Sequence
Yahoo	1	1
Return	0	2

39.4 Discussion

Have assessed and contained more criterion and persons who assess more in performance of auction website, it is fuzzy on possessing with assessing the criterion congenitally at the same time, difficult accurate quantization.

Therefore, it is often difficult to exactly amalgamate and verify its objectivity to assess the result. Among the subjects especially as assessing when surface of different literary compositions have either excellent or bad behavior, the whole performances of websites will become quite difficult to arrange in an order. In addition, the assessment criterion needing to be established of expert opinion, must often spend lengthy time and a large amount of cost, on a small scale assessment of plan have more difficultly implement.

To problem characteristic described above, originally research and propose in weight way of fuzzy time, extract the important assessment criterion out to replace and generally remit the whole expert opinion with technology such as Delphi method from the literature. And then through questionnaire way, received the performance appraisal of user's service for comparative theme of website. And will appraise and melt it fuzzily in order to agree with receiving the fuzzy weight inborn and fuzzily of language purpose. Then we arranged the website's performance in an order with TOPSIS.

Through the appraisal of 25 assessment performances, we received two comparative subjects (Yahoo and Return) in this research the performance is arranged in an order. We can be found out by the result of this research, the service performance of Yahoo is far higher than Return.

39.5 Conclusion

Assess the performance of the auction website for the example, this research has combined several kinds of employing extensively and simple and feasible fuzzy theory technology of the present stage, aim at proposing a common procedure of fuzzy much attribute decision, as assess target have many attribute, need many people assess and assess content have fuzzy difficult while quantizing clearly characteristic, the way that this research institute puts forward is suitable for the using of assessment of this kind of problem. Can assess the target to further arrange in an order clearly while combining TOPSIS technology, especially when assessing the target and arranging in an order numerously and difficultly. Choose such as large attribute makes policy regardless of the scheme, if assess the criterion and persons who assess and can be confirmed, can use the way that this research institute put forward to assess and arrange in an order the track case performance.

In addition, this research regards literature as experts, put forward the brand-new literature review concept. Screen the way to assess criterion with the fuzzy time weight, when it is difficult for the expert to investigate expensively and live, can offer the comparatively economic substituting scheme not losing its objectivity. The weight concept of fuzzy time, though the concept is quite simple, we think we can further probe into the application feasibility in other fields in this kind of concept.

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Chapter 40
Knowledge Discovery from Granule Features Mining

Jian-hong Luo, Xi-yong Zhu and Xiao-jun Wang

Abstract For the learning problem on imbalanced distribution of data sets, traditional machine learning algorithms tend to produce poor predictive accuracy over the minority class. In this paper, granule features mining model (GFMM) for knowledge discovery is proposed to improve classification accuracy on the minority class. Suitable information granules (IGs) are constructed by ETM-ART2, and then key features analysis method is proposed to discrete represent the IGs to mining compact knowledge rules. The final class for new samples inputted to GFMM can soon be decided by the knowledge rules. Experiments were conducted on three data sets with different skewed level, the results show that GFMM can lead to significant improvement on classification performance for the minority class and outperforms individual SVM and C4.5.

Keywords Classification · Data mining · Information granules · Key features analysis

40.1 Introduction

Data mining is the process that attempts to discover usable information in large data sets (Fayyad et al. 1996). It is a popular research topic in many fields. However, the data set sample distribution may be highly imbalanced or skewed. It means one class in the data set might be represented by a large number of examples, while the other might be relatively represented by a few. Since traditional classifiers which focus on seeking an overall accuracy over the full data set often produce high accuracy on the majority class, while poor predictive accuracy

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E. Qi et al. (eds.), *The 19th International Conference on Industrial Engineering and Engineering Management*, DOI: 10.1007/978-3-642-38391-5_40,

on the minority class, they are not apposite to deal with skewed data decision tasks (Batista et al. 2004; Chawla et al. 2004).

There are also some methods proposed to cope with this kind of problem, such as the methods of sampling (Batista et al. 2004; Tong et al. 2011), moving the decision thresholds (Cristianini 2000; Jo and Japkowicz 2004) and adjusting the cost-matrices (Cristianini 2000). Sampling methods tend to reduce data imbalance level by downsampling-removing instances from the majority class or upsampling-duplicating the training instances from the minority class or both. Moving the decision thresholds method tries to adapt the decision thresholds to impose bias on the minority class. The third kind of methods tries to adjust the cost (weight) for each class or change the strength of rules to improve the prediction accuracy (Batista et al. 2004). However, these three kinds of methods lack a rigorous and systematic treatment on imbalanced data (Huang et al. 2004). For example, downsampling the data might lose information, while upsampling the data will introduce noise (Bargiel and Andrze 2002).

How to build an effective and efficient model on this kind of problem is an important concern of the data mining (Tong et al. 2011; Nie et al. 2011; Liu et al. 2011). In this study, 'information granulation' is conducted to build knowledge discovery model to deal with this problem. Granular computing represents information in the form of some aggregates such as clusters, classes, and subsets of a universe, which is called as information granules (IGs), and then solves the targeted problem on each information granule (Yao 2001). When a problem involves incomplete, uncertain, or vague information, human beings tend to utilize aggregates to ponder the problem instead of numbers. If distinct elements cannot be differentiated by ordinary methods, one may study information granules which are collections of entities aggregated together due to their similarity, functional adjacency and indistinguishability or the like (Huang et al. 2004; Nie et al. 2011; Liu et al. 2011), and then solves the problem over the information granules .

The process of constructing information granules is referred to as information granulation. It was first pointed out by Zadeh (1996) who proposed the term 'information granulation'. Zadeh also emphasized that a plethora of details may not necessarily amount to knowledge. Information granulation serves as an abstraction mechanism to reduce an entire conceptual redundancy. Granular computing (GrC) which concerns the representation and processing of complex information entities as information granules is quickly becoming an emerging paradigm of information processing (Bargiel and Andrze 2002). GrC is a superset of the theory of fuzzy information granulation, rough set theory and interval computations, and is a subset of granular mathematics (Zadeh 1997). GrC arise in the process of data abstraction and derivation of knowledge from information

In this study, we propose granular features mining model for knowledge discovery (GFMM) to improve prediction performance, which should not only produce good prediction accuracy on the majority class but also produce good prediction accuracy over the minority class. Firstly, suitable information granules are constructed by ETM-ART2 (Luo and Chen 2008) which is an improved ART2 with good clustering performance, and then information granules based key feature analysis method is proposed to discrete represent the IGs to mining compact knowledge rules. According to the knowledge rules, it can soon predict the final class of new inputted data. Experiments for a glass classification problem show that our method outperforms individual SVM and C4.5 classifiers.

40.2 Granule Features Mining Model for Knowledge Discovery

Imbalanced data sets occur in many practical industries, such as business, medical and fraud detecting data. Imbalanced data sets exhibit skewed class distribution in which most instances belong to the majority class while far fewer instances belong to a smaller class. Usually, the majority class has bigger proportion than the smaller class. Take fraud data for example, there are usually very few instances of fraud as compared to the large number of honest instances because it should be honest rather than fraud by nature. Information granulation has a better insight into its essence of the data sets and can help to comprehend the target problem. In this section, our proposed granule features mining model for knowledge discovery is described in detail. Figure 40.1 shows the process.

IGs are constructed by ETM-ART2 according to the similarity of numerical data. The total number of IGs may be remarkably smaller than the size of numerical data set. Most of all, the number of IGs in the majority class would also be remarkably reduced compared to the size of numerical data. And it would increase the proportion of the minority class and improve the imbalanced data situation. By construct IGs, we also can get main characteristics of the data essences by reduce some redundancy from the data sets. Then we propose key feature analysis method processing IGs to mine compact knowledge rules.

40.2.1 Information Granulation

40.2.1.1 Information Granules Construction by ETM-ART2

Denote a data set $D = \{\mathbf{d}_i\}_{i=1}^{N}$, it includes N sample patterns with M classes and each is p-dimension. There is an attribute to express its class name for each sample pattern.

IGs are usually grouped according to the similar 'size' (that is granularity) in a single layer. Since IGs can exist at different levels of granularity, the appropriate levels of granularity can be helpful to deal with the target problem and it should be discovered as knowledge. There are many approaches to construct IGs, such as rough sets, Self-Organizing Map (SOM) network, and etc. (Bargiel and Andrze 2002).

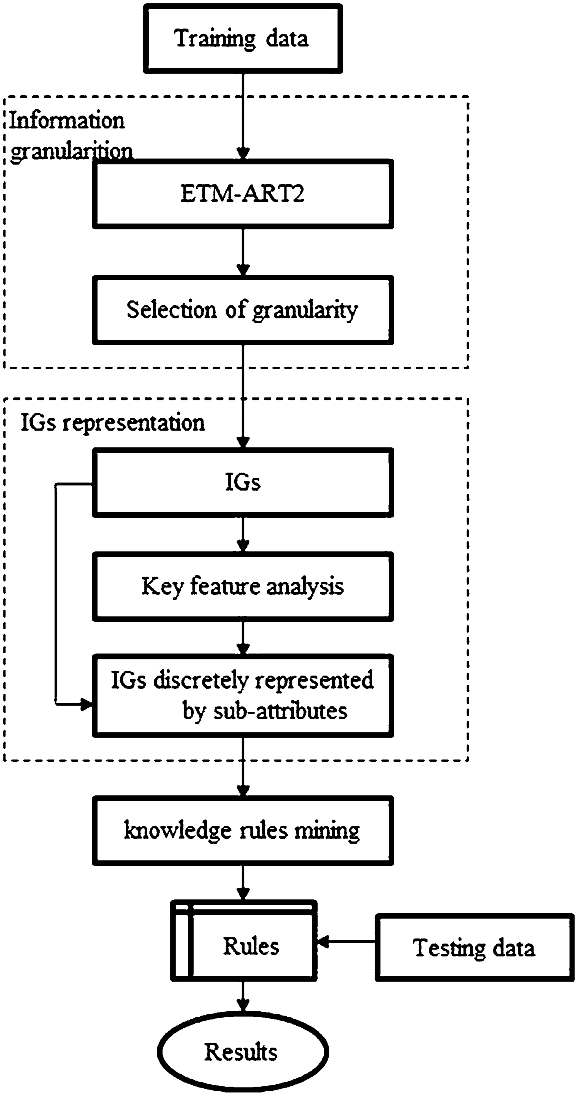

Fig. 40.1 Granule features mining model for knowledge discovery

In this paper, we utilize ETM-ART2 network to construct IGs. Because ETM-ART2 network is an improved ART2 network with enhanced triplex matching mechanism, which has better clustering analysis performance and can be easier to construct useful IGs. Furthermore, ETM-ART2 network has a vigilance parameter (ρ) which can be adjusted to control the degree of similarity of patterns grouped to the same cluster, this is viewed as an information granule. So ρ can be used to adjust the granularity of IGs. The vigilance parameter is the major difference and superiority between ART network and other unsupervised neural networks. Compared to some other clustering methods which do not implement vigilance parameter, ETM-ART2 network don't automatically group all input patterns into one cluster if they are not similar sufficiently. Furthermore, ETM-ART2 network shows the same appropriate stability properties as ART2 network, which is also self-organizing network capable of dynamic, on-line learning and with higher accuracy of hierarchical clustering. So we use ETM-ART2 network to construct IGs.

40.2.1.2 Selection of Granularity

The granularity determines how similar patterns should be grouped together to form one IG. It is not an easy task to select an appropriate granularity to construct IGs.

Firstly, we propose two basic indexes to depict the similarity of IGs. One is *IAR* and the other is *PIR*. *IAR* is designed to measure the consistency of the class for the patterns in one IG, which depicts the similarity of patterns in one IG. And it is defined as follows:

$$IAR = \frac{m}{n} \times 100\,\% \tag{40.1}$$

where n denotes the number of all patterns in one IG and m is the number of patterns possessing the majority class. The value of *IAR* is larger, the IG could be more ‘pure’ since more patterns in one IG possess the same class. If $IAR = 1$, the IG is called as a pure IG. Then another index can be conduct to measure the purity of granularity, which is denoted as *PIR* and defined as

$$PIR = \frac{e}{H} \times 100\,\% \tag{40.2}$$

where H is the number of all IGs and e is the number of pure IGs.

Secondly, we propose granularity index to help choosing appropriate granularity. Let $H(v)$ denotes the number of IGs by different granularity v, and $\overline{IAR}(v)$ denotes the average *IAR*. Then granularity index is defined as follows:

$$GI(v) = \frac{\overline{IAR}(v) \cdot PIR(v)}{H(v)} \tag{40.3}$$

where $\overline{IAR}(v)$ and $PIR(v)$ are larger, the IGs could be purer, and at the same time, $H(v)$ is smaller, this granularity is a good solution.

The vigilance parameter of ETM-ART2 can be set to about 1 and then decrease gradually until find a satisfying vigilance with maximum GI(v). Then the vigilance which make maximum GI(v) by granularity $v$is used to construct appropriate IGs. And the suitable level of granularity by ETM-ART2 is selected.

40.2.2 IGs Representation

Some IGs are formed through ETM-ART2 network learning according to the selected granularity. Denote the number of IGs is q, usually $q << N$, the number of IGs for the ith class is q_i.

It is difficult to mining knowledge rules directly from the attributes values of all IGs. So we propose the key feature analysis method for IGs to get key feature that can differentiate with the other classes significantly.

Firstly, we give some definitions:

For patterns of the ith class, the minimum and maximum value on the jth dimensional attribute can compose the class's jth dimensional attribute value range, which is denoted as CF_j^i.

For patterns in the kth granule of the ith class, the minimum and maximum value on the jth dimensional attribute can compose the granule's jth dimensional attribute value range, which is denoted as $\mathrm{GF}_j^{(i,k)}$. Any minimum or maximum value point of granules is denoted as Cut Point on CF_j^i. The interval between any two cut points is abbreviated as ICF.

For all patterns, the minimum and maximum value on the jth dimensional attribute can compose the data set's jth dimensional attribute value range, which is denoted as QF_j.

Then key features are analyzed as follows:

40.2.2.1 Cover Degree of Granules

Make the jth dimensional attribute of the ith class as an example, let S_j^i denotes a ICF on CF_j^i. If $GF_j^{(i,k)} \cap S_j^i \neq \phi$, we say the kth IGs cover S_j^i. Suppose the number of IGs of the ith class that cover S_j^i is $g(i, S_j^i)$, the number of IGs of non-ith class that cover S_j^i is $\overline{g}(i, S_j^i)$. Then we can compute the cover degree of IGs on S_j^i :

$$Gcd(i, S_j^i) = \frac{g(i, S_j^i) - \overline{g}(i, S_j^i)}{q_i} \tag{40.4}$$

It depicts the differentiate capability for the ith class from the other classes on S_j^i. The cover degree is larger, the differentiate capability is better.

For each attribute, compute the cover degree of each ICF for all classes according to Eq. (40.4).

40.2.2.2 Find Key Features

For the jth dimensional attribute of the ith class, choose the ICF with maximum cover degree as the key feature range of the jth dimensional attribute for ith class, and denoted as KF_j^i. If the number of ICF with maximum cover degree is larger than 1, choose the ICF with minimum $\overline{g}(i, S_j^i)$ value as the key feature. Then the key features of all attributes for all classes can be found.

40.2.2.3 Getting Sub-Attributes

For the *j*th dimensional attribute, make two endpoint of key feature range of each class segment QF_j into several sub-ranges which are denoted as sub-attributes. And the *j*th dimensional attribute can be segmented into several sub-attributes.

40.2.2.4 IGs Discretely Represented by Sub-Attributes

According to the sub-attributes, each IG's attribute $GF_j^{(i,k)}$ can be discretely represented by discrete value 1 or 0. Including the class of each IG, a decision table U can be figure out by each IG's sub-attributes.

Though the number of total attributes is increasing, the sub-attributes partitioned by key features has significant differentiate capability for class and they are non-strongly correlated, and is represented by discrete value 1 or 0. So mining from the decision table compose by sub-attributes is easier to get compact knowledge rules.

40.2.3 Knowledge Rules Mining and Application

According to the decision table U, we use C4.5 decision tree to mining knowledge rules since C4.5 decision tree algorithm is fast, easy to implement to get useful rules.

A mined rule has the following format: if $a_1 = x_1$ and …and $a_p = x_p$ then $c = c_t$. $a_p = x_p$ denotes sub-attribute a_p value is x_p, and c_t is the decision class.

We use *support* and *confidence* to measures the knowledge rules. The number of instances that contain all items in the antecedent denoted as $A(R)$, and the number of instances that contain all items in the consequent parts denoted as $Y(R)$. Then *support* and *confidence* can be defined as $Sup(R) = |A(R) \cap Y(R)|/|U|$ and $Cer(R) = |A(R) \cap Y(R)|/|A(R)|$.

Then we define instance match degree for rule R as $Mat(R)$. It is the ratio of the number of condition attributes the instance meet in the all condition attributes in antecedent.

The steps to predict the test instance's class by the knowledge rules are as follows:

(1) Make the instance's attributes discrete according to the sub-attribute found above.
(2) Compute the $Mat(R)$ for each knowledge rule.
(3) Predict the test instance's class by the rule with maximum Mat (R).

40.3 Experiments and Evaluation

40.3.1 Data Sets

We use glass data set from UCI machine learning repository (Lake and Merz 1998), on which assemble three data sets to make experiments. They are depicted in Table 40.1. Glass1 includes two classes: building_windows_float_processed, others. Glass2 includes two classes: headlamps, others. Glass3 include three classes:
    vehicle_windows_float_processed,
    vehicle_windows_non_float_processed, others

40.3.2 Evaluation Methodology

Fivefold cross-validation was used to evaluate the performance of the algorithm, and implemented our experiments using WEKA. For imbalanced data sets, the measure of overall classification accuracy is not effective to evaluate the prediction performance of the proposed approach. So we use the geometric mean (GM) to evaluate our GFMM model. GM is defined as

$$GM = \sqrt[T]{\prod_{i=1}^{T} Tc_i} \tag{40.5}$$

where Tc_i is the classification accuracy for the ith class.

Table 40.1 Data sets

Data sets	Number	Attributes	No. %Class
Glass1	214	9	32.71 %:67.29 %
Galss2	214	9	13.55 %:86.45 %
Glass3	214	9	40.65 %:35.51 %:23.83 %

Table 40.2 Information of parameters and IGs

Data sets	ρ	No. of IGs	$\overline{IAR}(\rho)/\ \%$	$PIR(\rho)/\ \%$
Glass1	0.85	63	93.92	81.81
Glass2	0.82	59	98.07	96.57
Glass3	0.82	57	90.05	79.87

Table 40.3 Comparison of GFMM, C4.5 AND SVM

Data sets	Method	*Acc* (%)	Tc_1 (%)	Tc_2 (%)	Tc_3 (%)	*GM* (%)
Glass1	GFMM	83.72	80.00	85.51	–	82.68
	C4.5	80.84	74.29	84.03	–	79.01
	SVM	83.64	62.86	93.75	–	76.77
Glass2	GFMM	95.81	86.67	97.30	–	91.76
	C4.5	95.79	82.76	97.84	–	89.98
	SVM	95.79	79.31	98.38	–	88.33
Glass3	GFMM	81.78	86.21	77.63	80.39	81.33
	C4.5	73.83	81.61	65.79	72.55	73.03
	SVM	77.10	85.06	67.11	78.43	76.50

40.3.3 Results

When input the samples to the ETM-ART2 to construct IGs, we set ρ to 0.9 and then decrease to 0.5 stepped by 0.05. The granularity v is selected with maximum $GI(v)$. The experimental data about IGs is list in Table 40.2

Compared to the size of training patterns, the number of IGs is reduced to about 30 %. $Aver(IAR)$ is above 90 % and PIR is above about 80 %. So these IGs are help to mining useful knowledge rules. Then test patterns were predicted their classes by the knowledge rules.

To compare the performance of GFMM, we conducted the experiments by two other approaches: (1) non-information granulations for single C4.5 decision tree algorithm. (2) SVM (Cristianini 2000; Platt 1999), which is based on *Person VII* Kernel Function and use Sequential minimal optimization. The results are listed in Table 40.3

It can be seen that GFMM has better classification accuracy especially for data set of minority class with manifest higher GM. C4.5 and SVM show good overall classification accuracy, while they show poorer accuracy for minority class and GM is poorer.

40.4 Conclusions

In this paper, granule features mining model for knowledge discovery (GFMM) is studied. We proposed granularity index and use ETM-ART2 to construct useful information granules, and then proposed information granules based key feature analysis method to discrete represent the IGs to mining compact knowledge rules. New patterns can be soon predicted by the knowledge rules.

In many real world data sets, most of the instances belong to a larger class and far fewer instances belong to a smaller. Usually, the smaller class should be concerned and interesting. And the cost is usually high when the smaller (positive) class instances are misclassified. Normal systems which ignore the imbalanced distribution of class tend to misclassify the minority class instances as majority, and will lead to a high false rate of the minority class. In this paper, we consider IGs instead of numerical data, it might increase the distribution proportion of minority class and improve imbalanced situation of data. We also utilize ETM-ART2's property to construct suitable IGs conveniently. Through extensive experiments with different imbalance ratio datasets, our proposed method is shown to be effective and superior to several other classification methods such as single C4.5 and SVM.

Acknowledgments This work is supported by the Research Foundation of Education Bureau of Zhejiang Province, China (Grant No. Y201122135), Science Foundation of Zhejiang Sci-Tech University (No. 1005841-Y, No. KY2011005).

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Chapter 41
Multivariable Forecasting Model Based on Trend Grey Correlation Degree and its Application

Li-ping Fu, Lu-yu Wang and Juan Han

Abstract Among the current forecasting methods, trend grey correlation degree forecasting method is limited to a single variable time series data, but cannot solve the problem of multivariable forecasting. While multiple regression forecasting can only be used for multivariable linear forecasting, and can be easily affected by random factors. Therefore, this paper combines trend grey correlation degree forecasting based on optimization method and the multiple regression forecasting, generates the multivariable forecasting model based on trend grey correlation analysis, and uses this model to forecast GDP in Henan Province, not only to overcome the effect of random factors on time series, but also to comprehensively consider the various factors that affect the development of objects, thus to achieve the effect of improving accuracy and increasing the reliability of forecasting. And this paper also provides a new method for the study of multivariable combination forecasting.

Keywords Grey prediction · Multivariate regression forecasting · Optimization model · Trend grey correlation degree

41.1 Introduction

The grey system theory was first proposed in 1982 by the Chinese scholar, Professor Deng Julong. This theory requires starting from the system perspective to study the relationship between the information, that is, to study how to use known

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E. Qi et al. (eds.), *The 19th International Conference on Industrial Engineering and Engineering Management*, DOI: 10.1007/978-3-642-38391-5_41,

information to reveal unknown information. The grey system theory needs a small amount of calculation and does not require the typical distribution regularity, so it has been widely used in many areas. The earliest and most typical forecasting model of the grey system theory is GM (1, 1) model, but there has been a case with too large deviation in specific application (Baozhang 1994). In order to overcome the shortage of GM (1, 1) in relevant applications, people have proposed various correction methods of GM (1, 1), such as GM (1, 1) with residual error correction, GM (1, 1) with K correction (Zhang and Dai 2009), etc. In terms of the multivariable grey prediction, the first model was GM (1, N) (Deng 1990). After that, people proposed other improved models, for example, GM (n, h), widening GM (n, h), and so on. However, these models are exponential model, which is unrealistic in many practical applications (Xiong et al. 2003). For this reason, Peng and Xiong 2008 proposed trend grey correlation degree forecasting model based on time series correlation analysis that proposed by Zhao et al. 2004, using orthogonal design strategy to consider the combination when comparing the size between the absolute differences. But this method only selected some representative combinations, did not exhaust all the possible combinations, which is bound to affect the forecast accuracy of the results. In order to achieve the purpose of exhausting the data combination containing the value to be predicted in series calculation process, according to the goal of forecasting method based on trend correlation degree, Wang 2011 established the objective functions to construct optimization problem, and then solved the value to be predicted in the global scope. However, this method is limited to the single variable time series, can not solve the problem of multivariable forecasting. Therefore this paper combines trend grey correlation degree forecasting based on optimization method and the multiple regression forecasting, not only to overcome the effect of random factors on time series, but also to comprehensively consider the various factors that affect the development of objects, thus to achieve the effect of improving the accuracy and reliability of forecasting.

41.2 Model Building and Checking

41.2.1 The Optimization Forecasting Model Based on Trend Grey Correlation Degree

(1) *Trend Grey Correlation Degree Model*

Definition 1: Provide series

$$X_0 = (x_0(1),\ x_0(2), \ldots x_0(n),)$$
$$X_1 = (x_1(1),\ x_1(2), \ldots x_1(n),)$$

Let:

$$\begin{aligned}\Delta x_0(k+1) &= x_0(k+1) - x_0(k)\\ \Delta x_1(k+1) &= x_1(k+1) - x_1(k)\end{aligned} \tag{41.1}$$

If $x_0(k+1)\Delta x_1(k+1) \geq 0\,(k = 1, 2, \ldots, n-1)$, then said series Δx_0 and Δx_1 have the same trend.

Definition 2 (Zhao et al. 2004):

$$\begin{matrix} X_0 = (x_0(1), x_0(2), \ldots, x_0(n)) \\ X_i = (x_i(1), x_i(2), \ldots, x_i(n)) \end{matrix}, (i = 1, 2, \ldots, m)$$

Provide X_0, X_i are time interval series which have the same length, and

$$\sum_{k=1}^{n-1} |x_i(k+1) - x_i(k)| \neq 0 \quad (i = 0, 1, \ldots, m)$$

Let:

$$D_i = \frac{1}{n-1}\sum_{k=1}^{n-1} |x_i(k+1) - x_i(k)| \tag{41.2}$$

$$y_i(k) = \frac{1}{D_i} x_i(k) \tag{41.3}$$

In these formulas, $k = 1, 2, \ldots, n$ and $i = 0, 1, 2, \ldots, m$.

$$\Delta y_i(k+1) = y_i(k+1) - y_i(k) \tag{41.4}$$

$(k = 1, 2, \ldots, n-1;\ i = 0, 1, 2, \ldots, m)$

$$\begin{cases} 0 \\ \qquad if\,\Delta y_0(k+1)\Delta y_i(k+1) = 0 \\ \operatorname{sgn}\left[\Delta y_0(k+1)_i(k+1)\right] \dfrac{|\Delta y_0(k+1)| + |\Delta y_i(k+1)|}{2max(|\Delta y_0(k+1)|, |\Delta y_i(k+1)|)} \\ \qquad if\,\Delta y_0(k+1)\Delta y_i(k+1) \neq 0 \end{cases} \tag{41.5}$$

$$\gamma(X_0, X_i) = \frac{1}{n}\sum_{k=1}^{n-1} \zeta_i(k+1) \tag{41.6}$$

$\gamma(X_0, X_i)$ is said to be the trend grey correlation degree, $\zeta_i(k+1)$ is said to be the relational coefficient of X_0 related to X_i at $K+1$ point.

(2) *The Optimization of the Mathematical Model Building* (Wang 2011)

Based on trend grey correlation degree model, we are going to predict the system state x(t) at time t of a single series $X = (x(1), x(2), \ldots, x(t-2), x(t-1), x(t))$, from the single series we can construct three time series written as:

$$
\begin{aligned}
X_0 &= (x(1), x(2), \ldots, x(t-2)) \\
X_1 &= (x(2), \ldots, x(t-2), x(t-1)) \\
X_2 &= (x(3), \ldots, x(t-1), x(t))
\end{aligned}
\tag{41.7}
$$

According to similarity principle, the sampling series of the grey system in the two sampling periods on the adjacent imply almost the same dynamical information. In this sense, the value to be predicted should satisfy that the trend grey correlation analysis $\gamma(X_0,\ X_1)$ between X_0 and X_1 is equal to the trend grey correlation analysis $\gamma(X_1,\ X_2)$ between X_1 and X_2.

It can construct optimal objective function:

$$
\min f = |\gamma(X_0,\ X_1) - \gamma(X_1,\ X_2)| \tag{41.8}
$$

In this formula, $\gamma(X_1,\ X_2)$ is the function of the value to be predicted, and its function form is decided by the definition process of the trend grey correlation degree. When calculating the relational measure, we must meet the problems of comparing $\Delta y_1(k+1)$ and the value to be predicted $\Delta y_2(k+1)$ and determining whether $\Delta y_2(k+1)$ is zero, so its function has the form of the phase function, every comparison and judgment produce a combination of calculating the formula of relational measure, and result in the relational measure expressed by a functional form of the value to be predicted. Solving the optimization problems can obtain the value to be predicted. In particular, using the algorithms with global search feature can solve the whole optimal solution, in order to avoid possible loss of the combination when calculating relational measure.

41.2.2 Multivariate Forecasting Model Based on Grey Correlation Degree Forecasting

For single-factor trend analysis and forecasting, we often use trend extrapolation method (Xu 1998; Yu and Huang 2003). But when using this method to the trend of series with random factors, it will engender considerable errors, and make predictions distorted. If using the principle of multiple regressions to establish a multivariable grey prediction model, it will be conducive to combine various factors impacted on the development of objects to do comprehensive prediction, and to improve the forecasting accuracy (Su et al. 2007; Chen and Wang 2012). Building multivariate forecasting model based on trend grey correlation degree is as follows:

$$
\hat{y}(t) = b_0 + b_1\hat{x}_1(t) + b_2\hat{x}_2(t) + \cdots + b_k\hat{x}_k(t) \tag{41.9}
$$

In this formula, $\hat{y}(t)$ is the predictive value of the object at time t; $\hat{x}_i(t)$ is the predictive value of the variable X_i at time t, which is obtained by using optimization model to solve the trend grey correlation degree model; $b_i(i = 1, 2, \ldots, k)$ is the parameter to be estimated.

In the model, b_i is decided by the least squares method (Li and Pan 2005):

$$B = (b_0, b_1, \ldots, b_k)' = (X'X)^{-1}X'Y \tag{41.10}$$

where:

$$X = \begin{bmatrix} 1 & x_1(1) & \cdots & x_k(1) \\ 1 & x_1(2) & \cdots & x_k(2) \\ \cdots & \cdots & \cdots & \cdots \\ 1 & x_1(n) & \cdots & x_k(n) \end{bmatrix}$$

$$Y = [\, y(1) \quad y(2) \quad \cdots \quad y(n) \,]'$$

Substitute historical data into formula (41.10), we can obtain B.

Finally, substitute the predictive value of each variable $\hat{x}_i(\mathrm{t})$ into the model $\hat{y}(\mathrm{t})$, we can get a final predictive value.

41.2.3 Model Test

(1) *The Coefficient of Determination* R^2(Zhang 2009)

$$R^2 = 1 - \frac{RSS/(n-k-1)}{TSS/(n-1)} = \frac{\sum_{i=1}^{n} (y_i - \hat{y}_i)^2/(n-k-1)}{\sum_{i=1}^{n} (y_i - \bar{y})^2/(n-1)} \tag{41.11}$$

In this formula, *RSS* represents the Residual Sum of Squares, *TSS* stands for Total Sum of Squares, *k* is the factor number, *n* is the total number of equations.

The closer R^2 to 1, the better goodness of fitting the estimated regression function effect on the sample points, that is, the stronger the role of the independent variable explaining on the dependent variable (Zhang 2009).

(2) *F-Test*

$$F = \frac{ESS/k}{RSS/(n-k-1)} = \frac{\sum_{i=1}^{n} (\hat{y}_i - \bar{y})^2/k}{\sum_{i=1}^{n} (y_i - \hat{y}_i)^2/(n-k-1)} \tag{41.12}$$

ESS is Regression Sum of Squares. *F* follows $\mathrm{F(k, n - k - 1)}$ distribution. Given the significant level a, if $F \le F_{a/2}(k, n-k-1)$, indicates that the linear regression model is not significant and can not be used to predict; if $F > F_{a/2}(k, n-k-1)$, indicates that the linear regression model is significant, can be used to forecast (Li and Liu 2010).

(3) *T Test*

T test is to test whether the coefficient of each explanatory variable is significant, the test statistic is:

$$t = \frac{\hat{b}_j}{s(b_j)} \quad (j = 1, 2, \ldots, k) \tag{41.13}$$

In this formula, t follows t(n−k−1) distribution. Given the significant level a, checking a t test table for critical value $t_{a/2}(\mathrm{n-k-1})$. If $|t| > t_{a/2}(\mathrm{n-k-1})$, rejecting the null hypothesis, which means that, the impact of the independent variable on the dependent variable is significant (Li and Liu 2010).

41.3 The Application of the Model

This paper selects the State-owned units' Investment in Fixed Assets (x_1), the Total Revenue from Leasing of the Use Right of State-owned Land (x_2) as the factor variables, studies the effect of two factors on GDP (y) of Henan province, and forecasts. The data come from the Statistical Yearbook of Henan Province (2005–2011) (Statistics Bureau of Henan Province 2005).

First, use formula (41.7) to build three series, they are X_0, X_1 and X_2, according to the State-owned units' Investment in Fixed Assets (x_1).

X_0 = (1127.02, 1367.02, 1608.59, 1715.78, 2127.02, 2586.9)

X_1 = (1367.02, 1608.59, 1715.78, 2127.02, 2586.9, 2857.41)

X_2 = (1608.59, 1715.78, 2127.02, 2586.9, 2857.41, S_1)

Second, use formulas ((41.1)–(41.6)) to calculate $\zeta_i(k+1)$ and $\gamma(X_0,\ X_1)$:

$$\zeta_1(2) = 0.9903;$$
$$\zeta_1(3) = 0.7173;$$
$$\zeta_1(4) = 0.6330;$$
$$\zeta_1(5) = 0.9565;$$
$$\zeta_1(6) = 0.7881;$$

$$\gamma(X_0,\ X_1) = 0.8176$$

Then, calculate $\gamma(X_1, X_2)$ containing the predictive value $\hat{x}_1$(t) of 2011, substitute into formula (41.8), use the *Matlab* software, get:

$$S_1 = 3139.5$$

Similarly, obtain $\zeta_i(k+1)s$ and $\gamma(X_0,\ X_1)$ of the Total Revenue from Leasing of the Use Right of State-owned Land (x_2) and GDP in Henan Province (y), and the predictive values S_2 and S_0. The results are shown in Table 41.1.

According to the data of y, x_1 and x_2 from the years of 2000–2010, use the software SPSS18.0 to obtain the numerical value of the estimated parameters b_i and the prediction model.

Table 41.1 Grey correlation degree correlation coefficient and predictive value of each variable

	GDP(y)	Total revenue from leasing of the use right of state-owned land (x_2)
$\zeta_1(2)$	0.8814	0.6006
$\zeta_1(3)$	0.8834	0.5929
$\zeta_1(4)$	0.9957	0.8988
$\zeta_1(5)$	0.7125	0.5271
$\zeta_1(6)$	0.7316	0.5461
$\gamma(X_0, X_1)$	0.8409	0.6331
$\hat{x}_1$(t)	20688	789.28

$$\begin{array}{ccccccc} \hat{y}(t) & = & -264.102 & + & 7.440\hat{x}_1(t) & + & 4.036\hat{x}_2(t) \\ t & & (-0.255) & & (6.133) & & (2.869) \end{array} \tag{41.14}$$

$$\mathrm{R}^2 = 0.987;\ \mathrm{F} = 294.976\,(\mathrm{p} = 0.000)$$

Upon examination, the t value of and x_1 are greater than the critical value. $R^2 = 0.987$ is close to 1, which means the goodness of fit is better. F = 294.976 is larger, and the corresponding p equals to zero, indicating the formulation is significant and can be used to forecast.

Finally, substitute the calculated the predictive values of variables x_1 and x_2 into formula (41.14), and get the final predictive value $\hat{y}(t) = 26279.298$.

41.4 Conclusions

Actually, GDP of Henan Province in 2011 is 2.723204 trillion Yuan (Henan channel on Xinhuanet). Comparing the predictive value and the result simply calculated by trend grey correlation analysis prediction based on optimization method ($S_0 = 26088$):

$$2723204 - S_0 = 6544.04$$
$$2723204 - \hat{y}(t) = 952.74$$

It is obviously that the deviation of $\hat{y}(t)$is smaller, which is closer to the actual situation. And this shows that combining trend grey correlation analysis prediction based on optimization method and the multiple regression prediction, has not only overcome the effect of random factors on time series, but also comprehensively considered the various factors that affect the development of objects, and made the results of prediction more accurate. This also provides a new method for the study of multifactor combination forecast.

Acknowledgments Project Subject: Soft Science Research Project in Henan Province: Research on State-owned Assets Supervision Mode in Henan Province (112400430009).

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Chapter 42
Partner Selection About the PPP Reclaimed Water Project Based on Extension Evaluation Method

Xu-kuo Gao and Xiao-hu Chen

Abstract The model of Private-Public-Partnership can solve the shortage of reclaimed water project funds effectively, which in favor of the reclaimed water popularization and application. Choose a suitable partner is one of the most important steps of Private-Public-Partnership project. In order to evaluate Potential Partners effectively, we set up evaluation index system of Private-Public-Partnership reclaimed water project, which based on the characteristics of reclaimed water project that combined the comprehensive characteristics of home and abroad. This extension index system applied extension evaluation method to build the evaluation model of matter-element, to evaluate partners comprehensive and choose a suitable partner.

Keywords Extension · Partner selection · Private-Public-Partnership · Reclaimed water project

42.1 Introduction

In recent years, at home and abroad, the practice and research about construction and management of public project has pursued energetically Private-Public-Partnership (PPP) (Gao 2007). Its aim is to attract non public sectors involved in infrastructure projects, alleviate the government financial pressure and improve the level of public services. Now PPP mode has been widely used in global scope, and is becoming the government achieves its economic goals and upgrades the level of public services to the core ideas and measures (Li and Qu 2004). The recycled water in city after depth handling can satisfy the need of industry, agriculture and

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E. Qi et al. (eds.), *The 19th International Conference on Industrial Engineering and Engineering Management*, DOI: 10.1007/978-3-642-38391-5_42,

view in the city fluid matter requests. As an effective path that alleviated shortage of water resources in water-deficient area. It is paid close attention. But, meanwhile, a lot of factors restrict the project's construction and development, while the funds problem is main factor in these factors.

As a constituent part of public project, the project finance mode of Private-Public-Partnership can effectively work out the funds problem that the recycled water item faces and push forward the construction of recycled water project. The PPP project is based on the cooperation of government and the private section. So that constructs a rational and an effective relationship determines the success of PPP project (Li 2009). Therefore, one of the first questions that the public sector facing in the project finance mode of PPP, is how to choose appropriate private partners (Meng and Meng 2005). And it's also a very important link that determines the success of PPP project. The research about selecting partners mostly concentrates on the supply chain business enterprise look for partners. But the research about government selecting private partners in PPP project is very few.

This paper, according to recycled water PPP project's characteristics and experience at home and abroad, tries to analysis the index sign of selecting partners. Then it uses the extension evaluation method to evaluate partners reasonably and effectively, optimized partner selection.

42.2 Build Evaluate Index Sign System

The recycled water project belonging to infrastructure occupies large sum of funds, and has the characteristics of low-return and long return, long recovery period characteristics. It also faces many risks, such as market, price and fluid matter etc. This paper, according to recycled water PPP project's characteristics and the experience at home and abroad, builds the selection of PPP recycled water project partner's evaluation index sign system (Hou 2011).

(1) The credit status of enterprise. The credit status of enterprise mainly includes two aspects: commercial credit which gets it according to credit rating and social credit which get it according to the implementing of social responsibility condition. If lacking commercial credit, it will increase project risk, and increase trades cost. If lacking social credit, it will be hard to balance business enterprise benefits and social benefits, and increase public private conflict, damage to the overall interests of the project goals.

(2) The scale of the enterprise cooperation. The size of the enterprise cooperation including three main conditions: registered capital, production capacity and staff number. Usually, the larger companies, its comprehensive strength and ability are stronger to resist risk. Choosing a larger cooperative enterprise can digest part of the risk independently in the face of the environmental factors changing. And it leads to the success.

(3) The cooperation enterprise's financial situation. The cooperation enterprise financial conditions include the total assets, cash flow, the asset-liability ratio,

return on assets and other major economic and financial index. It can understand the assets structure, capital conditions and operating conditions according to analysis this financial index.

(4) The technology level of cooperation enterprise. The technology level of cooperation enterprise includes three aspects: quantity of technical personnel, equipment, and similar project experience. Reviewing the technique of the cooperation enterprise helps to learn the advantage of the cooperation enterprise. That's what determines the result of the item.

(5) The operating and management level of cooperation enterprise. The operating and management level includes: profit ability, management quality, management system management system, organization form, and others. The recycled water project is a newer industry than many other industries. Public sector lacks experience of project management, construction and operation. Meanwhile, the recycled water project has long pay-back period. So the recycled water project needs partner has a higher management level.

(6) The willingness and ability to bear risks of cooperation enterprise. It mainly includes the following aspects: risk management ability, risk attitude and risk sharing level. Reasonable risk sharing is an important factor of success for PPP project (Smith 2004). And it is the foothold of stable cooperation relations. At present stage, the recycled water industry is still at the further promotion and development stage, has lots of complicated risks. If project partners lack of willingness and ability to share the risk, not only can increase the project of construction and operation cost, but also can reduce the overall efficiency of the implementation of the project (Cai 2000).

Synthesizes the above analysis, building PPP reclaimed water project partner evaluate index sign system.

42.3 The Basic Theory of Extenics

The extenics takes framework for the matter-element theory and extension mathematics theory. With ordered triple form R = (N, C, V) describing objects' basic unit, short for matter-element. Matter-element is triples that composed by object, feature and eigenvalue, recorded as R = (N, C, V). N represents object, C represents feature and V represents eigenvalue, recorded as V = (a, b). They are called three factors of matter-element. In the matter-element, V = C(N) reflects the object relationship of quality and quantity. It composed the name of features (C) and their eigenvalue (V) (Cai 1999). An object has many characteristic elements; it can use n dimension matter-element to description:

$$R_{\mathrm{i}} = \begin{bmatrix} N & C_1 & V_1 \\ & C_2 & V_2 \\ & \vdots & \vdots \\ & C_n & V_n \end{bmatrix} = \begin{bmatrix} R_1 \\ R_2 \\ \vdots \\ R_n \end{bmatrix}$$

$R_i = (N, C_i, V_i)$ (i = 1, 2, …, n).

Build extension evaluate model of cooperative partner.

Above-mentioned has two levels evaluate index, so that can build cooperative partner multi-level extension evaluate matter-element model.

42.3.1 Extension Evaluate Matter-Element Model

If the letter P signifies the problem which evaluated cooperative partners $R_1, R_2, \ldots, R_n$ $(n \geq 1)$ are potential cooperative partners matter-element; r represents partners comprehensive evaluation of matter-element conditions. So the comprehensive evaluation problem is: $P = R_x \times r, R_x \in \{R_1, R_2, \ldots, R_n\}$ (Huang 2007).

The above partner evaluation system has 6 first grade evaluation index $C_1, C_2, C_3, C_4, C_5, C_6$, 18 level-two evaluation indexes $C_{11}, C_{12}, \ldots, C_{62}$. According to the classification of evaluation index system, establish the multi-level extension synthesis assessment method. Conditions matter-element r corresponding attribute value is $[a_i, b_i]$. Enterprise choose partners conditions matter-element is

$$r = \begin{bmatrix} N & C_1 & V_1 \\ & C_2 & V_2 \\ & \vdots & \vdots \\ & C_6 & V_6 \end{bmatrix} = \begin{bmatrix} N & C_1 & [a_1, b_1] \\ & C_2 & [a_2, b_2] \\ & \vdots & \vdots \\ & C_6 & [a_6, b_6] \end{bmatrix}$$

R's level-two index can be expressed as conditions matter-element:

$$R_i = \begin{bmatrix} N & C_{i1} & V_{i1} \\ & C_{i2} & V_{i2} \\ & \vdots & \vdots \\ & C_{in_0} & V_{in_0} \end{bmatrix} = \begin{bmatrix} N & C_{i1} & [a_{i1}, b_{i1}] \\ & C_{i2} & [a_{i2}, b_{i2}] \\ & \vdots & \vdots \\ & C_{in_0} & [a_{in_0}, b_{in_0}] \end{bmatrix}$$

(i = 1, 2, …, 6). Each sub-goal includes n_0 indexes.

42.3.2 Partners Extension Synthesis Assessment Method

(1) The evaluation index classification
    The evaluation index has six types
    $C = \{C_1, C_2, C_3, C_4, C_5, C_6\}$;
    The sub-goal C_i has n_0 indexes, $C_i = \{C_{i1}, C_{i2} \ldots C_{n0}\}$.
(2) Determine the weight of every index
    Determine the weight of every evaluation index extension synthesis evaluation method is one of the key problems. The weight of each index should try to accord with the actual situation. The method is often used the Delphi method and analytic hierarchy process (AHP) (Zhao et al. 1996). In this paper, the

indexes weights determines by the Delphi method. The sub-goal each weight is:

$$\alpha_i(i = 1, 2, \ldots, n) \ , \left(\sum_{i=1}^{n} \alpha_i = 1\right).$$

(3) Calculating the acceptable degree and optimal degree.

(1) Dependent function. As each evaluation index dimension is different, some evaluation index is the bigger the better. And some may be smaller may be more beautiful. So build different correlation functions (Dai and Qu 2011).
The bigger the better:

$$\begin{cases} K(x) = (x - a)/(b - a), & x \in <a, b> \\ K(x) = 1, & x \geq b \\ bK(x) = 0, & x \leq a \end{cases} \tag{42.1}$$

The smaller the better:

$$\begin{cases} K(x) = (b - x)/(b - a), & x \in <a, b> \\ K(x) = 0, & x \leq a \\ bK(x) = 0, & x \geq b \end{cases} \tag{42.2}$$

(2) Evaluate each sub-goal C_i for first class evaluation.
Use dependent function calculated review things N for C_i relationship of degree.

$$K_i(N) = \sum_{k=1}^{n_0} \alpha_{ik} K(c_{ik}) \tag{42.3}$$

(3) The relationship of degree of review things N is:

$$K(N) = [K_1(N), K_2(N), \ldots, K_n(N)].$$

The goodness is:

$$C(N) = \sum_{i=1}^{n} \alpha_i K_i(N) \tag{42.4}$$

Composite indicators of enterprises to be evaluated can be quantified by comparing the goodness of potential partners, and a preferred partner can be selected.

42.4 Case Analysis

Supposing that now we need to evaluate the following four potential cooperative enterprises R_1, R_2, R_3, R_4, and then select the suitable companies as project partners. Each enterprise index values are as in Table 42.1.

Thus, In order to simplify the problem, we define that each sub-index weight is equal, and use the correlation function and the weight to obtain the qualified degrees of various indicators of various enterprises. Use formula (42.3) to calculate the correlation degree K (N) of the enterprise sub-goals C_i ($i = 1, 2, 3, 4, 5, 6$), and then use level analysis method to judge each weight of sub-goals of the matrix $\alpha = [0.21, 0.14, 0.23, 0.1, 0.16, 0.16]$, and finally use formula (42.4) to calculate the goodness C (N_1), C (N_2), C (N_3), C (N_4). Goodness of each enterprise C (N_i) = (0.48, 1.25, 0.36, 0.58), arrange each enterprise's goodness: C (N_2) > C (N_4) > C (N_1) > C (N_3), C (N_2) is largest, and then the optimal partner is enterprise R_2.

Table 42.1 Enterprise index values

	Evaluation objectives	Evaluation index	Classic domain	R_1	R_2	R_3	R_4
Potential partners	Credit conditions (C_1)	Commercial credit C_{11}	(70, 100)	93	85	87	96
		Social credit C_{12}	(70, 100)	95	87	85	95
	Scale (C_2)	Registered capital (million) C_{21}	(0.5, 1)	0.8	0.6	0.5	1
		Production Capacity C_{22}	(60, 100)	90	92	95	95
		Number of employees C_{23}	300	200	260	400	300
		Total assets C_{24}	(1, 2)	1.5	0.8	0.8	1.2
	Financial situation (C_3)	Cash flow C_{31}	(0.05, 1)	0.1	0.08	0.07	0.2
		Asset-liability ratio C_{32}	(0, 0.6)	0.35	0.4	0.5	0.4
		Return on capital C_{33}	(0.1, 1)	0.2	0.15	0.2	0.25
	Technical level (C_4)	Number of technical personnel C_{41}	(20, 100)	50	55	40	60
		Equipment C_{42}	(60, 100)	90	85	80	90
	Operating and management level (C_5)	Similar project experience C_{43}	(80, 100)	90	88	87	91
		Management quality C_{51}	(70, 100)	91	89	87	90
		Forms of organization C_{52}	(60, 100)	90	80	85	90
		Management system C_{53}	(60, 100)	89	85	88	89
		Profitability C_{54}	(0.15, 1)	0.3	0.3	0.25	0.35
	Risk willingness to take on (C_6)	Risk management capabilities C_{61}	(70, 100)	87	84	85	88
		The level of risk sharing C_{62}	(80, 100)	80	87	87	90

42.5 Conclusions

The paper constructs evaluation index system about partners selection of PPP reclaimed water project, and applies extension evaluation method on a comprehensive evaluation of potential partners. Considering From multiple perspectives and multiple factors, rational use the collected information and establish the evaluation model of multi-level indicator parameters, use quantitative values to show assessment results and can completely reflect the comprehensive level of program to make the evaluation simple, easy to operate and more practical. It provides a simple method for PPP recycled water projects to select partners.

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Chapter 43
Personnel BDAR Ability Assessment Model Based on Bayesian Stochastic Assessment Method

Zhi-feng You, Tian-bin Liu, Ning Ding and Kai-xuan Cui

Abstract It is important for us to evaluate each trainee's ability with the aim of improving BDAR training efficiency. The typical assessment methods include fuzzy evaluation, gray correlation evaluation, neural network and so on. All of these methods are not able to make full use of the historical information. Determining membership function in first two methods is not easy. And ANN needs a lot of data sample which is difficult to obtain in BDAR training. So we can't use these methods to model the assessment of personnel BDAR ability. Then we introduce Bayesian Stochastic Assessment Method which can deal well with the nonlinear and random problem. Each indexes' standard is given according to the characteristics of BDAR training. A modified normal distribution which can make full use of historical information was put forward to determine the prior probability. And the poster probability is determined by distance method.

Keywords Bayesian · Stochastic assessment · Bayesian theorem · Personnel BDAR ability · Prior probability

43.1 Introduction

Battlefield damage assessment and repair is a series of activities, which can make equipments' basic functions recover quickly by emergency diagnosis and rush-repair technologies. It consists of battlefield damage assessment and damage repair

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E. Qi et al. (eds.), *The 19th International Conference on Industrial Engineering and Engineering Management*, DOI: 10.1007/978-3-642-38391-5_43,

(Li et al. 2000). BDAR is the multiplier of equipments' functions in wartime. The quick and effective assessment and repair are keystones of a war. It needs management, technology and training to form the BDAR ability. Training plays an important role in mastering the basic skills, acquainting the BDAR procedure and improving their BDAR ability. Based on the ITS technology (Hyacinth 1999), we must train trainees in accordance with their aptitude. Hence, it must analyze the ability's composing and make a best plan for a certain trainee. It can make best use of training resources and time, and thus the effectiveness can be greatly improved.

There are many assessment methods, such as Fuzzy comprehensive evaluation (Wang and Sun 2008), Gray correlation analysis method (Gu et al. 2011), Bayesian discriminate analysis (Liang 2011), artificial neutral net (Jin and Sun 1996) and so on. They are applied on many domains and the effect is excellent. However, the BDAR ability assessment for personnel is on another way. There are more than one effected factors for BDAR assessment. And the relations between these factors are nonlinear and random. The class of BDAR ability is fuzzy. The history information which is not considered in the former assessment methods plays an important role in it. It must know the weight or white weight function of each index in the first three methods. The result must be affected by the artificial factors, which is not objective. Artificial neutral net (ANN) can learn and organize automatically, and it is very suitable to model the non-linear problem. Now, it is widely used in pattern recognition, fault diagnosis, comprehensive evaluation and so on. We need lots of suitable data swatches to train the ANN for good generalization. In other words, the ANN doesn't suit to model this problem. But we cannot get enough data swatches for personnel BDAR ability. As a consequence, it is not suitable to use the ANN to model BDAR ability assessment. To solve these shortcomings, we set up an assessment model based on Bayesian stochastic assessment method. Its applying result is effective and practical.

This article introduces the Bayesian stochastic assessment method and its application in terms of personnel BDAR ability assessment. In Sect. 43.1, we review the assessment methods used in other domains and analyze their disadvantages. Then, we introduce Bayesian stochastic assessment method to model ability assessment in Sect. 43.2. The BDAR ability assessment index system and their standard are given in this part and the method of determining the prior probability using modified normal distribution and poster probability using distance are promoted here. In Sect. 43.3, we give an instance to validate this method. Lastly, the conclusion is given in Sect. 43.4.

43.2 Bayesian Theorem Stochastic Assessment Method

43.2.1 Bayesian Stochastic Assessment Principle

Let $B_1, B_2, \ldots, B_n$ denote the events group. $B_i \cap B_j = \phi(i \neq j)$, where ϕ is impossible event, and $P(\bigcup_{i=1}^{n} B_i) = 1$, $P(B_i) > 0$. Then based on the Bayesian theorem in Probability Theory (Cheeseman et al. 1988), we can get the next formula:

$$P(B_i|A) = \frac{P(B_i)P(A|B_i)}{\sum_{i=1}^{n} P(B_i)P(A|B_i)} \tag{43.1}$$

where, $P(A|B_i)$, $P(B_i|A)$ are both the conditional probability, $P(B_i)$ is the prior probability of every events.

43.2.2 Bayesian Stochastic Assessment Model

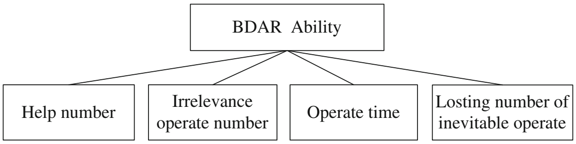
The personnel BDAR ability can be classified into four levels: *B1, B2, B3, B4*. The meanings of them are: BDAR engineer, BDAR assessment, normal technician and equipment operator (Cheeseman et al. 1988; Fried et al. 1997). $P(B_i)$ ($i = 1, 2, 3, 4$) is an initial estimation for each trainee's ability level without any data sample information, it is prior probability. We can get the prior probability based on the correlative indexes information in general grade evaluation. But it is reasoned only by experiments and judgments without enough data sample. Considering on both the BDAR characteristic and the requirement of applying trainee's history information enough, we modify the normal distribution to estimate the prior probability for each grade which each person's BDAR level belongs to. This method will be discussed detailedly in next part.

$P(A|B_i)$ is the probability of index A belong to level Bi. $P(B_i|A)$ is the re-estimation of each ability levels' probability after knowing the index A. It is poster probability. B_i is the standard of ith personnel ability level, $i = 1, 2, 3, 4$; A is index for BDAR assessment; A_{kj} is the value of ith assessment index for kth BDAR person; j is the assessment index's number $(j = 1, 2, \ldots, m)$. Based on the characteristic of personnel BDAR ability level evaluation, we can know: $m = 4$; Then we can apply (43.1) in this problem as following:

$$P(B_i|A_{kj}) = \frac{P(B_i)P(A_{kj}|B_i)}{\sum_{i=1}^{4} P(B_i)P(A_{kj}|B_i)} \tag{43.2}$$

(1) *Personnel BDAR ability assessment index and standard:* The personnel BDAR ability assessment is different as normal evaluations in which real man or

Fig. 43.1 Index system for assessment



woman operates real equipments and evaluated by real experts. This is because the circumstances needed by BDAR training cannot be well set in real world. So we must apply the simulation to train. This is the way that real man or woman operates the virtual prototypes and it is automatically evaluated by the assessment software. So the assessment index must be suitable to this characteristic. By analyzing (Li et al. 2000, 2003), we use the help numbers, the operator time, the irrelevance operator number and the losing number of inevitable operating to assessment the personnel BDAR ability (Fig. 43.1).

Where the fist three indexes is a certain value and the last one is a variable according to certain battle damage. We suppose the allowing max time is *T*, and then we can get the standard for each level (Wang et al. 2006). It is shown in Table 43.1.

(2) *Prior probability* (Ronald and Myers 1978): The prior probability is the primary estimation of personnel BDAR ability without any sample information. The prior probability will be uniform distribution on *(*Li et al. 2000; Gu et al. 2011*)* if the trainee is firstly evaluated without any ability history information in database. Its value is *1/n*. If the trainee is not firstly assessed, we will use a modified normal distribution which considers the ability history information enough in order to estimate the prior probability (Cheng et al. 1985). This method is detailed in following.

Firstly, setting a interzone value for Table 43.3 each ability level: $B \in \{B^1, B^2, B^3, \text{ and } B^4\} = \{[100, 80), [80, 60), [60, 30), [30, 0]\}$, the median of B is

$$B_* \in \{B_*^1, B_*^2, B_*^3, B_*^4\} \Rightarrow \{90, 70, 45, 15\};$$

Secondly, applying the median of each level B_*^r as expectation (μ), the σ is deviation and it meets the next condition:

$$\max\{|B_*^1 - B_*^r|, |B_*^4 - B_*^r|\} = 3\sigma$$

Table 43.1 Assessment index standard on each level

Assessment index BDAR ability level	Help number	Irrelevance operator number	Operate time	Losting number of inevitable operate
B1 enigneer	0–1	0–2	T/3-T/2	0–1
B2 assessmentor	2–3	3–5	T/2-2T/3	2–4
B3 technican	4–6	6–8	2T/3-4T/3	5–6
B4operator	7–8	9–10	4T/3-5T/3	8–10

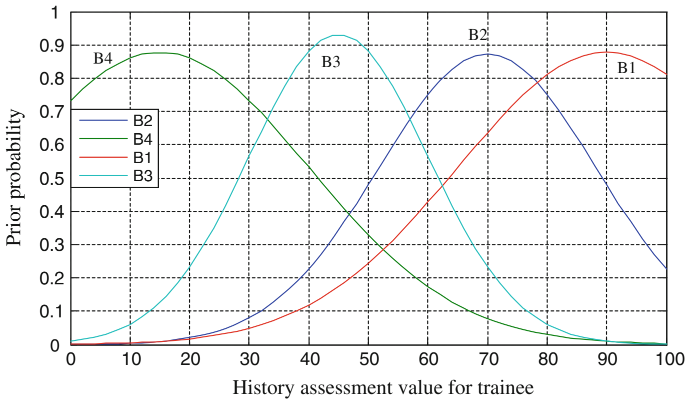


Fig. 43.2 Distribution figure of the trainee on each ability level

Then the prior probability subjects to modified normal distribution $N(\mu, \sigma^2)$;

$$p(\hat{B}_i) = \frac{\xi}{\sqrt{2\pi\sigma}} \exp \frac{\left(B_*^i - \mu\right)^2}{2\sigma^2} \tag{43.3}$$

where ξ is the compensation factor which can avoid the too small value of prior probability and too craggedness of the distribution curve. Its value is got by Monte Carlo simulation (Fishman et al. 1996; Patz and Junker 1999). Now we only give the result: when $B1$ and $B4$ $\xi = 55$, when $B2$, $\xi = 40$, and when $B3$, $\xi = 35$, and then we can get the distribution figure for the trainee on each ability level. Fig. 43.2.

Thirdly, we can get the initial probability of each ability level by inputting the median (B_*^i) of each level into (43.3). Because of the adding of compensation factor, $\sum_{i=1}^4 p(\hat{B}_i) \neq 1$. Then we normalized the initial probability to get the final prior probability using the next formula:

$$p(B_i) = \frac{p(\hat{B}_i)}{\sum_{i=1}^4 p(\hat{B}_i)} \tag{43.4}$$

(3)Calculating of $P(B_i/A_{kj})$: Here, we apply the distance method to calculate the probability (Cheng et al. 1985). Firstly, we calculate the distance between the actual value of each index and the standard value of each ability level L. Secondly, compute the reciprocal value of L.

Then we can use the next formula to calculate $P(B_i/A_{kj})$:

$$P\left(A_{kj}|B_i\right) = \frac{1/L_{ji}}{\sum_{i=1}^4 1/L_{ji}} \tag{43.5}$$

where $k = 1,2,\ldots,n$; $j = 1, 2, 3, 4$; $i = 1,2,3,4$; $L_{ji} = |A_{kj} - B_{ij}|$, k is the number of the trainee. B_{ij} is the arithmetic mean value of the upper and lower bounds on jth index on ith level. And then we can get the single index's conditional probability: $P(A_{kj}/B_i)$.

(4) *The poster probability of comprehensive assessment:* When doing the comprehensive assessment, we use Weighting method to calculate the single index's conditional probability (Cheeseman et al. 1988):

$$P_i = \sum_{j=1}^{4} P\left(B_i/A_{kj}\right) \times W_j \tag{43.6}$$

where W_j is the weight of each assessment index. There are many methods to calculate the index's weight, such as Analysis Hierarchy Process (AHP), binomial coefficient weighted sum, Rough set method, Delphi, Entropy method, main factor analysis method, multiple regression analysis and so on (Park and Kim 1999). Each method has its own advantages and disadvantages. Based on the BDAR ability assessment's characteristic, we apply the modified AHP to determine the weight for each index as shown in Table 43.2 (Jia 1995).

(5) Final decision of BDAR ability level based on maximum probability: According to the maximum likelihood classification rule, we can get the trainee's BDAR ability level (P_h) by choosing the maximum in all probabilities of each level:

$$P_h = \max P_i(i = 1, 2, 3, 4, 5) \tag{43.7}$$

Table 43.2 Modified AHP method to determine the weight

Assessment index	Help number	Irrelevance operator number	Operate time	Losting number of inevitable operate	Weight
Help number	1	1	2	1	0.2875
Irrelevance operator number	1	1	2	1	0.2875
Operate time	0.5	0.5	1	0.5	0.1429
Losting number of inevitable operate	1	1	2	1	0.2875

43.3 Applying Instances

43.3.1 Experiment Results

By experimenting on certain scenarios in virtual BDAR training system, we get all of the three trainees' statistical results in every index as shown in Table 43.3.

We can get the following results by (43.5) and (43.6):

$P1 = 0.1429*0.2875 + 0.5455*0.1429 + 0.2338*0.2875 + 0.0979*0.2875 = 0.2124$

$P2 = 0.2065*0.2875 + 0.2727*0.1429 + 0.5453*0.2875 + 0.1592*0.2875 = 0.2960$

$P3 = 0.4647*0.2875 + 0.1091*0.1429 + 0.1443*0.2875 + 0.0425*0.2875 = 0.3129$

$P4 = 0.1859*0.2875 + 0.0727*0.1429 + 0.0767*0.2875 + 0.3184*0.2875 = 0.1956$

Because $P3 = \max\{P1,P2,P3,P4\} = 0.3129$, then the first trainee's BDAR ability level is classified to third level, he is technician.

In similarity, the second trainee and the third trainee are both the fourth level, they are equipment operators.

43.3.2 Results Validating

To validate this method, we compare it with Fuzzy comprehensive evaluation, Gray correlation analysis method, BP artificial neutral net and PCNN method (Tan and Steinbach 2011). There are consistencies like Table 43.4. So the Bayesian stochastic assessment theory for personnel BDAR ability comprehensive assessment is effective and scientific.

Table 43.3 Statistical results

Assessment standard trainee	Help number	Irrelevance operator number	Operate time	Losting number of inevitable operate
First trainee	7	2	2.6T/6	7
Second trainee	8	5	5T/6	3
Third trainee	2	10	8T/6	0

Table 43.4 Comparing of different method

Method trainee	Gray correlation analysis	Fuzzy comprehensive evaluation	BP-ANN	Bayesian stochastic assessment
First trainee	B3	B3	B3	B3
Second trainee	B4	B4	B4	B4
Third trainee	B4	B4	B4	B4

43.4 Conclusion

The Bayesian stochastic assessment methods can use the history information effectively and it can deal with the complex nonlinear relationship in assessment. Its physical meaning is explicit, the calculating steps are very easy and the effectiveness is very good. By analysis, we regard help numbers; irrelevance operator number, operator time and Losing number of inevitable operate as the assessment factors. And then we build a comprehensive model for personnel BDAR ability based on Bayesian stochastic assessment methods. It is consistent with other assessment methods mentioned before and proved by the applying instance. In the future, we will apply this method to develop the BDAR training assessment system to improve the effectiveness of the BDAR training simulation.

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Chapter 44
Power Control of Cellular System in CDMA Technology Integrated with SIC

Pan-dong Zhang and Juan-juan Min

Abstract In terms of the problems in power control in the CDMA system of the existing SIC, whether SIC is perfect or not should be considered first, i.e., whether there is error in channel estimation or judgment. Secondly, the multi-cell situation should also be considered with outer-cell interference no longer be assumed independent of the transmitted (received) power of users. In the context, the paper firstly derives the expressions for optimal power allocation in the decoding order; then puts forwards the optimal decoding order which can minimize the outage probability of the system for the restriction of transmitted (received) power of users, and finally deduces the optimal decoding order that can minimize the total transmitted power. The paper comes to the conclusion of being able to minimize the total transmitted power on the condition that the E_b/I requirements of users are met through simulation comparison of total transmitted power in different decoding orders.

Keywords CDMA · Cellular system · Decoding order · Power control · SIC

Many users share the same frequency band in the cellular system based on the CDMA technology and the signals among users can be distinguished through spread spectrum code word. However, due to the multi-path effect of wireless channel transmission and limitation of spread spectrum code word, the user signals are not orthogonal at the receiver and accordingly, there is mutual interference or multi-access interference between the received signals of users, which will result in problems (Paulraj et al. 2004) like near-far effect and corner effect in the system. The power control technology can to some extent reduce the negative impact of this series of problems on the system performance. Meanwhile, the adoption of proper transmitted power will lengthen the service time of terminal battery and extend the life time. Moreover, the control of users' transmitted power and

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E. Qi et al. (eds.), *The 19th International Conference on Industrial Engineering and Engineering Management*, DOI: 10.1007/978-3-642-38391-5_44,

transmission rate is also a key method to guarantee the Quality of Service (QoS) requirements of different types of users and to improve the system capacity in case of co-existence of multiple operations.

At present, joint optimization (Ivanek 2008) has been conducted for the power control and decoding order adjustment in the CDMA system integrated with Serial Interference Cancellation (SIC). Nevertheless, in this kind of research, the optimization only aims to adjust the decoding order to minimize the total transmitted power of users under the premise of catering to the users' requirements on bit-energy-to-interference-spectral-density ratio, E_b/I. And there are following limitations in these operations respectively: the assumption (Paulraj et al. 2004) of SIC is perfect, i.e., the previously detected user signal interference has been eliminated completely in the subsequent detection of user signals; the interference of outer-cell user signal on the in-cell user signal (outer-cell interference for short) is assumed independent of the constant of users' transmitted (received) power or considered only for the single cell cases (Zahariadis and Doshi 2004); there is no limitation (Jorguseski 2001) of users' transmitted (received) power.

However, in practice, the channel estimation error and decoding judgment error make it impossible for the SIC to be perfect. That is to say the reconstructed signals of the user whose decoding has been detected will never be equivalent correctly to the received signals of the user and thus, after the elimination of the reconstructed signals of the user whose decoding has been detected from the composite signal, if there is still residual signal component of this kind of users in the composite signal, it will impact the system performance in decoding detection of the current users.

44.1 System Model

Suppose that there are K users in the target cell, the received composite signal $r_0(t)$ at the base station is composed of received signals $x_i(t)$ (i = 1,2,…,K) of various users, outer-cell interference signals i(t) (i.e., interference of user signals from outer-cell on in-cell signals) and background noise n(t). The expression is as follows:

$$r_0(t) = \sum_{i=1}^{K} x_i(t) + i(t) + n(t) \tag{44.1}$$

where the received signal $x_i(t)$ (i = 1,2, …, K) of user i is

$$x_i(t) = g_i(t - \tau_i)) \cdot e^{j\phi i(t-\tau_i)} \cdot \sqrt{E_i} \cdot b_i(t - \tau_i) \cdot a_i(t - \tau_i),\ i\ =\ 1, 2, \ldots, k \tag{44.2}$$

where $g_i(t)$ and $\phi_i(t)$ are respectively the growth rate of channel gain and phase component of user i and E_i, $b_i(t)$ and $a_i(t)$ are respectively the transmitted power, data bit and the sequence of spread spectrum code word, and τ_i refers to the relative time delay.

Figure 44.1 shows the structure (Jantti and Kim 2000) of CDMA base station receiver integrated with SIC technology. The base station receiver integrated with SIC detects and decodes the signals of various users in the received composite signals. In the event of detection and decoding of the user i, the base station receiver will reconstruct the received signals of the user through channel estimation with the reconstructed signal recorded as s_i (t). Eliminate the reconstructed signal from the composite signal before detection of the subsequent users; that is to say, before the detection and decoding of user i, the composite signal should be renewed as

$$r_i(t) = r_{i-1}(t) - s_{i-1}(t), i = 1, 2, \ldots k \tag{44.3}$$

where s_0 (t) = 0. The mth bit is decoded and decided (Saghaei and Neyestanak 2007) by the following means for user i.

$$\hat{b}_{i,m} = \text{sgn}\{\frac{1}{T}\int_{(m-1)T_i+\tau_i}^{mT_i+\tau_i} ri(t) \cdot a_i(t-\tau_i)dt\} \tag{44.4}$$

where, T_i indicates the duration of the bit symbol. This process will be repeated in the base station until the signals received by the K users are detected and decoded.

Accordingly, the signal to interference-plus-noise ratio (SINR) for the noise received by user i is:

$$SINR_i = \frac{P}{\sum_{j=1}^{i-1}\theta P_j + \sum_{j=i+1}^{K} P_j + f\cdot(\sum_{j=1}^{K} P_j) + N_0 W}, \quad i = 1, 2, \ldots k \tag{44.5}$$

It is assumed that all θ_i share the same value, and represented by θ, which is the peak value of all θ_i on conservative terms (Gu et al. 2005). In the above expression, N_0W indicates the background noise power, W the band width and N_0 the corresponding power spectral density. Moreover, $f\left(\sum_{j=1}^{K} P_j\right)$ indicates the outer cell interference power (Liao et al. 2007), and f the ratio of the outer cell

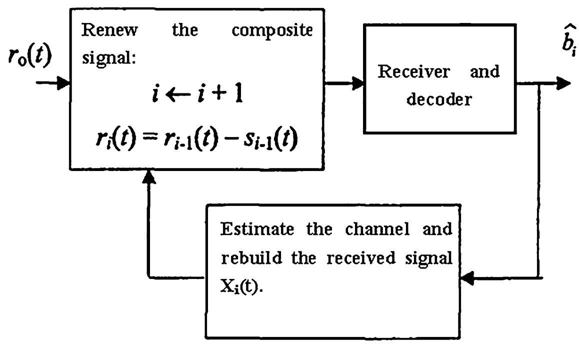

Fig. 44.1 SIC-based CDMA base station receiver

interference power to the in-cell received power, which means the outer cell interference is no longer independent of users' transmitted (received) power. This is due to the fact that different received power requirements of users mean different transmitted power requirements under different decoding orders; therefore, the interference is imposed by in-cell users on the outer cell varies. Likewise, the signal power differs with different decoding orders. That is why it is unjustifiable to assume the outer-cell interference to be a constant independent of users' transmitted (received) power in actual multi-cellular system.

44.2 Optimal Power Allocation for Multi-Cell

The expression for optimal power allocation with certain decoding order has been provided in documentation (Kwok and Lau 2003); however, it is only applicable to the supposition that the outer-cell interference is a constant independent of users' transmitted (received) power or aims at single-cell. The expression of optimal power allocation for multi-cell will be deduced in this article where the outer-cell interference is no longer assumed to be independent of users' transmitted (received) power.

Users in the system have their specific requests for QoS, and only when each QoS is satisfied can normal communication be ensured:

$$(W/R_i) \cdot SINR_i \geq \gamma_i,\ i = 1, 2, \ldots k \tag{44.6}$$

where, Υ_i indicates the SINR user i requests at the rate of R_i. In practice, if users' transmitted (received) power allocated by the system can validate the above expression, then there will be specific power allocated that can validate the following expression (Lee et al. 2002):

$$(W/R_i) \cdot SINR_i = \gamma_i, i = 1, 2, \ldots, k \tag{44.7}$$

This is provable in reference to how an individual user examines the receiver (Gu et al. 2005), but the proof will not be given here. Accordingly, it is the best way to allocate power with a given decoding order and minimum total transmitted power. Therefore, QoS requested by users is given by expression (44.7).

It is assumed that $\Upsilon_i = \mathrm{W}/(\mathrm{R}_i \Upsilon_i)$ so as to deduce the received power requested by users with the E_b/I requirement met. The following equations can be got using expressions (44.5) and (44.7):

$$Y_i \cdot P_i + P_i = \sum_{j=1}^{i-1} \theta P_i + P_i + \sum_{j=i+1}^{K} P_i + f \cdot \left(\sum_{j=1}^{K} P_j \right) + N_0 W, i = 1, 2, \ldots, k \tag{44.8}$$

$$Y_{i-1} \cdot P_{i-1} + \theta \cdot P_{i-1} = \theta \cdot P_{i-1} + \sum\nolimits_{j=1}^{i-2} \theta P + \sum\nolimits_{j=1}^{i-2} P_i + f \cdot \left(\sum\nolimits_{j=1}^{K} P_i \right) + N_0 Wi$$
$$= 1, 2, \ldots, k \tag{44.9}$$

where the proportions at the right side of expressions (44.8) and (44.9) are the same; therefore it can be deduced that the received powers of two users with neighboring decoding orders can be expressed as follows:

$$P_i = \frac{\theta + Y_{i-1}}{1 + Y_i} P_{i-1}, \quad i = 2, \ldots, K \tag{44.10}$$

Further, suppose that $i = 1$ and $i = K$ in expression (44.8), along with expression (44.10), the received powers requested by the user whose decoding is first examined (user l) and the user whose decoding is last examined (user K) are shown as follows:

$$P_1 = \frac{N_0 W}{(Y_1 - f) - (1 + f) \cdot \left\{ \sum_{i=2}^{K} \prod_{j=2}^{i} \left[(\theta + Y_{j-1}) / (1 + Y_j) \right] \right\}} \tag{44.11}$$

$$P_k = \frac{N_0 W}{(Y_k - f) - (\theta + f) \cdot \left\{ \sum_{i=2}^{K} \prod_{j=2}^{i} \left[(1 + Y_{j-1}) / (\theta + Y_j) \right] \right\}} \tag{44.12}$$

The above expressions give the allocation means of users' received powers more commonly when compared with the existing documentations. The expressions (44.11) and (44.12) give the same requested received powers as in documentation (Chatterjee et al. 2007) if there is no f, the ratio of outer-cell interference to in-cell interference, namely the outer-cell interference is supposed to be a constant independent of users' transmitted (received) power or only the single cell is taken into consideration. The expressions (44.11) and (44.12) describe the examination of the receiver by individual user (Lee et al. 2002) when residual power factor $\boldsymbol{\theta}$ equals 1. The two expressions give the same requested received power as in documentation (Jorguseski 2001) if there is no $\boldsymbol{f}$ and residual power factors are somehow different, and the same requested received power as in documentation (Ivanek 2008) if $\boldsymbol{f}$ does not exit and residual power factor $\boldsymbol{\theta}$ is 0, meaning, there is no perfect SIC for residual power after the interference of each user in a single cell is eliminated.

44.3 Decoding Order for Optimal Outage Performance

Definition 1 In given decoding order, if the constraint Eqs. (44.7) and (44.11) can not be satisfied, the condition is called the outage of the system in the decoding order.

If there are K users in the system, there may exist K! decoding orders, and the system has different outage in performance in different orders. In case the transmitted (received) power is limited, the research on optimal decoding order will be helpful to minimize the outage probability for the design of better system meeting actual requirement.

We can conclude the following inferences based on the Definition 1.

Inference 1: Among all possible decoding orders, the system can get the minimum outage probability in ZD (Zs Descending) order.

Demonstration: According to Definition 1, once the system is practicable, the constraint Eqs. (44.7) and (44.11) can be realized in decoding order ZD, even if the equations are not practicable in other decoding orders. Thus, we can conclude that among all possible decoding orders, the system can get the minimum outage probability in decoding order ZD. Q.E.D.

To comprehensively and intuitively understand the rationality of decoding order ZD in system minimum outage probability, we can consider the following 2 special cases:

(1) All the users have the same rate and corresponding E_b/I requirements, namely, all the $\boldsymbol{Y_i} = \boldsymbol{W}/(\boldsymbol{R_i}\gamma_i)$ results are the same. In such case, decoding order ZD is corresponding to the decoding order confirmed by the descending order $\boldsymbol{P_i^{max}}$ The later a user is decoded, the smaller degree other users are interfered, and the lower demand the received power requires based on Eqs. (44.7) and (44.11). So the constraint Eqs. (44.7) and (44.11) are most likely to be satisfied in the decoding order confirmed according to the $\boldsymbol{P_i^{max}}$ descending order which is adopted by the K users. Furthermore, if all the users have the same maximum transmitted power, then the decoding order confirmed according to the $\boldsymbol{P_i^{max}}$ descending order is corresponding to the decoding order confirmed according to the descending order based on the user channel gain.

(2) All the users have the same maximum received power $\boldsymbol{P_i^{max}}$. In such case, the decoding order ZD is corresponding to the decoding order confirmed by the descending order based on $\boldsymbol{Y_i} = \boldsymbol{W}/(\boldsymbol{R_i}\gamma_i)$. In the same way, according to Eqs. (44.7) and (44.11), the bigger the $\boldsymbol{Y_i} = \boldsymbol{W}/(\boldsymbol{R_i}\gamma_i)$ of a user is, the lower requirement of the corresponding SINR is. Meantime, the earlier a user is decoded, the more interference it will get from other users. Thus the Eqs. (44.7) and (44.11) probably be satisfied in the decoding order of all the users confirmed by the descending order based on $\boldsymbol{Y_i} = \boldsymbol{W}/(\boldsymbol{R_i}\gamma_i)$. Further, if all the users have the same $\boldsymbol{E_b}/\boldsymbol{I}$ requirement, the decoding order confirmed by the descending order based on $\boldsymbol{Y_i} = \boldsymbol{W}/(\boldsymbol{R_i}\gamma_i)$ is corresponding to the decoding order confirmed by the ascending order based on $R_{i.}$

44.4 Decoding Order Fro Minimum System Gross Transmitted Power

If there are K users in the system, there will be K! possible decoding orders. And in different decoding order, the gross transmitted power of the system is different. Low transmitted power is helpful to prolong the service time of the mobile terminal battery and extend its lifetime, and reduce the electromagnetic radiation pollution to environment. So it is necessary to study on the optimal decoding order for the minimum gross transmitted power. Though documentation (Saghaei and Neyestanak 2007) has considered the combination of the CDMA system in SIC in minimum gross transmitted power, its objects are mainly single cells and it assumes that the interference power from outer cells is a constant not dependent on user transmitted (received) power. In the cellular system, the cells are not isolated, and the change of the in cell's transmitted (received) power can influence that of outer cells. Even though documentation (Jorguseski 2001) has considered the interference of outer cells, it is only based on perfect SIC.

This paper analyzed the question of how to adjust the decoding order for a minimum gross transmitted power in multi-cell condition which assumes that the outer-cell interference is dependent on the user transmitted (received) power and at the same time the SIC is not in perfect condition.

44.4.1 Theoretical Analysis

Based on the Theorem 1 mentioned above, we can prove and obtain the following theorem and determine how to adjust decoding order for the total transmitted power minimization according to the following theorem.

Theorem 2 The decoding order is identified pursuant to the descending sort of users' channel gains, and then the transmitted (received) power will be distributed under the decoding order according to expressions (44.10), (44.11) and (44.12). Consequently, the total transmitted power can be minimized under the premise of satisfying the user's E_b/me requirement.

Demonstration: we suppose that the users A and B are respectively the Lth and (L + 1)th with decoding detected and for the user A′s channel gain h_A is lower than B′s h_B, that is $h_A < h_B$. Therefore, we investigate the changes of total transmitted power fore and after exchange of A′s and B′s decoding orders. It is supposed that during the exchange, both users' received powers are respectively P_i (i = 1, 2, …, K) and $\tilde{P}$ (i = 1, 2, …, K) under expressions (44.10), (44.11) and (44.12). So we consider the following three conditions to facilitate the analysis:

(1) L = 1 means that A is the first user getting decode detected among the original decoding order. And the rest users' received powers remain unchanged except A and B before the exchange of decoding orders of A and B according to

Theorem 1, that is, $P_i = \tilde{P}_i$, i ≥ 3. Correspondingly, the difference of total transmitted power before and after exchange of decoding orders of A and B is as follows

$$\begin{aligned}\sum\nolimits_{i=1}^{K} P_i/h_i - \sum\nolimits_{i=1}^{K} \tilde{P}_i/h_i &= (P_A/h_A + P_B/h_B) - (\tilde{P}_B/h_B + \tilde{P}_A/h_A) \\ &= P_3\left[\frac{(1+Y_3)(1+Y_B)}{(\theta+Y_B)(\theta+Y_A)}\Big/h_A + \frac{(1+Y_3)}{(\theta+Y_B)}\Big/h_B - \frac{(1+Y_3)(1+Y_A)}{(\theta+Y_A)(\theta+Y_B)}\Big/h_B - \frac{(1+Y_3)}{(\theta+Y_A)}\Big/h_A\right] \\ &= P_3 \cdot \frac{(1+Y_3)}{(\theta+Y_A)} \cdot \frac{(1-\theta)}{(\theta+Y_B)} \cdot (1/h_A - 1/h_B) > 0\end{aligned} \tag{44.13}$$

That is, the total transmitted power is reduced after the exchange.

(2) L = K−1 means B is the last user getting decode detected among the original decoding order. And the rest users' received powers remain unchanged except A and B before the exchange of decoding orders of A and B according to Theorem 1, that is, $P_i = \tilde{P}_i$, i ≤ K−2. Correspondingly, the difference of total transmitted power before and after exchange of decoding orders of A and B is as follows

$$\begin{aligned}\sum\nolimits_{i=1}^{K} P_i/h_i - \sum\nolimits_{i=1}^{K} \tilde{P}_i/h_i &= (P_A/h_A + P_B/h_B) - (\tilde{P}_B/h_B + \tilde{P}_A/h_A) \\ &= P_{k-2}\left[\frac{(\theta+Y_{k-2})}{(1+Y_A)}\Big/h_A \frac{(\theta+Y_{K-2})(\theta+Y_A)}{(1+Y_A)(1+Y_B)}\Big/h_B - \frac{(\theta+Y_{k-2})}{(1+Y_B)}\Big/h_B - \frac{(\theta+Y_{k-2})(\theta+Y_B)}{(1+Y_B)(1+Y_A)}\Big/h_A\right] \\ &= P_{k-2} \cdot \frac{(\theta+Y_{k-2})}{(1+Y_A)} \cdot \frac{(1-\theta)}{(\theta+Y_B)} \cdot (1/h_A - 1/h_B) > 0\end{aligned} \tag{44.14}$$

So the total transmitted power can be lowered after the exchange.

(3) If 1 < L<K−1, A is the first user with decode detected among the original decoding order while B is not the last user. Therefore, the rest users' received powers remain besides A and B before the exchange of decoding orders according to Theorem 1, that is, $\boldsymbol{P_i} = \tilde{\boldsymbol{P}}_{\boldsymbol{i}}$, i ≤ L−1 or i ≥ L+2. Similarly to above-mentioned (1) and (2), the total transmitted power can be lowered after the exchange.

From the above three conditions, the requirements of total transmitted power can be lowered after the exchange of decoding orders for adjacent users A and B.

Repeat the adjacent users' exchange of decoding orders until the decoding order is the one identified by descending order of users' channel gains. Based on the above-mentioned three conditions, the requirement of total transmitted power can be continuously lowered during such exchange process of decoding orders of users. Thus, the Theorem 2 is established. Q.E.D.

In this paper, gains descending (GD) means the decoding order identified through the descending order of users' channel gains. The users' powers will be distributed under such decoding order according to expressions (44.10), (44.11) and (44.12). Consequently, the total transmitted power can be minimized under the premise of satisfying the user's E_b/I requirement.

In addition, although the above-mentioned conclusions are the same to the documentation (Ivanek 2008), the author takes account of SIC under non-perfect conditions. Moreover, the outer-cell interference is no longer supposed to be independent from the users' transmitted (received) powers while this paper aims at multi-cell conditions. So such model is different from the existing model.

44.4.2 Simulation Experiment and Result Analysis

The following simulation experiment verifies the minimization of the system's total transmitted power under GD decoding order.

Figure 44.2 shows the change curves of the total transmitted power requirements versus the number of users under different decoding orders, among which the number of users changes from 30 to 60 and the residual power factor θ remains 0.1. The x-coordinate means the number of users while the y-coordinate the total transmitted power in Fig. 44.2. Figure 44.3 shows the change curves of the total transmitted power requirements versus residual power factor θ under different decoding orders, among which the residual power factor θ changes from 0.05 to 0.5 and the number of users remains 36. The x-coordinate means the residual power factor θ while the y-coordinate the total transmitted power in Fig. 44.3. In this section, gains ascending (GA) is the decoding order determined by ascending order of users' channel gains, rates descending (RD) is the decoding order determined by descending order of users' rates, and rates ascending (RA) is the decoding order determined by ascending order of users' rates.

It can be known from Figs. 44.2 and 44.3 that the total transmitted power requirement is the lowest under GD—decoding order identified by descending order of users' channel gains. This conclusion is consistent with theoretical analysis

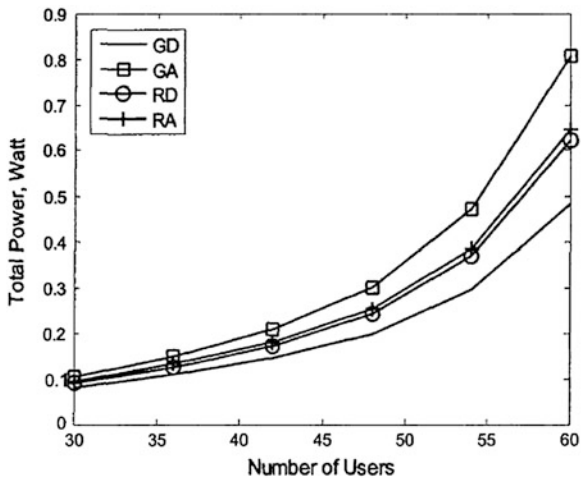

Fig. 44.2 Change curve of total transmitted power versus number of users

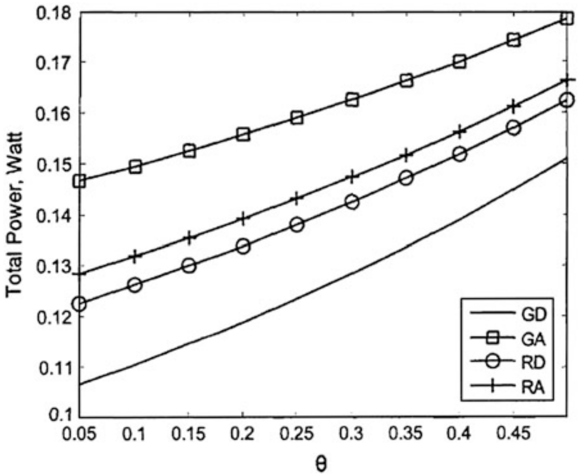

Fig. 44.3 Change curve of total transmitted power versus residual power factor θ

of Sect. 44.1. In addition, it is also highlighted from Figs. 44.2 and 44.3 that the requirement of total transmitted power grows in direct proportion to the number of users or of the residual power factor θ, which conforms to actual situation.

44.5 Conclusion

This paper takes account of the relevant power control in cellular system with CDMA technique in combination with SIC. The expression of optimal power distribution is firstly deduced under the given decoding order; and then, the optimal decoding order is proposed to minimize the outage probability in the system if there are limitations to users' transmitted (received) powers; finally, the optimal decoding order is deducted to minimize the total transmitted power. The simulation compares the total transmitted powers of the system under different decoding orders, and the results support the analysis of this paper.

Acknowledgments The research work in this paper is supported by Research on the Technology of Load Balancing on Server Cluster under the grant 2012KJ05.

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Chapter 45
Research of Embedded Intelligent Decision Support System for Natural Disasters

Jiang Shen, Tao Li and Man Xu

Abstract Based on the requirement of real-time, accuracy and stability of natural disasters emergency interact decision support system, the essay does research on the structure of natural disasters' decision-making support system, realization of information sharing platform and key technology of embedded system, establishes fuzzy lookup, connective-administration workstation and bus structure and system support structure, etc. Then the author ties the interfaces of the decision data layer, the logic layer and the application layer to the whole emergency system interface, and establishes embedded intelligent decision support system for natural disasters which achieve the optimum combination of hardware and software and information resources sharing and emergency command in natural disaster emergency system. Finally, the paper discusses the system technology performance index and taste tests method.

Keywords Natural disasters · Embedded system · Intelligent decision support system · Information sharing

45.1 Introduction

With the higher level of urbanization, function becomes more complex, the potential problems of natural disasters is more and more, human beings' dependence on energy supply and the city configuration is increasing and system

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E. Qi et al. (eds.), *The 19th International Conference on Industrial Engineering and Engineering Management*, DOI: 10.1007/978-3-642-38391-5_45,

security and reliability of the machines which work in cities is required much more higher. In 2010, a severe storms triggered landslide in Zhouqu County, Gansu. In 2008, our country suffered a rare snow disaster and the Wenchuan earthquake. All about these show that our country' natural disaster integrated emergency response system have many shortcomings. Based on Bayes Consulting Co., Ltd.'s research, with the perfection of natural disasters emergency system, share of investment of Chinese informatization is increasing. For example, some great cities and municipalities such as Beijing invest an average of 100 million RMB in the natural disaster integrated emergency response system and follow-up system's upgrade and engineering investment will reach 100 million RMB in five years. So the next five years will be a large-scale construction period of emergency support platform. As the further development of the natural disaster emergency application market, the proportion of software and services will sharp increase which produces larger market development space. Decision support system is the new market demand in recent years on the basis of comprehensive emergency (UNDP 2004; Apel et al. 2004; Arnell 1989).

The construction of integrated emergency response and intelligent decision support system for natural disasters will contribute to the comprehensive efficiency and benefits of existing emergency system, which make the whole system produce more social benefits and economic benefits and help information sharing function do much better. The study establishes an embedded decision support integrated system for natural disasters and realizes information sharing and emergency command of natural disasters emergency system on the basis of the research on embedded information sharing system and embedded support system and intelligent decision support platform. The study will promote the process of natural disaster emergency management research, and improve the level of natural disaster management research and emergency response (Blaikie et al. 1994). Also, it may make the daily management countermeasure and emergency plan system and disaster mitigation plan on natural disasters for related administrative departments, and provide scientific proof and technical support for disaster preparedness and response and urban development planning.

45.2 Situation at Home and Abroad and Technology Development Trend

45.2.1 Embedded Information Sharing System

Embedded system is a kind of computer system in which software links with hardware tightly. The hardware bases on embedded microprocessor and integrates storage systems and all kind of input/output devices. The software contains set-up procedure, driver, embedded operating system and application program. The organic combination of the software constitutes the integration software, which has many characteristics such as effective combination of hardware and software, solidified source, hard real-time and high reliability. Dunkels et al. do research on how to realize embedded network communication protocol stack by combination of embedded system of limited resources, software-hardware environment and network application. Geoff et al. propose a lightweight, flexible, system software-oriented OPENCOM embedded component models. Bruneton et al. propose a Fractal model which is independent of programming language and any system and running services. The model can use Fractal component in low software layers and within operating system. On the existing foundation, embedded system includes two research directions: one is real-time operating system (32 bit embedded microprocessor chips take over 4 bit, 8 bit, 16 bit microprocessor chips gradually), another is Internet-oriented system (it combines embedded technology and internet technology), which is developing to be a portable, cuttable, high real-time, highly available network platform and standard.

Field bus structure and Ethernet structure has commonly used to automatic control field in the aspect of embedded information sharing structure. We can use different LAN protocols according to different application such as TCP/IP, NETBIOS, NOVELL, IPX/SPX, Appletalk, SNA, Banyanvines and so on which can achieve to link LAN/LAN with LAN/Internet well. The fieldbus is communication network which is the connection between field equipment and control device in bi-directional, serial, digital, multi-node way. This open control network adapts to the decentralized, networked, high-speed direction. The international fashion fieldbus mainly contains: FF of fieldbus foundation, Profibus of German, Lon works of Echelon, CANBUS of Bosch and Dupline of Sweden and so on. Fieldbus Control System is taking over closed DCS System gradually to become the major in process control. However, it should further to construct the common interface and structure mode to adapt to two heterogeneous platforms to improve the system compatibility and the reconstruction in key technology.

45.2.2 Intelligent Decision Support Platform

The following are the foreign exemplary decision support system: Portfolio Management System, which supports for investors to manage customers' securities, has the following functions: stock analysis, securities processing and classification; Brand aid, a hybrid market model which is used to product promotion, product pricing and advertising decisions, can help the manager and management analyses strategies and make decisions by connecting goods sales, profits with the manager's action; Projector helps the manager to construct and explore the methods to solve problems, which supports enterprise's short-term planning. Geodata Analysis and Display System, developed by IBM Research, is used to aided design of police patrol routes, urban design and school jurisdiction scope arrangement. Ford did research on a decision support system for the flood disaster warning decisions; William et al. constructed spatial decision support system to decide dangerous chemicals transport routes; Ezio tried to utilize real-time decision support system to manage natural disaster risk. The following are domestic application and research: The government macro-economic management and public management issues; The water resources allocation and early warning system for flood control; Industry planning and management and all kinds of the development and utilization of resources; Decision-making of ecological and environmental control system; Natural disaster management.

Zhongtuo Wang described the decision support system by functionality. During his analysis, the experience of the decision makers penetrated the mathematical model of the decision support system; Sprague et al. proposed decision support system three parts structure, namely dialogue component, data component (database and database management system) and model component(model base and model base management system); Bonczak et al. proposed DSS three system structure, namely Language system, problem processing system and knowledge system. Now, Aided decision-making ability of decision support system develops from single decision model to more comprehensive decision-making model; By combining decision support system and expert system, a decision support system combining intelligent decision support system (Yong et al. 2007), qualitative aid decision making and quantitative aid decision making is developed.

45.3 The General Framework of Integrated System

This research studies the structure of the decision support system for natural disasters, the realization of information sharing platform and the key technology of embedded systems such as interface issues (microprocessors, scalable RAM and ROM, the data latch and bus coprocessor) to build a fuzzy lookup table,to connect the management station and the bus architecture, system software and the knowledge of the natural disasters, information resource database integration, and system support structure. In this study, we use embedded technology to embed information fusion technology integration and information-based decision support system into the entire emergency management system based on interface technology, which achieves the optimal combination of hardware and software and the sharing of information resources of natural disaster response system and emergency command. Through the embedded technology, we connect data layer, logic layer and application layer of decision-making platform with interface of the entire emergency response system to enhance the efficiency and effectiveness of the entire complex system that is to optimize the design, faster system responsiveness, reduce the consumption of system resources and reduce hardware costs, while enabling a variety of resources for the entire emergency response system to share information (Yong et al.2007; Sun et al. 2007).

The overall framework of natural disasters embedded decision support integrated system constructed in this study includes the following five levels.

- The presentation layer. To provide a classification of the client as the user interface part, for the different object needs.
- Computing layer. Composed by multiple servers, the object may demand extended to N-tier structure. The server is responsible for receiving the specific data of the main online information source, the monitor image signal (Fig. 45.1).
- Data layer. Architecture DB-ODS-DW, and the establishment of the DBMS and the DLA data model.
- Control layer. Use RS-232 standard, and instead of hard-wired to wireless serial communication.
- Embedded layer. Including multiple terminals embedded chip and external devices, such as information collection, sensors, etc.

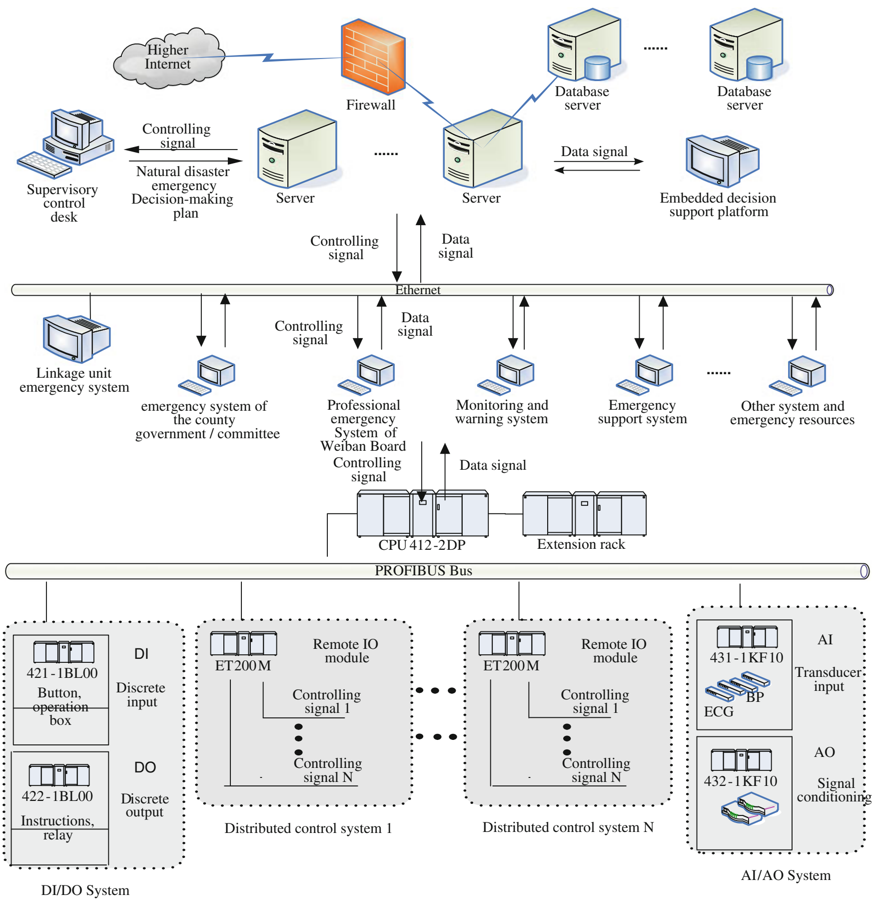

Fig. 45.1 Emergency interact embedded decision support integration system framework for natural disasters

45.3.1 The Main Hardware

The CPU uses Siemens CPU416-2DP. Switch DI template uses the 421-1BL00 for field devices such as switches, operating box I/O points of access. DO template uses the 422-1BL00. Both are 24VDC*32CH-type template. The use of intermediate relays to control equipment used to indicate the unit to direct output. Analog template AI uses the 431-1KF10, which is use to access for instrumentation monitoring signals, such as pressure sensors. The AO templates use the 432-1KH10, in which channel type can be any configuration for controlling the regulator valve 9+. Ethernet card with the CP443-1 communicates over twisted pair. Image there are two racks: One is central rack and other one is expansion rack. We use template Interface IM460 to connect central rack and expansion rack and utilize the CPU built-in PROFIBUS-DP interface to achieve communication with the inverter. Then we use expansion unit—M communication card to connect to a remote station ET200 M. The system's communication networks uses Siemens high speed industrial Ethernet the Culan connection for communication between the PLC and the PLC, in which the communication speed reaches 10 Mb/s. We use PROFIBUS-DP, one of the international fieldbus standards, and inverter, used to communication and control and belongs to the device bus, for the complex field devices and distributed I/O. The physical structure is the RS-485, the transmission rate is up to 12 Mb/s. As we use the same protocol standards and transmission media, and utilize ET200 M as remote I/O station, we should set ET200 M in a location where there exist many I/O such as operating floor. In this way we can reduce cable volume effectively. Twisted-pairline media and TCP/IP open protocol are used for communication between monitoring station and the PLC.

45.3.2 Embedded Support System

The hardware of the embedded support system takes the embedded microprocessor as the core and integrates storage systems, and various input/output devices; software contains the system startup programs, drivers, embedded operating system, applications, etc.

(1) Embedded chip
Include embedded microprocessors, embedded microcontrollers, embedded DSP processor and embedded on-chip system.
(2) Interface circuit of embedded system
We design or select the hardware interface according to the receipt signal that need to deal with or the control signals that should be send to by the integrated storage systems and a variety of input/output devices. These interfaces include: embedded microprocessors, scalable RAM and ROM, the data latch and bus coprocessor selection, design and field testing.

(3) Management station and the bus structure
Realize Interconnection of simplicity, flexibility and versatility. Research and test in the way of Bus communication provide more features and flexibility to support multiple transport protocols and different types of services, develop API functions and class libraries, and reduce on-site hardware and software requirements.
(4) Embedded software system
Build embedded software which can be divided into embedded operating systems and embedded applications.
(5) Generic component model
To meet embedded systems' non-functional constraints, such as real-time features, reliability, and stability. We combine the characteristics of the general component technology and embedded systems and use the embedded component technology to build the embedded set up model. The general component model includes the CORBA Component Model defined by the OMG and ezCOM of KETAI Century Company.

45.4 Technical Performance Indicators

(1) Embedded system interface circuit
Microprocessor: 80C51 chips, by calling the data within the RAM and ROM process to complete the encoding and decoding of data. 80C51 power consumption: 120 mW; working environment −40° –+85°.
Scalable RAM and ROM: in accordance with the procedures and fuzzy lookup table status, 2716, 2764, 6116 or 6264. Extended memory is directly connected by bus with a microprocessor, directly addressable to the MCU.
Data latch and bus coprocessor: the management of the address and data signals on bus multiplexed bus clock cycle, the successful completion of the data read-write operations. Chip 74LS138 or 74LS373.
(2) The establishment of the fuzzy lookup table
Build up a fuzzy lookup table whose addressing speed of up to 2–3 times the ordinary INDEX addressing according to structure-based data storage of Binary tree, so that the system response time reduced by an average of 40–50 ms.
(3) Management workstation and the connection of the bus structure
Using Sockets to achieve the connection of the Fieldbus Fieldbus and management workstation MS.
Transmission is completed through the Fieldbus module; the data type of the third layer of the fieldbus specification sub-layer FMS package of different devices to the user application layer UA provides a unified data type interface in order to achieve interchangeability and interoperability of equipment. Socket Transmission only transmits two parts of the data of physical Zhen

(one is FMSPCI and other one is UED) to improve the transmission efficiency of the line. The following table is the form of data Zhen of physical layer.

PRE	SD	DLL PCI	FAS PCI	FMS PCI	UED	FCS	ED

PRE: synchronization sequence
SD:Starting defined operator
DLL PCI:DLL protocol Information Mining
FAS PCI:FAS protocol control information
FMS PCI:FMS protocol Information Mining
UED:The user coding data
FCS:frame check sequence
ED:Final value defined operator

(4) Embedded application software based on network

    (1) Enhanced TCP protocol, propagation delay time: <20 ms
    (2) Improved interface RS232 of external device, propagation delay time: <5 ms
    (3) Maximum number of concurrent TCP session: >50
    (4) Correct rate for data transmission: >98 %
    (5) Embedded module
    (6) Operating system: Embedded operating system based on WINDOWS

45.5 Taste Tests Method

According to the characteristics of the embedded system, a system test should be done after the completion of the preliminary system development. We choose dynamic test method including control flow testing, data flow testing, test, function test points domain and random testing. The following are the related test content:

(1) Current test
(2) Compatibility test
Hardware compatibility, BIOS compatibility, operating system compatibility, the corresponding software with PC compatibility should also be taken into account.
(3) Reliability evaluation

    (1) Maturity measure

    ① False Discovery Rate DPP (Defect Detection Percentage)
    ② Test coverage measure

(2) Fault tolerance evaluation
(3) Control the fault tolerance measure

① The control ability of concurrent processing
② Error's quality of revision and the ability to deal with

(4) Data fault tolerance measure

① Tolerance of the illegal input data
② Tolerance of the requirements of the conflict and the illegal combinations
③ Tolerance of the rationality of the output data

(5) Tolerance of hardware's recovery measure
(6) Tolerance of the ability to recovery

(4) Recovery measure

(1) Recovery of space intensity
(2) Recovery of time intensity
(3) Recovery of data intensity
(4) Recovery of abnormal communications
(5) Recovery of data breach
(6) Recovery of battery limit

45.6 Conclusion

This article uses embedded technology to connect the data level, logical level and application level of the decision-making system with the interface of the whole stand-by system and meanwhile form an integrated decision-making support system of natural disasters. This can improve the efficiency and outcome of the whole complicated system, that is, it can optimize the design, raise its responding speed, reduce its resource consumption and its costs of hardware. In addition, it can also realize the information sharing of its various resources in the whole stand-by system.

This article will contribute to a raise in both the response to natural disasters and the anti-risk abilities. It will also provide better services, that is, the stand-by system, embedded supporting system and information-sharing platform, to institutions including government offices, legislation, tax, police, administration, flood prevention and so on.

Acknowledgments This work was supported by the National Natural Science Foundation of China (71171143), by Tianjin Research Program of Application Foundation and Advanced Technology (10JCYBJC07300), and Science and Technology Program of FOXCONN Group (120024001156).

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Chapter 46
Research on Classifying Interim Products in Ship Manufacturing Based on Clustering Algorithm

Lin Gong, Yan Song, Hao Lin and Zi-xu Chen

Abstract This paper first reviews some methods of classifying interim products during shop manufacturing. Then, the general cluster analysis is present. The progress of classifying interim products based on cluster analysis is given, and seven features of interim products are present to analysis. Finally, a case is calculated to show the effective of the method, which provides a useful way for effective classification of the intermediate products in the shipbuilding process.

Keywords Classifying · Clustering algorithm · Interim products · Ship manufacturing

46.1 Introduction

The shipbuilding industry is a strategic industry which relates to national security and national economic construction. In 2011, shipbuilding capacity in China was 76.65 million Deadweight tons (DWTs), orders for new ships reached 36.22 million DWTs, and by the end of December, handheld shipbuilding orders was 149.91 million DWTs. Chinese shipbuilding capacity, new orders received and handheld orders accounted for 45.1, 52.2 and 43.3 % of world market share (http://zbs.miit.gov.cn/n11293472/n11295142/n11299228/14428463.html, http://wenku.baidu.com/view/0ec320befd0a79563c1e7203.html.) At present, ship production model for assembly, as the representative of modern shipbuilding mode, is

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E. Qi et al. (eds.), *The 19th International Conference on Industrial Engineering and Engineering Management*, DOI: 10.1007/978-3-642-38391-5_46,

vigorously in our shipyard. Ship production model for assembly includes segmental construction and pre-outfitting on the basis of the group technology. Using interim products oriented, it combines the hull construction, outfitting and painting work, which makes modern shipbuilding mode of hull, outfitting and painting integration.

In this process, the traditional decomposition mode which is in system-oriented must be changed to the mode which is dispersed specialized production of interim products-oriented. This mode can allocate resources rationally, which means every production risk can be allocated to the corresponding production resources. The key issue of it is the classification of interim products by product characteristics and production characteristics.

This paper first reviews some methods of classifying interim products during shop manufacturing. Then, the general cluster analysis is presented. The progress of classifying interim products based on cluster analysis is given, and seven features of interim products are present to analysis. Finally, an instance is calculated to show the effective of the method, which provides a useful way for effective classification of the intermediate products in the shipbuilding process.

46.2 Research Background

Classification of the intermediate products rely on the experience of qualitative cannot meet the requirements of the modern ship production technology. It must use mathematical methods to do quantitative classification work (Wu et al. 2008 Liu and Liang 2011). At present, there was some classification study of the interim products of the shipbuilding system. Zhong Yuguang has proposed a classifier of ART-2 artificial neural network on the basis of the Adaptive Resonance Theory. It can automatically classify and identify the input data by analyzing the characteristics of interim products in shipbuilding (Zhong et al. 2008). Zhong Hongcai presented an interim products characteristics measurement method and used cluster analysis method to classify sub-assemblies (Zhong et al. 2003a, 2003b). In addition, Wang Shili designed a hull piece coding system based on modern shipbuilding mode, which focuses on project number, block number, assembly coding, piece kind, piece number and piece bending kind configure, etc. (Wang et al. 2006).

The cluster analysis method is simple and effective. Using the cluster analysis method, the interim products can be classified in quantitative division on the basis of the digital characteristics of interim products. The research on the interim products classified using of cluster analysis methods is given in this paper.

46.3 General Cluster Analysis Methods

Cluster analysis is a technology which focuses on finding the logical or physical relationship between data. The data set is divided into several classes of similar data points in nature by certain rules. The results of cluster analysis not only can reveal the intrinsic link and differences between the data, but also provides an important basis for further data analysis and knowledge discovery (Jain et al. 1999).

46.3.1 Cluster Analysis Methods

Cluster analysis methods include the following:

①AHP: AHP is through the decomposition of a given set of data objects to create a hierarchy. Two types of hierarchical decomposition of the formation of hierarchical methods can be divided further into cohesion (Agglomerative) and division (Divisive).

②Divisions method: Given a data collection contained n objects, Divisions method is to build data k divided, each division represents one cluster, and $k \leq n$. Moreover, these groups meet the following conditions: each group contains at least one object; each object must belong to and only belongs to one group (the requirements may be relaxed in the fuzzy partition techniques). For a given k, this method first creates an initial partition. Then the iterative method to change the grouping makes the group every improvement program than before. Good division of the criteria is: the distance in the same grouping as close as possible to different groups, the greater the distance, the better.

③Density-based method: As long as the density of objects or data points in a region is more than a certain threshold, then continue to clustering. Each data point in a given class in the area of a given range must contain at least a certain number of points.

④Grid-based method: The grid-based method divide the data space into a grid structure of a finite number of units, all the processing is a single unit. The main advantage of this method is the processing speed; the processing time is only depend on the number of units quantify of the space in each dimension, no relationship to the event the number of data objects.

⑤Model-based method: Model-based method is to assume a model for each class to find the best fit of the given model. Such a model may be the probability density function or other functions of the data points in space. Its underlying assumption is: the target data set is determined by a series of probability distribution. A model-based algorithm may locate the cluster by constructing a density function reflected the data points in the spatial distribution. Representative model-based methods include statistical method and neural network method.

In addition to the above five categories, there are a large number of clustering methods, such as dealing with high dimensional data clustering method (Strehl and Ghosh 2003), to deal with dynamic data clustering method, based on genetic algorithm clustering method, as well as basic clustering method a variety of new technology combined with the clustering method.

46.3.2 The Related Concepts of Cluster Analysis

m samples to be the clustering can be described by n indicators and characteristic values. This constitutes an $m * n$ data set or data matrix $X_{m \times n}$, the matrix elements is x_{ij}, that is value of j characteristic index of sample i (i = 1,2,…,m; j = 1,2,…,n).

$$X = \begin{bmatrix} x_{11} & x_{12} & \cdots & x_{1j} & \cdots & x_{1n} \\ x_{21} & x_{22} & \cdots & x_{2j} & \cdots & x_{2n} \\ \vdots & \vdots & \vdots & \vdots & \vdots & \vdots \\ x_{i1} & x_{i2} & \cdots & x_{ij} & \cdots & x_{in} \\ \vdots & \vdots & \vdots & \vdots & \vdots & \vdots \\ x_{m1} & x_{m2} & \cdots & x_{mj} & \cdots & x_{mn} \end{bmatrix}$$

Sample i can be expressed by vector $\overrightarrow{x_i}$, $\overrightarrow{x_i} = (x_{i1}, x_{i2}, \cdots, x_{in})$, This vector is called the pattern vector of the sample i.

The sample is the classification of objects of a single individual. In classifying subsections, each small segment is a sample.

The class is a collection of similar samples. The class not only can contain one or more samples, but also can contain all the samples.

The similarity coefficient or distance is to describe the similarity degrees of statistic between two samples or two classes, or between one sample and one class. Distance is used to stress difference between classes or samples, but the similarity coefficient is used to stress the similarity.

The distance can also be used to describe the degree of similarity, which includes Euclidean distance, Minkowski distance, Mahalanobis distance, and the distance of the mixed data set.

Two dimensional Euclidean distance of expression is:

$$D_{kl} = \sqrt{\sum_{j=1}^{2} \left(x_{kj} - x_{lj}\right)^2} \tag{46.1}$$

k and l are two samples, x_{kj}, x_{lj} are value of sample k and l on dimension j, the distance between them is D_{kl}.

N-dimensional expression is:

$$D_{kl} = \sqrt{\sum_{j=1}^{n} \left(x_{kj} - x_{lj}\right)^n} \tag{46.2}$$

Because dimensions are different in the mixed data set, the data should be regulated before the distance calculation. Generally, the following methods for data regulation are use.

There are two samples k and l and the index j, the coefficient $\alpha^j(k,l)$ is defined in the following:

If j is a binary variable:

$$\alpha^j(k,l) = \begin{cases} 0(K\, and\;\ 1\; values\; is\; same) \\ 1(K\, and\;\ 1\; values\; is\; not\; same) \end{cases} \tag{46.3}$$

If j is a nominal index:

$$\alpha^j(k,l) = \begin{cases} 0(K\;\ and\;\ 1 is\, belong\, to\, the\, same\, class) \\ 1(K\;\ and\;\ 1 is\, belong\, to\, the\, different\, class) \end{cases} \tag{46.4}$$

If j is an indicator of a sequence, set the value of j is desirable 1, 2, …, t:

$$\alpha^j(k,l) = \left|\frac{x_{kj} - x_{lj}}{t}\right| \tag{46.5}$$

If j is an interval indicator or arithmetic index:

$$\alpha^j(k,l) = \left|\frac{x_{kj} - \min\limits_f x_{fj}}{\max\limits_f x_{fj} - \min\limits_f x_{fj}} - \frac{x_{lj} - \min\limits_f x_{fj}}{\max\limits_f x_{fj} - \min\limits_f x_{fj}}\right| = \left|\frac{x_{kj} - x_{lj}}{\max\limits_f x_{fj} - \min\limits_f x_{fj}}\right| \tag{46.6}$$

Distance:

$$d(k,l) = \sqrt{\frac{1}{n}\sum_{j=1}^{n}\left[\alpha^j(k,l)\right]^2} \tag{46.7}$$

46.4 Cluster Analysis of the Ship Manufacturing Interim Products

46.4.1 The Segment Characteristics of Ship Manufacturing Interim Products

In the ship manufacturing process, a variety of characteristics of interim products (segmentation) can be chose, to describe before cluster analysis. According to the actual production, the seven characteristics to describe the segmentation are: type, welding length, pipe length, weight, projected area, height, and whether to turn over. Of course, in the production practice, the shipyards can constantly add characteristics for their own production style and need. In the above seven characteristics, type and whether to turn over belong to the qualitative features, weight, length of welding, pipe length, projected area, height are quantitative characteristics (Song et al. 2010).

(1) Type

Type is to describe the main types of segmentation from the shape, which can be divided into flat segmentation, special flat segmentation, curved segmentation, special curved segmentation and superstructure. Process route of different types of sub-manufacturing are not the same.

(2) Assembly length

Assembly length means the connection length in part assembling,assembly assembling, and segmentation assembling. The assembly length reflects the size of the assembly workload to a certain extent.

(3) Welding length

Welding length is the welding length of puzzle, part, assembly, and segmentation. In order to reflect the welding workload and degree of difficulty, it is necessary to transfer welding length into the conversion length. This conversion is derived by multiplying the coefficient. The coefficient of this effect sometimes are multiple, such as the size and thickness of steel plates and profiles, weld type, welding edge forms, working conditions and steel factors, etc.

(4) Weight

The segment weight determines the segmentation of the demand for production equipment. Generally based on the lifting equipment and transport equipment capacity, the weight is divided into several levels: less than 10 T, 10–30 T, 30–60 T, 60–100 T, etc.

(5) Projected area

The size of segmentation projected area reflects the size of the site area of the segmented manufacturing production.

(6) Height

Segment height is the height of subsections and the base surface of the connected construction, which decides whether need to install the framework in welding connection components.

(7) Turn Over (Zhong et al. 2003)

Whether to turn over is an important production characteristic in manufacturing. By turning over, some welding work in of the original overhead position becomes down welding, which is lower in work difficulties. However, turn over needs lifting equipment, at the same time, some assistive devices should be welded for turning over. The process route including turn over has a huge impact in manufacturing process.

46.4.2 Cluster Analysis Process

The cluster analysis process of interim products is shown in Fig. 46.1

The first step is to establish the characteristics index matrix. m interim products are analysis by cluster analysis with n characteristic indexes. The following matrix is created.

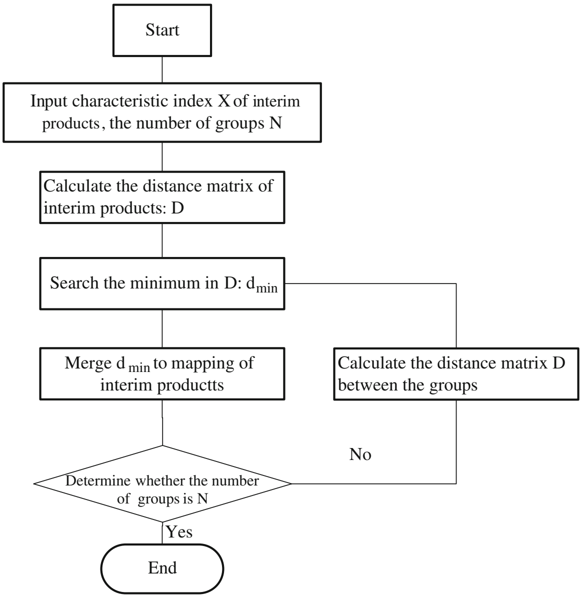

Fig. 46.1 Cluster analysis flow chart of interim products

$$X = \begin{bmatrix} x_{11} & x_{12} & \cdots & x_{1j} & \cdots & x_{1n} \\ x_{21} & x_{22} & \cdots & x_{2j} & \cdots & x_{2n} \\ \vdots & \vdots & \vdots & \vdots & \vdots & \vdots \\ x_{i1} & x_{i2} & \cdots & x_{ij} & \cdots & x_{in} \\ \vdots & \vdots & \vdots & \vdots & \vdots & \vdots \\ x_{m1} & x_{m2} & \cdots & x_{mj} & \cdots & x_{mn} \end{bmatrix}$$

The original distance matrix is calculated by calculate the distance between the interim products:

$$D(0) = \begin{bmatrix} 0 & & & \\ d_{21} & 0 & & \\ \vdots & \vdots & \ddots & \\ d_{m1} & d_{m2} & \cdots & 0 \end{bmatrix}_{m \times m}$$

Find the minimum value d_{min} in D(0), the corresponding interim products are merged into one class. Then, the distance between the class and other interim products are calculated to get the new distance matrix D(1). The distance between the new class which combines p and q, with the class r can be calculated by weighted pair group method of the average distance.

$$d(u, v + w) = [d(u, v) + d(u, w)]/2 \tag{46.8}$$

Continue to find the minimum value of D(1), the corresponding interim products are grouped. Repeat this process until the last interim products are merged.

46.5 Instance Validation

Table 46.1 shows some ship segmentations. According to the actual production needs, these six segmentations should be grouped into four classes for production.

Its original distance matrix D (0) is as follows:

$$\begin{bmatrix} 0 & & & & & \\ 0.89 & 0 & & & & \\ 0.63 & 0.56 & 0 & & & \\ 0.30 & 0.78 & 0.59 & 0 & & \\ 0.57 & 0.81 & 0.51 & 0.69 & 0 & \\ 0.63 & 0.62 & 0.28 & 0.67 & 0.52 & 0 \end{bmatrix}$$

Minimum value $d_{min} = 0.28$, so Section C, F segmentation are combined into one class.

$$\begin{bmatrix} 0 & & & & \\ 0.89 & 0 & & & \\ 0.30 & 0.78 & 0 & & \\ 0.57 & 0.81 & 0.69 & 0 & \\ 0.63 & 0.59 & 0.63 & 0.52 & 0 \end{bmatrix}$$

The minimum value $d_{min} = 0.30$, so Section A, D segmentation are combined into one class.

At this point, these segments are divided into four groups: C and F, A and D, B, E.

Table 46.1 Output of four projects

Segment name	Segmentation characteristics						
	Type	Weight(t)	Assembly length (m)	Welding length (m)	Projected area (m^2)	Height (m)	Turn over
A	Superstructure	72	320	671	73	9.7	No
B	Special curved segmentation	45	173	347	90	3	Yes
C	Curved segmentation	63	265	513	77	5.5	Yes
D	Superstructure	60	247	499	65	8.6	Yes
E	Special flat segmentation	78	352	721	79	7	Yes
F	Curved segmentation	54	303	589	89	8.3	Yes

46.6 Conclusion

This paper mentions a method to classify interim products in ship manufacturing based on clustering algorithm. It is a useful way for effective classification of the intermediate products, which means every production risk can be allocated to the corresponding production resources. The further work is to refine the index system and study other models of classifying to get a more accurate result.

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Chapter 47
Research on Financial Accounting Information Disclosure of China's Social Security Fund Based on Game Analysis

Sha-sha Dai, Ke Pan and Yuan-yuan Dai

Abstract Due to the non-consistency of the interests and objectives, confrontation and conflict will naturally occur between the accounting information providers of social security fund and regulators of the social security funds, and consequently the game will be generated. Applying the basic principles of game theory, the author firstly analyzes the mixed-strategy game between the social insurance fund management institutions and regulators; then conducts improvement and analysis on game model by regulatory measures like joining the civil regulatory and reporting; and finally concludes the relevant policy recommendations.

Keywords Basic social security fund · Financial and accounting information · Information disclosed · Game analysis

47.1 Introduction

The financial and accounting information disclosure of social security funds takes the social security funds as the accounting entity, and it provides the information formed through processing and sorting the financial accounting information of this entity to users of financial statements, and makes it to the public, which is an important part of the social security fund finance. As the purpose of social security funds operation is to pursue self-balance, to ensure the normal balance of payments, and to achieve the maintenance and appreciation of funds' value; the primary purpose of the financial information disclosure is to manage responsibilities so as to ensure that the owners of the social security funds—the state, pay units and individuals are clear about the

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E. Qi et al. (eds.), *The 19th International Conference on Industrial Engineering and Engineering Management*, DOI: 10.1007/978-3-642-38391-5_47,

operational status of the various funds. The posterior purpose is to provide decision-relevant information to the users of financial statements. However, due to the confusion of the decentralized management system of social security funds and the lack of social security funds' supervision, the funds are often diverted, misappropriated, wasted and special funds are difficult to be used only for special purpose, which reduces the efficiency of social insurance, and seriously impacts on security of social security funds and continuous operation of the system. For example: Officials from the Ministry of Labor and Social Security claimed that since 1998, the Ministry of Labor and Social Security have carried out 5 inspections with other ministries, in which they found that more than 170 billion Yuan was misappropriated in 2000 and discovered 16 provinces are diverted and misappropriated in 2004. Especially the Shanghai social security fund case and the Guangzhou social security fund misappropriation case in recent years have triggered common concern on the operational and regulatory issues of social security funds. In the meantime, serious issues such as the loose daily supervision of social insurance funds, the backward regulatory legal system of the social insurance funds, over-dependence on the system of administrative supervision, the absence of social regulation, and the lack of medium-term and the long-term early warning regulatory are exposed.

47.2 Literature Review

The publish of the classic paper Uncertainty and Welfare Economics written by Kenneth Arrow in 1963 marks the establishment of Health Economics. This paper discusses risk aversion, moral hazard, asymmetric information, externalities of charitable actions and a lot of other issues that occupy important positions in the later health economics research (Arrow 1963). Cho and Kreps (1987) study that a rational person will choose a strictly dominant strategy in game. In 1991, Claire et al. applied measurement techniques to measure the level of information disclosure in financial reports and the effects have achieved by use of this measurement technique till now (1991). Gong and Zhou (2006) believed that the financial information disclosed have three basic theoretical models. Zhou (2001) thinks each of social security funds is an accounting entity. In 2001, Wang proposed that in-depth research must be done to improve the pay off vectors of investors and listed companies in the game matrix and Nash equilibrium; while in the game of government and listed companies, the supervision level should be improved so as to control the can false accounting information disclosed by the listed companies (Wang 2001). In 2002, Gou believed that the objective of the social security accounting was to provide information users with accounting information based on financial information and with certain qualitative characteristics (Gou 2002). In 2003, Joseph and Terry examined the relationship between the independence of the regulatory members and the information disclosure quality of the company with financial difficulties, and proved that there was a positive correlation between them (Joseph and Terry 2003). Wei et al. (2003) utilized game theory to systematically analyze the attitudes and behaviors of the stakeholders like operators, accountants, investors, certified public accountants, government regulators in the process of disclosing the accounting information, pointed out the various reasons for accounting information fraud, and raised some suggestions for governance (Deng 2003). Deng (2003) put forward countermeasures and suggestions on standardizing the surplus behavior of the listed companies in China from the perspective of game theory, hoping to provide reference for the relevant departments to establish and perfect the sound accounting system, accounting standards and policies, laws and regulations of governance structure (Wei et al. 2003) In 2004, Du took the corporate governance as the background, accounting development history as the evidence, and game theory as the analysis tools, he focused on elaborating the formation process of institutional structure of the accounting information disclosure regulation during the evolution process of corporate governance (Du 2004). In 2008, Zhao put forwards some relevant suggestions on strengthening the legal construction for supervising the social security funds, the establishment of the supervision and budgeting systems for the social security fund and improving the information disclosure system of fund regulation (Zhao 2008). In 2010, based on the operations and regulation theories of current social insurance fund, Li Wen-bo and Duan Hong-bo conducted in-depth analysis and evaluation on the regulatory situation of Chinese social insurance fund, and studied to establish social insurance fund monitoring system with the characteristics of Chinese society from many aspects and based on China's national conditions (Li et al. 2010). In 2011, Tong and Liu established several different game models, used game analysis method to study the social security fund managers and the behaviors of the social security funds' regulators, and concluded the necessity of social security funds' regulators and their impact on the social security funds (Tong and Liu 2011).

In recent years, a lot of the articles apply game theory to explain the information disclosure of the listed companies emerge, and those studies mainly conduct research from the topics like information disclosure behavior, information disclosure and supervision as well as information distortion and accounting irregularities. However, few scholars have used game theory to explain the accounting information disclosure of social security funds.

47.3 Theoretical Analysis

47.3.1 Analysis of Supply and Demand of Financial Accounting Information of Social Insurance Funds Financial

Accounting information as a public good also has supply and demand like other products. Though the reason for the generation of demand and supply of accounting information is that the information learned by the supply and demand parties is asymmetric, and asymmetric information leads to the imbalance of both power and interests. Therefore, the demand party produces the need for accounting information with its purpose of maintaining the balance of power and interests of both supply and demand parties; while the supply party certainly wants to keep the status of its information advantage to obtain additional benefits. Because of this, both supply and demand parties will ultimately form the disclosure of financial accounting information through continuous game. In the study of accounting information disclosure, the demand party generally refers to the main users of accounting information. However, from our analysis of the accounting goals, no matter it is "accountability theory" or "decision availability", they all take the separation of ownership from management as the premise. The agency relationship between management authorities and property owners is the major contradiction in the study of accounting information disclosure. Therefore, the demanders for accounting information in this paper are researched, which mainly means to provide accounting information to external information demanders in the form of financial information reports.

According to our analysis, the providers of accounting information refer to the party with the information superiority position in the game of supply and demand. In general, it refers to the business owners as well as other internal managers. Accounting information providers disclose the accounting information for two motives; one is voluntary disclosure, the other is non-voluntary disclosure. The supply party in the status of information superiority will not easily disclose accounting information unfavorable to itself. In order to safeguard the healthy and good economic order, the State will force accounting information providers to provide the required information through administrative means such as developing the accounting system and criteria by the government and relevant organizations.

47.3.2 Game Theory

Economist Nash's solution to the classic game case of—the "prisoner's dilemma" indicates that the premise of the agreement to be complied with is that the benefits of complying with the agreement outweigh the benefits of breaking the agreement, or the loss of breaking the agreement is greater than the loss of complying with the agreement. Otherwise, the parties will not have the interest to comply with the agreements. It is believed that game theory has great reference significance on analyzing the selection of the parties between the financial and accounting information disclosers on the social security funds and the regulators. Meanwhile, the both game parties will induce the parties to produce the motive of breaking the agreement for the results of their own interests pursuit. Accounting principles, accounting standards and other related economic laws and regulations, are a kind of agreement. How to ensure that this agreement is implemented, and effectively restrains the concerned parties, especially the behavior of regulators and the financial and accounting information disclosers? According to the basic idea of the "Nash equilibrium", the key premises to achieve the "Nash equilibrium" are the scientific and reasonable system design, strictly working in accordance with the system, complying the system, and everyone is equal before in the system (Zhang 1996).

47.4 Game Analysis

47.4.1 Game Analysis on the Accounting Information Providers of Basic Social Security Fund and Government Regulators

Assumption: 1. Game participants in the game model are rational, and they will make the optimized rational decision under some constrained conditions. 2. Assumption that there are two kinds of actions for the government regulators to choose: check or not check; two kinds of actions for financial and accounting information discloser to choose: financial accounting fraud or financial accounting credit. (Here in order to simplified model, fraud include actions that cause distortion of accounting information disclosure such as profit forecast inaccurate, reporting manipulation and the disclosure of financial information still exists in time) 3. Assumption that understanding of each participant about action selection of other participant is not necessarily accurate, and the information of participants in this model is not complete. According to the above assumptions, complete information static state game model between financial and accounting information discloser and government regulators can be built (see Table 47.1). This game is a static state game between government regulators and the financial accounting information discloser of social insurance fund.

Table 47.1, the first number in the table shows earnings of the government regulators; the second number shows earnings of financial and accounting information discloser. Strategies taken by game participants and condition of earnings are common knowledge and common information of both sides, whose game are developed by these. When financial accounting credit of financial accounting information discloser of social insurance fund and government regulators don't check and both sides have no extra income and loss, "extra income" of both sides at this moment can be seen as 0. When government regulators don't check and financial accounting of the social security fund managers makes a fraud, the obtained extra income is E. when financial accounting of the social security fund managers makes a fraud and is investigated by the government regulators, fines should be paid besides extra income E is confiscated and its income is-F(fine). Fines in real life usually are several times the illegal extra income. However, the government regulators should pay the cost C, such as dispatch of labor power and material resources, time to check and so on. The performance reward of government regulators obtained by investigating fraud of financial accounting information is B. Here, E, R, F, C, B are positive.

Table 47.1 Static state game model between financial and accounting information discloser and government regulators

Government regulatorsc	Accounting information discloser			
	Accounting fraud (γ)		Accounting credit ($1-\gamma$)	
Irregularity (θ)	$E+B+F-C$,	$-F$	$-C$,	0
Non-inspection ($1-\theta$)	0,	E	0,	0

According to this payoff matrix, we can calculate expected profit function of the financial accounting information discloser of social insurance fund:

$$S = \gamma\,\theta(-F) + \gamma\,(1-\theta)\,E \tag{47.1}$$

Expected profit function investigated by the government regulators are:

$$L = \gamma\,\theta(E + F + B - C) + (1-\gamma)\theta(-C) \tag{47.2}$$

In this formula, expected profit function of the financial accounting information discloser of social insurance fund is S. According to fraud probability, we can get its reaction function by derivation:

$$\frac{\partial S}{\partial \gamma} = E - \theta\,(E + F) \tag{47.3}$$

Similarly, for expected profit function investigated by the government regulators L, we can get its reaction function by derivation according to regulatory probability:

$$\frac{\partial L}{\partial \theta} = \gamma(E + F + B) - C \tag{47.4}$$

Combination of (47.1) and (47.2) can get the optimal regulation probability of the government regulators and the optimal fraud probability of the financial accounting information discloser of social insurance fund, which are as follows:

$$\theta^* = \frac{E}{E+F} \qquad \gamma^* = \frac{C}{E+F+B}$$

It is synthesizing the above mathematical reasoning process; we can get Nash equilibrium of mixed-strategy game.

Because the additional income E obtained from the fake information disclosure is independent of this model, it will be regarded as constants out of human control in the analysis. It can be seen that in the Nash equilibrium solution in the model, is directly proportional to C and inversely proportional to $F + B$.

The fraud in financial and accounting information disclosure of the social security fund depends on the government regulators: if the smaller the law enforcement of the government regulators C is, the bigger the awards B obtained by the government regulators due to investigating the frauds in the accounting information disclosure are and the penalties income F is and the smaller the probability of the frauds in the accounting information disclosure is. The probability of the regulation and supervision of the government regulators mainly depends on the extra benefits E obtained from false accounting information and degree of punishment on the accounting information disclosure fraud F. The higher the fraud income E is, the lower the punishment degree F is, and the higher the probability of supervision and regulation of the government regulators is for their own work, performance and reputation.

47.4.2 Improved Game Model After Adding Public Supervision and Report Measures in the Above Game Model

On the basis of the government regulation is not in place due to lack of financial and material resources, public supervision institutions and the system for reporting the social security fund disclosure fraud are considered to be established, or the report can be done through the network or telephone.

As mentioned in Sect. 47.4.1, assume that the social security fund management institutions are found to choose to disclose the fake accounting information and punished seriously, which can make the Nash equilibrium point close to the Nash equilibrium with best total social utility Pareto. It is not quite as simple as that, though. First, it is uncertainty whether the government regulators have enough energy to verify all the social security fund management institutions. Second, even if verification is conducted, the verification shall not be guaranteed to be fully successful, that is, the concealment of some false accounting information is too intense to be found by the existing technology. Next, it shall be dependent on the degree of the punishment on those agencies which disclose the false accounting information. If the punishment is less than the benefits obtained from the disclosure of false information, this phenomenon can't be governed well. In the end, the regulatory effect will depend on the benefits and costs of the regulators. All of these show that social security agencies and the government regulators optimize their action strategies in the game constantly.

In Table 47.2, the first figure indicates the benefits of the regulators and the second one indicates the benefits of accounting information disclosers.

Suppose P is the probability that the government regulators receive the reports without inspecting the social security fund management institutions. Therefore, the probability that the government regulators don't receive the reports without inspection is $1-P$. The probability that the regulators succeed in the verifying the social securities fund disclosers is K while the probability of failed verification is $1-K$. The reputation losses of the government regulators due to the fraud in the

Table 47.2 The benefits of the regulators and accounting information disclosers

Accounting information discloser	Government regulators			
	Irregularity (θ)		Non-inspection ($1-\theta$)	
	Confirmed (K)	Not confirmed ($1-K$)	No result ($1-P$)	Report and verify the irregularities (P)
Accounting fraud (γ)	$E+B+F-C,\ -F$	C, E	$0, E$	$E+F-R, -F$
Accounting integrity ($1-\gamma$)	$-C$, 0	$-C$, 0	0, 0	0, 0

financial and accounting information disclosure of the social securities fund are R (Reputation).

1. Where the situation of the probability of the fraud in financial and accounting information disclosure of the social security fund is given, the expected benefits obtained in the event of inspection and non-inspection conducted by the regulators is respectively:

$$\pi_1 = [(\mathrm{E} + \mathrm{B} + \mathrm{F} - \mathrm{C})\,\mathrm{K} + (-\mathrm{C})(1 - \mathrm{K})\gamma] + [-\mathrm{C}\,\mathrm{K} - \mathrm{C}\,(\mathrm{L} - \mathrm{K})](1 - \mathrm{K}) \tag{47.5}$$

$$\pi_2 = (E + F - R)\gamma P + 0 \tag{47.6}$$

$$\pi_1 = \pi_2, \quad \gamma^* = \frac{C}{(E+F)(K-P) + K\,B + R\,P}$$

2. Where the probability that the regulators conduct the inspection is given, the expected benefits obtained by social securities fund from fake information disclosure and true information disclosure are separately:

$$\pi_3 = [E(1-K)\theta - FK]\theta + [E(1-P) - EP](1-\theta) \tag{47.7}$$

$$\pi_4 = 0 \tag{47.8}$$

$$\pi_3 = \pi_4, Get \quad \theta^* = \frac{(E+F)P - E}{(E+F)(P-K)}$$

Therefore, the improved mixed-strategy Nash Equilibrium is

$$\gamma^* = \frac{C}{(E+F)(K-P) + K\,B + RP'}$$

$$\theta^* = \frac{(\mathrm{E}+\mathrm{F})\mathrm{P} - \mathrm{E}}{(\mathrm{E}+\mathrm{F})(\mathrm{P}-\mathrm{K})}$$

The improved mixed strategy Nash equilibrium indicates: if the social security fund managers choose to undertake the false accounting information disclosure in the form of $\gamma > \gamma^*$, then the best choice for the regulators is to inspect. Otherwise, the regulators will not inspect. If $\gamma = \gamma^*$ to undertake the false information disclosure, the best choice for the regulators is not to inspect. Similarly regulators conduct the inspection in the form of $\theta > \theta^*$, the best choice for the social securities fund management institutions is to disclose the true accounting information. Otherwise, the reverse. Because the additional income E obtained from the fake information disclosure and irregularities report and investigation P are independent of this model, they will be regarded as constants out of human control in the analysis. It can be seen that the probability of the fraud in financial and accounting information disclosure of the social security fund depends on the government regulators:

(1) when *K–P* is more than 0: if the smaller the law enforcement of the government regulators *C* is, the bigger the awards *B* obtained by the government regulators due to investigating the frauds in the accounting information disclosure are and the penalties income *F* is. Besides, the bigger *R* and the probability for regulators to succeed in the verification *K* is, the smaller the probability of the frauds in the accounting information disclosure is.

At this time, the probability of the regulation and supervision of the government regulators is mainly dependent on the degree of punishment *F*. The bigger *F* is, the greater the probability of the supervision is.

(2) When *K–P* is less than 0: if the smaller the law enforcement of the government regulators *C* is, the bigger the awards *B* and R obtained by the government regulators due to investigating the frauds in the accounting information disclosure and the probability for regulators to succeed in the verification *K* are. Besides, the less the penalties income *F* is, the smaller the probability of the frauds in the accounting information disclosure is.

At this time, the probability of the regulation and supervision of the government regulators is mainly dependent on the degree of punishment *F*. The smaller *F* is, the greater the probability of the supervision is.

Usually, *K–P* is greater than zero. If *K–P* is less than 0, it indicates that the regulators don't have any supervision effects. This situation is not allowed to appear. As a result, the probability of the frauds in the accounting information disclosure is mainly inversely proportional to *B, F, R, K* and directly proportional to *C*. The measures shall be taken to contain *B, F, R, K* and *C* together, which will minimize the probability of the frauds in the accounting information disclosure.

47.5 Conclusion

A. Social Securities Fund Accounting System and Social Securities Fund Financial System issued in 1999 should be improved and updated. From the point of view of game theory, the system arrangement is the rule of games. At the same time, the system arrangement is the result of the game. Unreasonable or imperfect system arrangement will update and improve in the continuous dynamic game to reach a new equilibrium at last. That is, the system designer and system executor conduct a dynamic game. A good system arrangement should be perfected continuously. In a certain sense, the "system" is more important than the game itself.

B. The government shall establish not only the efficient, honest, relatively independent social security fund supervisory institutions, but also the non-governmental supervisory institutions independent of the government regulators and provide the public phones, web sites, mailboxes and other report measures. At the same time, this can make the various regulators supervise each other.

C. On the basis of the application of the advanced computer technology, the construction of the social security fund information management platform, the supervision of revenues and expenditures of the social security fund and management in advance, and the network management of the whole progress of fund usage, the off-site surveillance and dynamic supervision will be realized gradually.

D. To establish an account checking system between the social security administration department and the social security fund administrative agencies to prevent the deviations of the their accounts. At the same time, actuarial reports and submissions of the enrolled actuaries and the audit reports and submissions of the certificated public accountants shall be provided in the financial accounting reports and management reports of the social security fund.

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Chapter 48
Research on the Multi-Target Tracking Algorithm Based on Double FPGA

Xu-dong Liu

Abstract The accuracy and real-time of the multi-target tracking system have been the main study problems in the targets tracking field. In this research, two slices of FPGA are applied as the main processing chips. Kalman Filter and Particle Filter, the two commonly used filtering algorithms are dynamically integrated to make use of their characteristics in multi-target tracking processing. The real-time of multi-target tracking is realized through the complementation of double FPGA chips.

Keywords FPGA · Kalman filter · Multi-target tracking · Particle filter

48.1 Introduction

With the increasing complexity of the targets tracking background and the rapid development of digital technology, the requirements for radar multi-target tracking ability in the interference background become much higher than ever. The multi-target tracking technology has been widely used in the fields of military, communications, satellite navigation, and remote sensing etc. The core of the targets tracking study is the filter algorithm. Therefore, it is the hot spot and difficult point of the research field to find a better performance filtering algorithm to deal with the linear and nonlinear problems in the actual system. In order to conduct more effective real-time multi-target tracking in complex environments, the paper introduces a new filtering algorithm by applying double FPGA as the processor core, and combining Kalman Filter Algorithm and the Particle Filter Algorithm together.

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E. Qi et al. (eds.), *The 19th International Conference on Industrial Engineering and Engineering Management*, DOI: 10.1007/978-3-642-38391-5_48,

48.2 The Filter: A Algorithm Realized by FPGA

The multi-target tracking is the process of identifying and tracking of the multi-target motion parameters, such as position, velocity, acceleration and targets classification feature, decomposing and estimating the measurement data from the receiver, and finally forming each target trajectory (Liu 2003). In the whole system, filtering is of vital importance. The effect of filtering exerts a direct impact on the result of the whole tracking system. The so-called filtering refers to the optimal estimation of the current value from the observation values got currently and in the past. The filter theory is the system state or parameters estimation theory and method, which is in accordance with certain filter criterion and based on measurements of the system observed signals.

Since the filter process needs to access and calculate large state data, the main processing chips of the tracking system require high operation speed and large storage space. Meanwhile, the main processing chips have data communication with the peripheral circuits. Therefore, the main processing chips should have strong interface communication ability to ensure the real-time of the Multi-target tracking. Based on SP3, Spartan-3A is an I/O optimization FPGA launched by Xilinx for users' more I/O demands. The advantage of SP3A lies in its highest I/O density in the same FPGA series, which can support more I/O standards. It is an ideal select as the main processing chips in the Multi-target tracking. The filter algorithm in this research is realized by adopting FPGA Spartan -3A.

For the multi-target tracking system, there are various kinds of filter algorithms, such as Bayes Filter, Optimal Estimation Filter, Suboptimal Estimate Filter, etc. At present, Kalman Filter (a type of Optimal Estimation Filter) and Particle Filter are more mature, and commonly used. The two kinds of filter methods are dynamically integrated and studied in this paper.

48.2.1 Kalman Filter

Kalman Filter describes system by state space method, and is composed of state equations and measurement equations. Kalman Filter estimates the state current value with the previous state estimated value and some recent observation data, and describes the current value in the form of state variable estimated value (Ding 2003).

Suppose the system state variable is X_k at the moment k, the state equation and the measurement equation are as follows.

$$X_{k+1} = A_k X_k + \omega_k \tag{48.1}$$

$$y_k = C_k X_k + v_k \tag{48.2}$$

In the equations, "k" means time, and here it refers to the "k" iteration value of the corresponding signal. The input signal "ω_k" is white noise. The observation

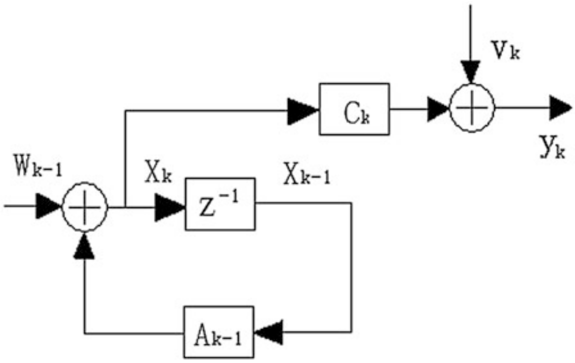

Fig. 48.1 Kalman Filter Signal Model

noise of the output signal "V_k" is White Noise, too. The branch gain of the input signal to the state variable equals to 1. "A" is the gain matrix among the state variables, which can change with the time. "C" means the gain matrix between the state variables and output signals. The signal model is shown in Fig. 48.1. If time variable "k – 1" replaces "k" in the state equation, the equations are as follows.

$$X_k = A_{k-1}X_{k-1} + \omega_{k-1} \tag{48.3}$$

$$y_k = C_k X_k + v_k \tag{48.4}$$

Here "X_k" is a state variable. "ω_{k-1}" means the input signal, which is white noise. "V_k" is observation noise. "Y_k" is observation dada.

Kalman Filter Algorithm by FPGA is shown in Fig. 48.2. The calculation of the covariance and the calculation of filter gain are realized by one FPGA. While the posterior state estimate and the posterior error covariance estimate are conducted by another FPGA. By this way, double FPGA can work simultaneously on the algorithm computation and storage, and improve the performance of the real-time.

For the linear Gaussian random system, Kalman Filter can get an accurate analytical solution of posterior probability density function. But in some cases, it is hard to get an accurate posterior probability density function, so the approximate suboptimal estimates are required (Xu 2008; Abdel-Hakim and Farag 2006). Besides, because of the poor system's observability and the low-degree linearity of the state space model, Kalman Filter Algorithm can not meet the requirements in the aspects of the convergence precision and the convergence time (Deng 2008). In order to solve the problem, Gordon introduced re-sampling algorithm into sequential importance sampling, and put forward the importance sequential importance re-sampling algorithm. Thus the algorithm becomes more perfect. The Sequential Importance Re-sampling Algorithm is also the base of the Particle Filter Algorithm. Compared with conventional Kalman Filter Algorithm and its improving algorithm (Zawar and Malaney 2006), the Particle Filter can perform better in non-linear & non-Gaussian environment (Wu et al. 2009). When the particle quantity is enough, its estimate can approximate the optimal solution.

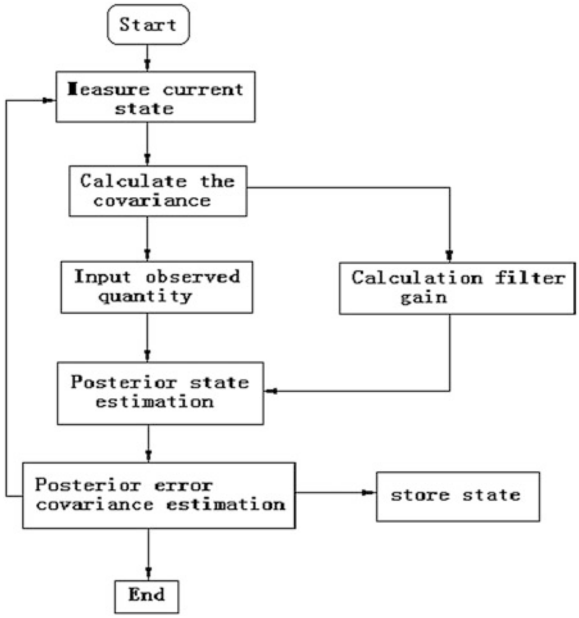

Fig. 48.2 Kalman Filter FPGA Algorithm Process

48.2.2 Particle Filter

The Particle Filter is a filter method for non-linear & non-Gaussian system, based on Monte Carlo Methods (MCM) and the Recursive Bayes Estimation. As the fundamental idea of Particle Filter, firstly, in terms of the experience conditional distribution of the system state vector (Czyz et al. 2007), a group of random samples set is generated by state space sampling. The sample set is called "Particle". And then the particles weight and the sample position is adjusted ceaselessly in accordance with the observation data (Wang 2009). Finally, the correction initial experience conditional distribution and the estimation system states and parameters can be achieved through the adjustments of the particles information. Algorithm shows in Fig. 48.3.

Normally, the descriptions of nonlinear & non-Gaussian system are as follow.

$$X_k = f_k(X_{k-1}, v_k) \tag{48.5}$$

$$Y_k = h_k(X_k, w_k) \tag{48.6}$$

In the equations, "$X_k \in R_n$" means system state of "K" time. "$Y_k \in R_n$" means measurement. "$V_k \in R_n$" and "$W_k \in R_n$" represent the independently and simultaneously distributed system noise and observation noise sequence respectively. State space model describes dynamic system model. The implied time is white variable. In the study of multi-target tracking, state vector contains goal

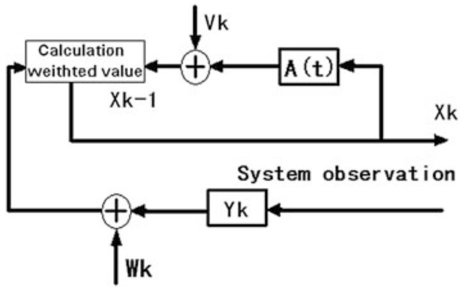

Fig. 48 3 Signal Model of Particle Filter

dynamics characteristic parameters, for instance, the specific location in the coordinate system and the speed value of a definite direction. This algorithm is a kind of recursive filtering algorithm, and in principle, it can estimate the state and parameters of an arbitrary nonlinear & non-Gaussian stochastic system (Zhang 2010). Thus it overcomes the shortcomings of Kalman Filter Algorithm.

In the process of Particle Filter, particle degradation exists (Feng 2008). Re-sampling method can be adopted to solve the problem preliminarily (Vo and Ma 2006). But this will bring forth more computation amount, and add more burden to the main processor, and influence the real-time of the system (Qian 2011). The Particle Filter FPGA algorithm process is shown in Fig. 48.4.

The application of double FPGA processing form can solve the problem thoroughly. The two slices of FPGA chips adopt parallel operations model, one is used mainly to handle Kalman Filtering process, Particle Filter re-sampling process and the communication between the double chips, the other completes the main operation process of Particle Filter. Thus, the filter method can switch from one to the other according to the specific signal condition, and two kinds of filter methods can run synchronously through making full use of resources to cope with more complex non-linear& non-Gaussian system (Wang 2004). In some maneuvering multi-target tracking system, the system needs to switch at any time in any sorts of models (Hu 2010). The mutual cooperation of the two FPGA can provides guarantee that the system can perform real-time tracking to the multiple targets (Hu 2008).

48.3 Simulation Contrast

The paper only takes first 100 frame images in the simulation process as reference. For simple realization, suppose both the system noise and the measurement noise are zero mean Gaussian white noise.

The simulation results shows in Fig. 48.5. The track constituted by solid circles is the actual multi-target motion trajectory, and hollow rings form the algorithm estimate trajectory. From the graph, for each target, the difference value between the filtering algorithm estimate trajectory and the actual target motion trajectory is

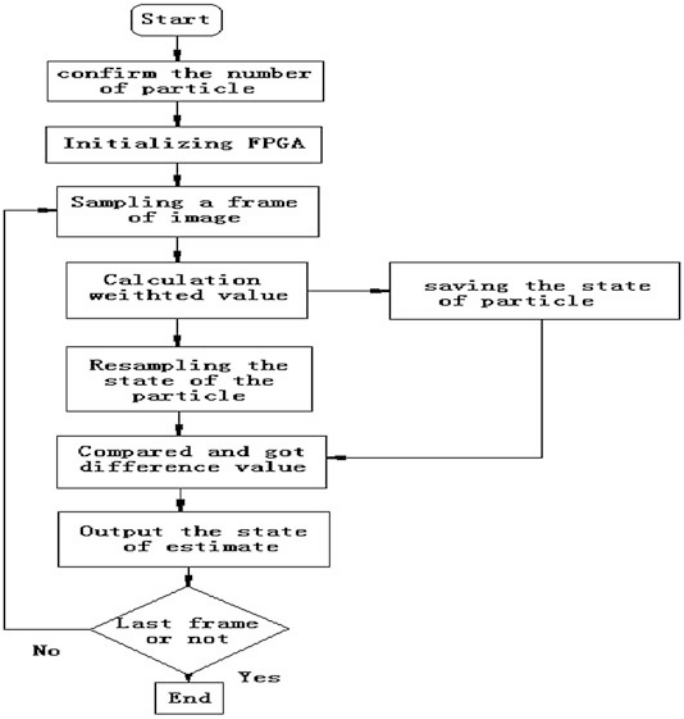

Fig. 48.4 FPGA Algorithm Process of Particle Filter

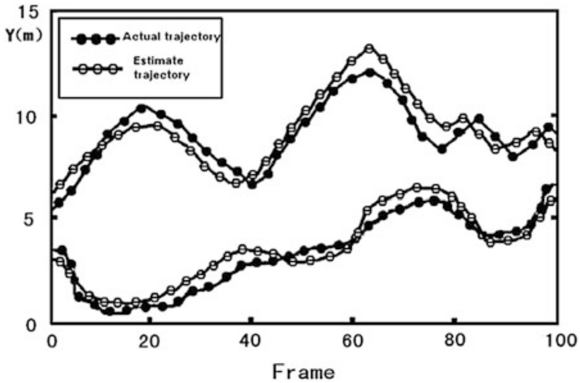

Fig. 48.5 Kalman Filter and Particle Filter Simulation Results

small. In the process of the target movement, even if there exists a high acceleration, the filtering effect can still be achieved, which completely meet the requirement of the multi-target tracking.

48.4 Conclusion

This paper designed and realized the application of multi-target tracking system algorithm in complex environment by using FPGA as its main processing chips, which can satisfy the requirement of the subsequent processing for multi-target detection and tracking. The simulation results show that the expected objectives can be achieved. If there is a further demand to improve the system signal real-time processing speed, a piece of DSP (TMS320C6416) can be applied for signal preprocessing before the two pieces of FPGA perform signal processing specifically. By this way, better signal characteristics can be distinguished. Besides, it will have a bright market prospect to add a USB form output interface in the system which uses this kind of algorithm.

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Chapter 49
A Study of the Effect of Xi'an Subway on the Rent of Office Building

Ying Wang and Wen-jia Wei

Abstract On the basis of comprehensive consideration of internal and external factors affecting the rent of office building, this article aims at the rent of the office buildings along the Xi'an Metro Line 2. It applies BP neural network model to quantitatively analyze the degree of influence of Xi'an subway on the office rent. The analysis results demonstrate that Xi'an Subway Line 2 has a significant effect on office rent. It ranked the fourth in 11 factors, effect weight of which is 10.5 %. It shows that Office enterprises especially prefer on the convenience of the subway traffic, which indicates this subway line plays an important role in enhancing the value of surrounding office properties.

Keywords Office rents · Xi'an Subway Line 2 · BP neural network model

49.1 Introduction

Whether investors will develop a real estate, or firms choose office location, office space location is a critical factor. Existing urban rail transit construction experience has shown that urban rail transit through the "value capture" phenomenon in improving the quality and attractiveness of urban areas can play a significant role (Du and Mulley 2007). It will not only improve the traffic convenience along the region, and can attract a variety of life, business, education, entertainment and other facilities along the metro aggregation, enhance and improve the life environment of the office along the subway.

Therefore, it has strong stimulation to the development of surrounding property, thus contributes to the high-density development of the site and enhancement of

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E. Qi et al. (eds.), *The 19th International Conference on Industrial Engineering and Engineering Management*, DOI: 10.1007/978-3-642-38391-5_49,

the real estate value along the subway. In general, the closer the office building is to the Metro arrivals, the greater the transit has impact on office rental. However, some studies suggest no impact on the rent of office along the subway.

The impact of the subway on the rent of office building reflects not only the strength of the external economic role of the subway construction, but the driving agglomerating force on the surrounding economy. In essence, it reflects the input and output value of the subway construction, rail transport space resource values and the economic sustainability of the future development of urban rail transit. Therefore, this research can provide valuable suggestions, which is about more rational and scientific development of urban rail transit planning and use-planning of land along the subway in order to fully realize the optimal allocation of urban space resources, and also provide strong support for the decision-making of the investors on the siting.

Subway Line 2 is currently the only subway line in Xi'an, which has been built and put into operation. It is a total length of 26.4 km, runs through north and south of the city. The installment is from the Xi'an North Passenger Transport Station to south, through the Bell Tower, along the South Hamlet and Xiao-zhai to the Qu-jiang International Convention and Exhibition Centre. It officially has put into operation in September 2011. This paper studies the rental office along Xi'an Subway Line 2 and conduct an empirical analysis of the impact of subway construction on office rentals by employing BP neural network model.

49.2 Domestic and International Research Review

Since the 1970s, there has been extensive and in-depth research about interests influence on urban rail transit project development in foreign countries. Therein, the impact research of rail transit construction on the surrounding property values is an important research topic in this field. Mejia-Dorantes et al. (2011) studied Madrid metro and by using spatial statistical technique come to the conclusion that the subway plays a very important role in improving transport efficiency and urban planning. Pagliara and Papa (2011) studied the value impact of the city region along the subway, and research shows as time goes, the value of surrounding land will gradually improve.

The subway from the Beijing Railway Station to Western Suburb Apple Orchards is the China's first metro line, and started trial operation in 1971. In recent years, with the rapid development of domestic metro, the relationship of rail transportation and real estate values along it is the concern of many scholars. Some studies focused on the residential real estate, such as the studies of Yang and Shao (2008) and Liu and Shang (2009). Other studies aimed at the office market such as Jiao et al. (2009). It carried out the empirical results on the office rentals change along Beijing Metro 10 line and show that there is no significant effect of urban rail transit on the office space rental changes. The main reason was that the center effect of the city center and the aggregation effect of shopping district weakened the impact of urban rail transit. The tool of empirical analysis of these studies mainly has transportation cost model, the hedonic price model or neural network analysis. Transportation cost model is the model based on the relationship between transport costs and real estate value without considering the value impact of real estate factors. The hedonic price model commonly uses the form of linear equations functions mainly to solve the static problem. But the neural network model with particular autonomous learning is able to accurately simulate and solve non-linear relationship. It has the higher accuracy and reliability (Yang and Shao 2008).

On the basis of existing research, the paper uses the BP neural network model to analyses the influence strength of Xi'an Metro Line 2 on the office rental considering various internal and external factors affecting office rentals.

49.3 Empirical Analysis of the Impact of Office Rentals Alone Xi'an Subway

49.3.1 Sample and Variable Selection

In order to get more qualified samples, the samples are limited to the following: (1) samples are taken from rental offices surrounding some great station, such as Chang'an Road Station, South gate Door Stations, taking into account of the big gap in commercial atmosphere and traffic conditions along the north–south of the Metro Line 2; (2) samples are only the rental offices 800 m depart from the subway, due to no effects beyond a certain range; (3) excluding the exotic sample of which the rent is significantly low or high. In accordance with above the limit, this paper collected 80 samples out of the 20 leased office apartments along Xi'an Subway Line 2. Based on existing research, the paper selects 11 impact factors variables of office rentals as following: distance from the subway exit, office type, commercial agglomeration degree, public facilities, traffic conditions, image of the appearance, decoration level, internal support facilities, where the floor, property costs and property level. All variables are defined as follows in Table 49.1 (Wang and Chen 2009).

Among them, the descriptive variables in the sample are quantified, referring to the real estate valuation method and expert scoring method. First a standard sample is selected for each independent variable, Scoring 100, and then the other samples are scored one by one comparing to the standard sample rate. The quantified samples are normalized, the formula of normalization is:

$$\mathrm{Y}_i = \left(\mathrm{X}_i - \mathrm{Min}\sum_{i=1}^{n}\mathrm{X}_i\right)\Big/\left(\mathrm{Max}\sum_{i=1}^{n}\mathrm{X}_i - \mathrm{Min}\sum_{i=1}^{n}\mathrm{X}_i\right)$$

X_i and Y_i are the Values before and after the conversion (Fang and Chen 2004) .

Table 49.1 The definition of the model variables

Variable name	Definition
Distance from the subway exit	The distance to the subway station (m, quantitative data)
Office type	The grade level of the office (given class of data)
Commercial agglomeration degree	The flow of people around station (descriptive data)
Public facilities	Hotels, shopping malls, hospitals, schools and other facilities (descriptive data)
Traffic conditions	Traffic convenience (descriptive data)
Image of the appearance	Building height, shape, wall decoration and building condition (descriptive data)
Decoration level	Interior grade (given class of data)
Internal support facilities	Power, communications, transportation, electronics and other equipment and facilities (descriptive data)
Where the floor	Location of floor (quantitative data)
Property costs	Property service fees (Yuan\m^2\mouth, quantitative data)
Property level	The level of property services (given class of data)

49.3.2 BP Neural Network Model Analysis and Results

This article selects BP neural network model with three-layer hierarchy network, nodes of input layer, node of output layer and nodes of hidden layer. There are a number of hidden nodes on the adjacent; neurons of adjacent on the lower are fully connected. That is, each lower neuron with each upper neuron to achieve the right connections, while each floor no connection between neurons. First, the input signal propagates forward to the hidden layer nodes, after the role of function, then the hidden output signal transmitted to the output node, and finally output is obtained. The role of sigmoid-type function of node activation function is selected the non-linear physical. Network training is selected TRAINGDM optimization algorithms to improve the network generalization ability and convergence speed, and the largest training sated 500, the target error value sated to 0.01, the frequency showing sated 50. Eleven main factors are as the input of the BP neural network model, rental of office space rent is the output. The paper selects 60 groups as the training samples and 20 groups as the simulation data. The results of the model Training is shown in Figs. 49.1 and 49.2.

The result of model after repeated experiments is that hidden layer nodes is 30. The best results Fig. 49.1 shows that the error of the desired output of training sample and calculating output is less than 1 % after 168 times simulation training by the network. When the network reaches a predetermined target error, model training will get success. Figure 49.2 shows a sample model fitting, R = 0.83912, the model fitting of the sample data close relatively high to 84 %.

From Table 49.2, using the trained model to test, the maximum error between the output value and the "expectation" is 10.52 %, with an average error of 5.2 %. Comprehensive evaluation result is consistent with the expected data. This shows

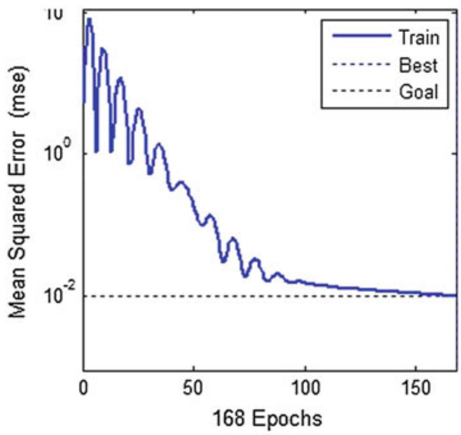

Fig. 49.1 Training results

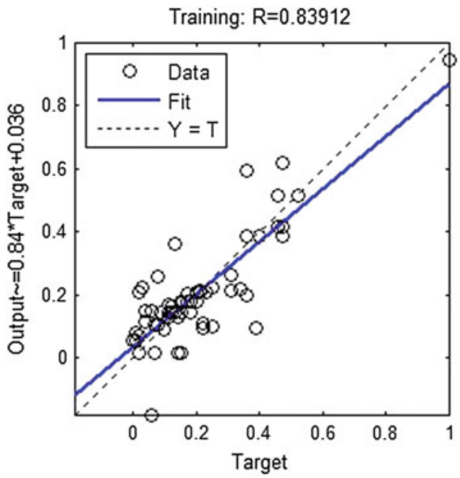

Fig. 49.2 Fitting figure

that using comprehensive evaluation of the three-layer BP neural network method to simulate the data is valid. Training office influencing factors B, by the 3-layer neural network model can be explained the effects of office influence factors on rent.

Table 49.3 is the impact proportion of office rental influencing factors of the model output, the greater effect proportion factors include: commercial aggregation, public facilities, and internal support facilities, distance from the subway exit and traffic conditions. Because office rentals form from the office market demand and supply conditions, the impact of various factors on office rentals reflects the demand of the enterprises settled in offices for office space preferences. Business concentration's impact proportion of office rentals is 15.7 %, indicating that the impact of the overall atmosphere of the shopping district and the maturity on office rentals is the most important. It is also the most important for Business enterprises. The effect proportion of public facilities is 13.30 % ranking the second. Besides,

Table 49.2 The samples tested in the input and model estimates the value of output

Tested samples (Yi)	1	2	3	4	5	6	7
Real value	0.1607	0.2047	0.0689	0.2216	0.063	0.1198	0.1524
Model estimates	0.1022	0.1803	0.1642	0.1682	0.1065	0.028	0.1501
Relative error	0.0585	0.0244	−0.095	0.0533	−0.0435	0.0918	0.0023
Tested samples (Yi)	8	9	10	11	13	14	15
Real value	0.0398	0.2392	0.4625	0.5199	0.1069	0.1606	0.157
Model estimates	0.145	0.2021	0.4589	0.4839	0.1744	0.2084	0.2084
Relative error	−0.105	0.0372	0.0036	0.036	−0.0675	−0.048	−0.0515
Tested samples (Yi)	16	17	18	19	20		
Real value	0.0398	0.0188	0.2502	0.3473	0.045		
Model estimates	0.1046	0.0781	0.2622	0.2631	0.0536		
Relative error	−0.065	−0.059	−0.012	0.0842	−0.0086		

the shopping malls, hotels, apartments, hospitals and other public facilities can greatly enhance the value of office space. Internal supporting facilities have a great impact on office rentals, namely 11.7 %, due to the intelligent management of the office bringing great convenience to the business office.

The impact of distance from the subway exit on office rentals is 10.5 %, located the fourth in the selected factors, which indicates that the impact of the Xi'an Subway Line 2 on the rents of office buildings along it is more significant. In recent years, following Xi'an's rapid economic development, a sharp increase in foreign population and the rapid growth of private car, the problem of urban traffic congestion is increasingly serious. Xi'an Subway Line 2 is located in the city north–south traffic artery and it is opened to a greater extent to mitigate this traffic load in the trunk on the ground, and raise the transportation convenience of office properties, but also be lower transportation costs of enterprises settled, thus the greater value of office properties.

However, "the city of Xi'an, rapid rail transit construction plan" shows that Xi'an will build a total of six subway lines and a total length of 251.8 km, forming the network structure of the board radial layout. Now, in Xi'an, only Metro Line 2 is completed, the length is only one tenth of the total length of all metro Planning, and it can only solve the convenient traffic problems on a trunk road. Since metro

Table 49.3 Significance of Factors Affecting

Affect	Commercial agglomeration degree	Public facilities	Internal support facilities	Distance from subway exit	Traffic conditions
Importance (%)	15.70	13.30	11.70	10.50	9.60
Affect (%)	Property level	Where the floor	Image of appearance	Decoration level	Property costs
Importance (%)	7.40	7.10	6.80	6.70	6.20

transport network has yet to be not formed, the synergy between the subway lines also cannot play, and powerful subway externalities are not adequately reflected. Competition between the subway lines will also have a negative effect for the rental of office premises, so the combined effect of these two aspects of comparative study has yet to be further after the completion of the subway network (Chen and Wu 2005).

49.4 Conclusion

Urban rail transit not only is able to respond to rapid economic development of urban traffic congestion, but also can improve the quality and attractiveness of urban areas. Based on BP neural network model for quantitative, the paper analyses the influence degree of the Xi'an Subway Line 2 on the rent of office buildings. Studies show that Xi'an Line 2 subway has a significant impact on the office buildings rent along, the importance weight is of 10.5 % and places the fourth out 11 office influencing factors. The construction of the Xi'an Subway Line 2 not only enhances the convenient transportation and the convenience of the people's work and life, also enhances the value of office buildings along it. However, as the Metro Line 2 is the only one metro line in Xi'an, and metro transport network has not yet formed, the value enhancement of the property brought by synergy effect among the subway lines cannot be fully manifested, On the other hand, the subway line of this article will lose the current the monopoly competitive strength due to the formation of the future metro network. Thus weakening the role of the subway line for the office rent promotion, Hence, the future research is very significant after the metro network completion (Ma and Yang 2010).

Acknowledgments Supported by the key discipline of Shaanxi Province and Supported by the featured discipline of philosophy and general social sciences of Shaanxi higher education institutions.

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Chapter 50
Urban–Rural Income Gap in China: Evolutionary Trend and Influencing Factors

Cun-gui Li

Abstract This paper is concerned with the evolutionary trend of Chinese urban–rural residents' income gap and find out its main influencing factors. Firstly, the current situation and historical evolutionary trend of urban–rural residents' income gap in China were analyzed. The results demonstrated that since the reform and opening up in 1978, the Chinese urban–rural income gap shows the phase change characteristics: reduced—expanded—again reduced—again expanded—flattened. Then, by using the data from 1978 to 2010, multiple linear regression models were established to identify the correlation between urban–rural income gap and its influencing factors. The study proves that the urban–rural dual structure, employment structure and urbanization have positive correlation with urban–rural income gap, and there is a negative correlation between rural financial development level and urban–rural income gap.

Keywords Evolutionary trend · Influencing factors · Multiple regression analysis · Urban–rural income gap

50.1 Introduction

For a long time, the development strategy of "industrial priority and urban bias" was implemented in China; with respect to industrial policy, stressed the priority of urban industrial; with respect to capital flows, the agricultural surplus was transferred from countryside to city through taxation, price scissors between industrial goods and agricultural products, financial institutions and so on; with respect to population migration, there were many obstacles and constraints for labors to migrate from countryside to city. Those urban–rural dual policies result

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E. Qi et al. (eds.), *The 19th International Conference on Industrial Engineering and Engineering Management*, DOI: 10.1007/978-3-642-38391-5_50,

in the urban–rural income gap is increasingly widening. In 2011, the per capita annual disposable income of Chinese urban households is 21 810 Yuan, and the Per Capita Annual Net Income of Rural Households is 6 977 Yuan. The ratio of urban income to rural income reaches to 3.13:1. Moreover, a lot of hidden incomes are not included in the income of urban households, such as housing subsidies medicate, medical insurance, unemployment insurance, old-age pension, guarantee a minimum income and other social welfare. If we took them into account, the urban–rural income gap would become much bigger (Li and Luo 2007).

Currently China has become one of the countries of largest urban–rural income gap all over the world. The enlarging urban–rural income gap will inevitably affect China's economic sustainable development. Levin (2001) holds that like many other developing countries, the urban-biased policies are the main reason of enlarging urban–rural income gap (Levin 2001). A study by Cai (2003) has shown that the urban–rural relationship in many developing countries is mandatory, namely, urban biased. The urban–rural income gap caused by urban biased policies is the common phenomenon in developing countries (Cai 2003). Hertel (2006) found that the household registration system, rural land contract system, and non-agricultural labor migration restrictions have significant impact on urban–rural income gap (Hertela and Zhai 2006). Lei and Cai (2012) draws a conclusion that the distortion of primary income distribution and urban-biased fiscal expenditure policy enlarge the urban–rural inequality significantly (Lei and Cai 2012). Chen and Peng (2012) thinks that the opportunity inequality caused by the household registration system is an important reason for the urban–rural income gap (Chen and Peng 2012). Zuo draws a conclusion that the main measures to narrow the urban–rural income gap is to speed up the process of urbanization (Zuo 2012).

Based on these literatures, using the time series from 1978 to 2010, this paper will built multiple regression models to test the relationship between urban–rural income gap and its influencing factors, such as urban–rural dual economic structure, urbanization, growth rate of GDP, employment structure, rural industrialization level, and rural financial development level. The purpose is to find out the key factors of influencing the urban–rural income gap and provide basis for decision making of reducing urban–rural dual economic system and forming a new pattern that integrates economic and social development in urban–rural areas. The arrangements of following parts of this paper are as follows: the second part will analyze the current status and historical evolutionary trend of urban–rural residents' income gap in China; the third part will make an empirical analysis on the influencing factors of urban–rural income gap; in the fourth part, the useful conclusions will be given.

50.2 The Evolutionary Trend of Urban–Rural Income Gap

According to Fig. 50.1, since 1978, although the growth rate of absolute urban–rural income, the ratio of urban residents' income to rural residents' income becomes bigger. From 1978 to 2011, the per capita disposable income of urban

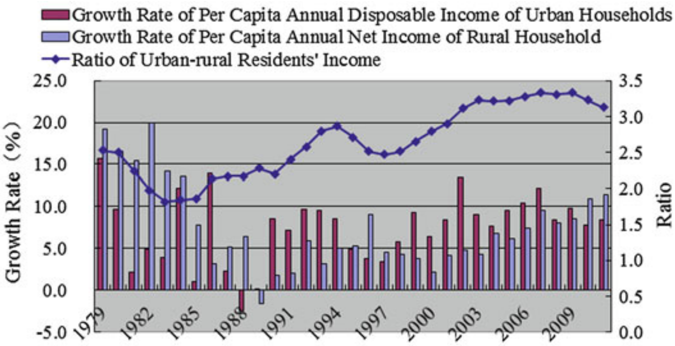

Fig. 50.1 The changing trend of urban–rural income growth rate and gap from 1978 to 2011 in China

households and the per capita net income of rural households have increased from 343.40 Yuan and 133.60 Yuan to 21 810 Yuan and 6 977 Yuan. The annual average growth rate is 13.40 and 12.73 % respectively. Because the urban residents' income grows faster than rural, the absolute urban–rural income gap is becoming wider.

As shown in Fig. 50.1, the urban–rural income gap shows obvious phase characteristics since the reform and opening up in China.

(1) The first phase (1978–1983), the urban–rural income gap shows the trend of fast reduction. The central task of this phase was rural economic system reform, and the rural household contract responsibility system was approved and promoted. The enthusiasm of the peasants for production was greatly motivated, the rural productive force was liberated and the agricultural labor productivity was raised by a big margin. On the contrary, the urban economic system reform was relatively backward. As a result, the growth rate of rural residents' income was higher than that of urban residents. From 1978 to 1983, the per-capita net income of rural households rose by 18.32 %, the per capita disposable income of urban residents by 10.46 %. The relative urban–rural income gap dropped from 2.57 in 1978 to 1.82 in 1983.
(2) The second phase (1984–1994), the urban–rural income gap shows the trend of fast expansion in general. At this phase, the focus of economic reform changed from countryside to city, result in a rapid growth of the urban economy. Over the same period, the incentive effects of the rural household contract responsibility system on the agriculture was diminishing, the agricultural labor force increased gradually, and the price of agricultural means of production increased substantially, therefore, the rural economic growth slowed down. From 1984 to 1994, the average annual growth rate of the urban per capita disposable income and rural per-capita net income was 18.30 and 13.14 % respectively. The relative urban–rural income gap increased from 1.83 in 1984 to 2.86 in 1994.

(3) The third phase (1995–1997), the urban–rural income gap shows a diminishing trend once again. At this phase, the purchasing price of agricultural and sideline products was raised considerably; the rural township enterprises developed rapidly, so the income from wages and salaries of rural households increased by a large margin. During the same period, the government implemented tight macro-control policies, leading to a slow down of urban economic development and a soft landing for the economy. From 1995 to 1997, the average annual growth rate of the urban per capita disposable income was 13.86 % and the average annual growth of rural per-capita net income was 19.62 %. The growth rate of income of urban residents urban was much lower than the growth rate of rural residents' income. The relative urban–rural income gap dropped from 2.71 in 1995 to 2.47 in 1997.
(4) The fourth phase (1998–2003), the urban–rural income gap shows the trend of expansion once again. At this phase, there commonly appeared the following situations, such as it was difficult for peasants to sell food, the output increased, but income did not increase. The pace of development of rural township enterprises slowed down, its ability to absorb rural surplus labor force weakened gradually and its contribution to increase farmers' income decreased obviously. In addition, the urban-oriented policies and institutional arrangements with the household registration system at its core have great constraints for the rural surplus labor to migrate to non-agricultural industries of rural areas or urban areas. Household registration system and urban employment system have become the primary restricting bottleneck of increasing income of peasants. From 1998 to 2003, the average annual growth rate of the urban per capita disposable income was 9.32 % and the average annual growth of rural per capita net income was only 3.94 %, less than half of urban. The relative urban–rural income gap increased from 2.51 in 1998 to 3.23 in 2003.
(5) The fifth phase (2004-present), the urban–rural income gap tend to become flattened. From 2004 to 2012, nine No. 1 central documents were issued by central committee of the CPC to solve the three dimensional rural issues. A series of policy measures to support and benefit agriculture, rural areas and farmers were implemented, such as agricultural tax, livestock tax and taxes on special agricultural products were rescinded throughout the countryside; increase financial support for agriculture; carry out the subsidy policies of direct subsidies to grain peasants, fine breed allowance and Farm machinery purchase subsidy; implement the strategy of balancing urban and rural economic and social development. Both the urban and rural income has a relatively high growth. From 2004 to 2011, the average annual growth rate of the urban per capita disposable income was 12.74 % and the average annual growth of rural per-capita net income was 13.16 %. The relative urban–rural income gap is reduced from 3.21 in 1998 to 3.13 in 2011.

50.3 Empirical Analysis

50.3.1 Selection of Variables

This paper takes the urban–rural income gap (Y) as the explained variable (dependent variable), which is measured by the ratio of the urban residents' incomes to rural residents' incomes. Urban–rural income gap = disposable income of urban residents/per capita net income of rural residents. The bigger it is, the larger urban–rural income gap will be.

It is unnecessary to consider all factors effected urban–rural income gap. According to the significance of the influence and availability of the data, this paper mainly considers the following independent variables.

(1) The coefficient of urban–rural dual structure (X_1). Lewis (1954) proposed the essay "economic development model with unlimited supplies of labor". This essay assumed that an unlimited supply of labor was available in traditional agricultural sector and the marginal labor productivity is negligible, zero, or even negative, much lower than urban labor productivity generally. Accompanied by the transfer of labor, the dual economic structure will eliminate (Lewis 1954). The coefficient of urban–rural dual structure (X_1) = (the secondary and tertiary industries output/the secondary and tertiary industries labor force)/(the primary industry output/the primary industrial labor force).

(2) The urbanization level (X_2). In theory, with the improvement of the urbanization level, the urban–rural income gap will decrease. On the one hand, the aggregation effect of cities can absorb a lot of rural labors, which will result in the improvement of agricultural productivity and increase of farmers' income (Lu and Chen 2004). On the other hand, the cities have a strong radiation and driving function to rural economy. The city can promote rural economic development by means of technology transfer, industries transfer, capital output, information dissemination and so on. China's current urbanization is incomplete, which lead to agricultural scale management cannot realize and rural migrant workers in cities cannot live in cities permanently (Ma 2008). Meanwhile, among rural residents, only those who possess higher human capital or have certain skills can easily migrate to cities; those who stay in countryside are usually low education, lack of necessary skills, elder and female persons. These people are also known as "386199 troops, 38 refer to women, and 61 refer to the child, 99 refer to the elderly. The massive spillover of human capital in rural areas of China may account for widening urban–rural income gap.

(3) Growth rate of per capita GDP (X_3). Kuznets (1995) proposed the "inverted U" hypothesis to explain the income distribution gap changes with the process of economic development in industrial countries. Kuznets inversed U curve indicates that at the beginning of the process of economic development, especially in the national per capita income increased from the lowest to the

middle level, the income gap will increase along with the growth of per capita GDP; when the economic development reaches to a certain stage, the income gap will gradually reduce with further growth of per capita GDP (Kuznets 1995).

(4) Employment structure (X_4). In theory, with the labors migrating from the primary industry to the secondary and tertiary industries, the urban–rural income gap will decrease. On the one hand, the transfer of the primary industrial labor is helpful to realize agricultural large-scale management and improve the agricultural labor productivity. On the other hand, non-agricultural employment will improve rural residents' wage income, which would reduce the urban–rural income gap. But, since the reform and opening up in 1978, the restrictions on rural labor mobility were loosen gradually, but the urban-biased welfare systems still exist. When rural labors find a job in cities, they will subject to discriminatory treatment in the aspect of industry access, wages, rights and interests maintenance, and so on. The employment structure (X_4) = non-agricultural industries employed persons/total employed persons.

(5) Rural industrialization level (X_5). The development of rural industrialization not only can absorb a lot of rural labors, but also can promote the process of rural modernization. When more and more rural persons left land, the farmers will possess more resources. Thus, the appropriate large-scale management of agriculture will achieve (Hou 2005). Rural industrialization level (X_5) = rural non-agricultural industries employed persons/rural total employed persons.

(6) Rural financial development level (X_6). The production theory of economics shows that the increase of capital will result in the growth of output. The development of rural financial can increase rural capital stock, and then lead to the growth of agricultural output and improvement of farmers' income. The Rural financial development level (X_6) = rural loans/the out of primary industry (Liu and Hu 2010).

50.3.2 Model Building

Multiple linear regression models are often used as empirical models when more than one independent variable is involved, which can approximate the true unknown functional relationship between the dependent variable and independent variables (Pao 2008).

Based on the statistical data from 1978 to 2010 (Table 50.1), the multiple regression model is built to test the relationship between urban–rural income gap and its influencing factors.

$$Y = \beta_0 + \sum_{j=1}^{6} \beta_j \cdot X_j + \varepsilon \qquad (50.1)$$

Table 50.1 The statistical data of urban–rural income gap and its influencing factors in china (1978–2010)

Years	Y	X_1	X_2 (%)	X_3 (%)	X_4 (%)	X_5 (%)	X_6 (%)
1978	2.57	6.10	17.92	10.19	29.48	7.57	15.17
1979	2.42	5.08	18.96	6.15	30.20	7.71	14.14
1980	2.50	5.09	19.39	6.50	31.25	8.52	18.20
1981	2.20	4.56	20.16	3.90	31.90	8.86	18.02
1982	1.95	4.26	21.13	7.46	31.87	8.88	18.17
1983	1.82	4.10	21.62	9.26	32.92	10.20	19.14
1984	1.83	3.76	23.01	13.67	35.95	14.18	29.85
1985	1.86	4.18	23.71	11.93	37.58	16.01	30.53
1986	2.12	4.19	24.52	7.24	39.05	17.73	39.30
1987	2.17	4.09	25.32	9.81	40.01	18.81	43.91
1988	2.17	4.22	25.81	9.50	40.65	19.51	43.67
1989	2.29	4.48	26.21	2.48	39.95	18.84	45.83
1990	2.20	4.05	26.41	2.33	39.90	18.43	47.66
1991	2.40	4.56	26.94	7.70	40.30	18.59	55.71
1992	2.58	5.06	27.46	12.85	41.50	19.86	65.94
1993	2.80	5.27	27.99	12.66	43.60	22.38	69.49
1994	2.86	4.79	28.51	11.81	45.70	24.95	48.52
1995	2.71	4.38	29.04	9.73	47.80	27.53	24.88
1996	2.51	4.16	30.48	8.86	49.50	28.98	50.82
1997	2.47	4.45	31.91	8.18	50.10	28.95	57.82
1998	2.51	4.66	33.35	6.80	50.20	28.24	67.65
1999	2.65	5.09	34.78	6.69	49.90	26.98	74.16
2000	2.79	5.64	36.22	7.58	50.00	26.34	73.28
2001	2.90	5.95	37.66	7.52	50.00	25.22	76.83
2002	3.11	6.28	39.09	8.35	50.00	23.86	82.83
2003	3.23	6.57	40.53	9.34	50.90	23.79	92.47
2004	3.21	5.71	41.76	9.43	53.10	25.85	83.65
2005	3.22	5.88	42.99	10.66	55.20	27.71	86.67
2006	3.28	5.94	44.34	12.05	57.40	29.57	80.82
2007	3.33	5.71	45.89	13.57	59.20	30.74	78.74
2008	3.31	5.45	46.99	9.07	60.40	31.15	74.43
2009	3.33	5.34	48.34	8.67	61.90	32.03	87.01
2010	3.23	5.16	49.95	9.91	63.30	32.56	85.74

Data resources: China statistical yearbook, almanac of China's finance and banking, China township enterprise yearbook and China compendium of statistics 1949–2004

In above formula (50.1), ε is random error term, β_0 is a constant term, $\beta_j\ (j = 1, 2, \ldots, 6)$ is the partial regression coefficient, which represents the variation of the predicted score when the corresponding independent variable X_i varies 1 unit. They are estimated by $\widehat{\beta}_j\ (j = 1, 2, \ldots, 6)$ separately.

50.3.3 Multicollinearity Diagnosis

Variance inflation factor (VIF) is estimated for each independent variable to identify causes of multicollinearity. When VIF_j is more than ten, it reveals that the j-th independent variable is highly correlated with other independent variables of the model.

Using SPSS (19.0) and selecting the enter method in regression analysis, the result is shown in Table 50.2. The result of equation fitting showed that the sample multiple correlation coefficient $R = 0.973$, its value gives the proportion of the variance of the dependent variable that can be predicted from the independent variables. The determination coefficient $R^2 = 0.947$, F-statistics = 76.825, significant $P \approx 0.000$, indicating that the strength of the straight-line relationship is high. But, as is seen from Table 50.2, some regression coefficients cannot pass the *t*-Test of significance, such as X_3 and X_6. Meanwhile, the variance inflation factors (VIF) of X_2, X_4 and X_5 are much larger than 10, showing that there is multicollinearity in the model.

50.3.4 Result of Stepwise Regression Analysis

In econometrics, there are many methods for overcoming multicollinearity problem, such as to expand sample size, to transform model form, stepwise regression, ridge regression, principal component regression and so on. In this paper, the stepwise regression is adopted to overcome multicollinearity problem. According to Table 50.3, the following two multiple-linear regression models were obtained for the relationship between the urban–rural income gap and the above mentioned influencing factors using the statistical data of the Table 50.1.

Model (1):

$$\widehat{Y} = 0.194 + 0.300X_1 + 0.030X_2 \tag{50.2}$$

Table 50.2 Regression analysis result using with the method of enter-coefficients [a]

Model	Unstandardized coefficients		Standardized coefficients	t	Sig.	Collinearity statistics	
	B	Std. Error	Beta			Tolerance	VIF
(Constant)	−2.849	0.910		−3.132	0.004		
(X_1)	0.413	0.045	0.654	9.212	0.000	0.407	2.457
(X_2)	−0.102	0.042	−2.007	−2.398	0.024	0.003	341.301
(X_3)	−0.006	0.008	−0.033	−0.675	0.506	0.872	1.147
(X_4)	0.189	0.065	3.832	2.918	0.007	0.001	839.643
(X_5)	−0.089	0.040	−1.444	−2.225	0.035	0.005	205.142
(X_6)	0.001	0.003	0.041	0.244	0.809	0.072	13.893

[a] Dependent variable: Urban–rural Income gap (Y)

Table 50.3 Regression analysis result using with the method of stepwise-coefficients [a]

Model		Unstandardized coefficients		Standardized coefficients	t	Sig.	Collinearity statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	0.194	0.185		1.046	0.304		
	(X_2)	0.030	0.004	0.587	8.181	0.000	0.652	1.533
	(X_1)	0.300	0.045	0.475	6.618	0.000	0.652	1.533
2	(Constant)	−0.756	0.233		−3.252	0.003		
	(X_1)	0.392	0.039	0.620	10.025	0.000	0.588	1.700
	(X_4)	0.037	0.005	0.759	7.350	0.000	0.211	4.735
	(X_6)	−0.005	0.002	−0.254	−2.183	0.037	0.167	5.989

[a] Dependent variable: Urban–rural Income gap (Y)

$R^2 = 0.899$, $R = 0.948$, F-statistics = 133.824, significant $P \approx 0.000$, the model can pass the F-test, indicating that there were significant correlations between dependent variable and all independent variables.

Model (2) :

$$\widehat{Y} = -0.756 + 0.392X_1 + 0.037X_4 - 0.005X_6 \tag{50.3}$$

$R^2 = 0.935$, $R = 0.967$, F-statistics = 138.327, significant $P \approx 0.000$, the model can pass the F-test, indicating that there were significant correlations between dependent variable and all independent variables.

According to Table 50.3, all the regression coefficients of model (1) and model (2) can pass the *t*-Test of significance and the estimated VIF coefficients of all variables are less than 10, indicating that the multicollinearity problem have been overcoming and the above two models are effective, which can be used to approximate the true functional relationship between the urban–rural income gap and its influencing factors.

50.4 Conclusion

Since the reform and opening up in 1978, the urban–rural income gap in China shows the phase change characteristics of reduced—expanded— again reduced—again expanded—flattened, and each change has a great relationship with the affection of policy changes.

According to empirical analysis, the relationship between urban to rural income gap and its key influencing factors is as follows.

(1) There is a positive correlation between the urban–rural dual structure and urban–rural income gap. According to the model (1) and model (2), the partial regression coefficients of X_1 are both positive and maximum, proving that the urban–rural dual structure is the most key factor that leads to the expansion of

urban–rural income gap. Therefore, changing the dual economic structure should be the first choice to narrow the urban–rural income gap.

(2) There is a positive correlation between urbanization and urban–rural income gap. As shown in the model (1), the partial regression coefficient of X_2 is 0.030, indicating that when the urbanization level increases by one unit, the urban–rural income gap will increase by 0.030 units averagely, assuming that all other factors remain unchanged. China's urbanization process has not reduced the urban–rural income gap, but led to the urban–rural income gap expand unceasingly. The fundamental reason is that the patterns of urbanization is inappropriate and the process of urbanization is slow, rather than urbanization itself. In the process of urbanization restricted by kinds of discriminatory policy constraints, it maybe leads to the outflow of human capital and physical capital in rural areas, and then the urban–rural income gap would expand.

(3) There is a positive correlation between employment structure and urban–rural income gap. As shown in the model (2), the partial regression coefficient of X_4 is 0.037, indicating that the urban–rural income gap will increase by 0.037 unit in average when the ratio of non-agricultural industries employed persons to total employed persons increases by one unit, assuming that all other factors remain unchanged. It was suggested that under the influence of institutional barriers that represented by the household registration system, the mobility of labor hasn't the effect of narrowing the urban–rural income gap (Murata 2002).

(4) There is a negative correlation between rural financial development level and urban–rural income gap. According to the model (2), the partial regression coefficient of X_6 is -0.005, indicating that the urban–rural income gap will decrease by 0.005 unit in average, when the rural financial development level increases by one unit, assuming that all other factors remain unchanged. The development of rural financial plays an important role to reduce the urban–rural income disparity.

Acknowledgments The work was supported by the tender subject of Henan government decision-making research (No. 2012B239) and the investigation subject of Henan federation of humanities and social sciences and Henan federation of economic organizations (No. SKL-2012-3318).

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Chapter 51
Sensitivity Analysis on Optimized Sampling for Sealing Performance of GVTP

Long Yu, Shu-rong Yu and Wen-li Yang

Abstract According to the method of sensitivity analysis, responding factors of sealing performance on gate valve of thermal power (GVTP) are simplified. The relationship of sensitivity and displacement of sealing surface is expressed by mathematical equation. From 41 design parameters, it chooses 10 major global parameters to compare the degree of sensitivity and get the highest sensitivity parameters. The quantity of counting is reduced and the times of iteration are shortened obviously. Using the Monte-Carlo method, sampling points are reduced by 35 % and the maximum total deformation is reduced by 21 %. By using of optimized, the sealing performance of the GVTP is improved, the leaking on the sealing surface is restrained completely. The result of sensitivity analysis can provided reference in the optimized process in power system with high parameter.

Keywords Displacement · Sensitivity analysis · Sampling · Optimization · Monte-Carlo method

51.1 Introduction

Gate valve of thermal power (GVTP) is used to nuclear power and thermal power station which work in high pressure and temperature. The technological parameters still increase continuously for improving thermal efficiency. According to the

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E. Qi et al. (eds.), *The 19th International Conference on Industrial Engineering and Engineering Management*, DOI: 10.1007/978-3-642-38391-5_51,

forecast provided by British Ministry of Industry and Trade (BMIT),The initial parameters of steam of ultra-supercritical power unit have higher temperature and pressure which are 40 MPa and 700 °C, and the thermal efficiency will reach to 50–55 % in the future 5 years. So the performance of the GVTP must be enhanced to fit the higher parameters of ultra-supercritical power station.

The plants of nuclear power and thermal power are composed by four major units witch are constituted by boiler, turbine, pump and heat exchanger. Steam generator provides superheated steam to driving turbine and outputting kinetic energy. The turbine drives generator to producing power and making kinetic energy turn to electric energy. The GVTP can lead the steam to heat exchanger for protecting the turbine. The mechanics performance of the bypass valve is importance for the safety in total power system. The GVTP has the role of controlling the steam in front of turbine, because the pressure may be abrupt changed and the temperature is lower than necessary. The sealing performance of the GVTP is importance to the safety in total power system.

There have some results on the related valves, Nagaki Alegre et al. (2007), Chen and Li (2007), studied on low cyclic fatigue failure for the steam valve in high pressure. Zhu and Lei (2011), Wang et al. (2010), presented that the effect of lower parameters valve be optimized relationship in its internal structure and flow characteristics. Lu (2007), pointed out the views that the ultra-supercritical valve has the relationships between mathematical models with operating parameters. Zhu and Chuan (2010), Xiang et al. (2006), Tao and Cai (2009), presented the method of three dimensional numerical simulation on flow field for ultra-supercritical valve. Yu and Yu (2007), studied on the sensitivity analysis for structure parameters on valve in normal temperature. But there are rarely related documents discussed the method of optimizing sealing performance for the GVTP.

The paper discussed the optimized method of enhancing sealing performance for the GVTP. It chooses design variables from global parameters of the GVTP, and appoints target function which is displacement distribution on sealing surface counted by the FEM. It gets the optimal solutions through the sampling method of Monte Carlo. The relationship of sensitivity response between global parameters and displacement is counted. The sealing properties of the GVTP are improved obviously by revising higher sensitivity parameters.

51.2 Mathematical Model

The global parameters of sealing performance of the GVTP are design variables and the quantity is so numerous that is hard to optimize through general counting. The sensitivity analysis is the method that judges the responsible degree of the target function following with the disturbance of design variable. The optimized target function can be chosen from the result of the FEM. For enhance the sealing performance, the total deformation on the sealing surface of the GVTP is regarded as target function to optimize, and convergence direction is approaching minimum displacement. The Monte-Carlo method can decrease the quantity of sampling obviously and enhance the accuracy of counting, and it plays the importance role in the optimized process.

(1) *Sensitivity analysis*: Sensitivity analysis is a method which optimized the responsive relationships between design variations and objective functions. Sensitivity analysis is used to optimize design for searching the relationships and the impact degrees of input parameters on different simulation outputs. It can be applied in the study of sealing performance for the valve working in thermal power station.

The testing model of sensitivity analysis imposes the variance-based technique. The model can be shown in the form of $Y = f(x_1, x_2, \ldots, x_n)$, where $x_1, x_2, \ldots, x_n$ are imported design variations and Y is the exported parameter as objective function.

The total variance is presented as follows (Saltelli et al. 2009; Chan et al. 2000):

$$V(Y) = \sum_{i=1}^{k} V_i + \sum_{1 \le i < j \le n} V_{ij} + \ldots + V_{1,2,\cdots,n} \tag{51.1}$$

where $V(Y)$ is the total variance of exported variable Y. V_i is the main response of x_i, and the other parameters are analyzed the response degree of interaction.

The sensitivity indices can be computed using a Monte Carlo method (Homma and Saltelli 1996). The principle is to generate randomly samples of parameters within their permissible ranges and to estimate $V(Y)$, V_i and V_{-i} as follows (Fesanghary 2009):

(A) Assumed the base sample dimension N.
(B) Point dimension $N \times k$ to two sampling matrices M_1 and M_2 and N.
(C) Define a matrix N_i formed by all columns of M_2, except the ith column which is taken from M_1, and a matrix N_{Ti} complementary to N_i, formed with the ith column of M1 and with all the remaining columns of M_2.
(D) Compute the model output for all the input values in the sample matrices M_1, and, obtaining three column vectors of model outputs of dimension N_{-1}:
(E) The sensitivity indices are computed based on scalar products of the above defined vectors of model outputs.

$$V_i = \frac{1}{N} \sum_{j=1}^{N} Y^{(j)} Y'^{(j)} - f_0^2 \tag{51.2}$$

$$V_{-i} = \frac{1}{N} \sum_{j=1}^{N} Y^{(j)} Y_T'^{(j)} - f_0^2 \tag{51.3}$$

And finally

$$S_i = \frac{V_i}{V(Y)} \tag{51.4}$$

$$S_n = 1 - \frac{V_{-i}}{V(Y)} \tag{51.5}$$

where S_i is the first-order sensitivity of the *i*th parameter. V_i is the sum of all the variance parameter except *i*. *f* is the function of *Y* as variable. *N* is the times of iteration. Using the displacement parameters *S* as the object function, and the sensitivity response can be obtained to optimize the global parameters of the valve for improving sealing performance.

(2) *Sampling of the Monte-Carlo method*: The basic theory of the Monte-Carlo method is loose the iteration times by finite samplings. While the probability distribution of the state variable x_i $(i = 1,2,\ldots,n)$ is known and independent, it generates the random count for x_i fitting its probability distribution according to the limit condition $Z = g(x_1,x_2, \ldots,x_n)$. The series $x_i(i)$ is put into the state function $Z = g(x_i)$ and can be present as independent series $Z(i)$ by iteration. Assuming the quantity *M* of state function as safety coefficient if $Z(i) < 1$, and security reserve if $Z(i) < 0$, while the times of simulation are enough, the frequency *M/N* is close to probability by the law of Theorem, and the damage probability can be presented as $P_f = P\{Z\text{-}g(X_1,X_2,\ldots,X_n)\}$. The Monte-Carlo method can accurate fitting the distribute function of probability $G(Z)$ for *Z*, and counts the mean value u_z and normalized value σ_z.

The program structure of the Monte-Carlo method is simple and bears no relation to the computational efficiency and dimensionality of the problems to be studied, lots of samples are needed to get precise results (Zhang et al. 2010). This method can speed up the process for searching the design point, which is then used as the sampling center and importance sampling is conducted. Monte-Carlo method is further employed to obtain the failure probability (Su et al. 2009).

Using the importance sampling Monte-Carlo method can choose the core of the sampling and reduce the sampling quantity of the non-core. The accuracy of counting is improved and the time of simulation is deceased by the method. The Monte-Carlo method has the function as follows:

$$N \geq \frac{100}{\int_\Omega I[G(x)] \frac{f_X(x)}{h_X(x)} h_X(x) dx} \tag{51.6}$$

$$I[G(x)] = \begin{cases} 1 & , \quad G(x) < 0 \\ 0 & , \quad G(x) > 0 \end{cases} \tag{51.7}$$

where Ω is the define region of $X, I[G(x)]$ is the indicative function, x is the basic random vector, and $X = [X_1, X_2, \ldots, X_n]$, $f_X(x)$ is the probability density function, $h_X(x)$ is the importance sampling density function.

51.3 Simulation and Result

The material of the GVTP is forgeable and creep resistant, and the material is ASTM A335 F92 according to Case 2179-6. There have not perfect materials to be applied to thermal cycle system more than 600 °C in internet so far, and the material using in the temperature is on studying and testing period. ASTM A335 F92, P112 and E911 are used to valve of ultra-supercritical power unit widely and F92 has better forging property and stability in higher temperature than former materials, and it have less thermal coefficient of expansion and more thermal conductivity coefficient which can reduce thermal stress on inside and outside wall. These materials have better creep strength in high temperature fitting thermal stress requirement caused by thermal expansion than other alloy steels, and the creep strength working high temperature and 105 h can attain to 90–100 MPa. The applied range of ASTM A335 F92 is wider than P112 and E911 in internet and it is applied materials of the GVTP in this paper.

Sensitive analysis can get the solution directly by the FEM (Kahraman 2009; Lin 1999), and use the Monte-Carlo method to reduce the quantity of sampling points (Melchers and Ahammed 2004; Ahammed and Melcher 2006). The performance of F92 is attained to physical parameters for counting of the FEM. The operating station is 33.1 MPa and 560 °C, the medium is superheat steam flowing 12.3 m/s. The initial conditions are defined to the FEM for getting the distribution of total deformation on the sealing surface of the GVTP. The performance of A335 F92 can be seen in Table 51.1.

The methods of structural optimization are control deformation mostly, and the processes are making minimization of deformation with increasing the quality of the structure (Wang et al. 2009; Pettit and Wang 2000). The displacement on sealing surface of the GVTP can be seen as the deformation and defined as objective function. Constraint condition is certain control domains for solving the

Table 51.1 Performance of ASTM A335 F92

Parameters	Value
Temperature T [°C]	610
Allowable stress [σ] [MPa]	68.0
Tensile strength σ_b [MPa]	620
Yield strength σ_s [MPa]	440
Coefficient of thermal conductivity λ[W/(m·K)]	45.5
Specific heat capacity c_p[J/(kg·K)]	460
Density ρ[kg/m^3]	7820

Table 51.2 Performance of design variables

Lab	Range [mm]	Distribution	Approximation direction
P1	142 ← 160 → 175	N	I
P2	130 ← 150 → 176	R	D
P3	247 ← 260 → 278	N	I
P4	328 ← 340 → 369	A	R
P5	187 ← 250 → 240	N	D
P6	260 ← 270 → 280	R	D
P7	20 ← 25 → 30	A	I
P8	30 ← 60 → 90	N	R
P9	75 ← 90 → 115	A	I
P10	95 ← 115 → 130	N	R

extreme value of target function. The improper constraint condition can leads to lengthy solving process if the range is oversize, or makes more errors if the range is undersize. The constraint condition of design variable is listed in Table 51.2. There are 10 parameters been distributes as Pi ($i = 1,2,\ldots,10$), and value range is marked in the bracket. The distribution of sampling has three patterns, N means normal distribution, A means average distribution and R means random distribution. The approximation direction of iteration has three patterns, I means increment direction, D means decrement direction and R means random direction.

51.4 Simulation and Result

The minimum total deformation is defines as target function for optimized. By the Monte Carlo method, the sampling points choosing in global parameters decrease from 240 to 156 and iterating times is reduced from 1032 to 697. The efficiency and accuracy of counting is improved obviously. The sensitive relationship of structure parameters can be expressed by bar chart directly, respond degree of sensitivity can be contrasted by the length of structure parameters, the larger length mean it have more affecting degree to objective function and the shorter length mean the sensitive degree is lower than others. Positive value of sensitive response means sensitive degree of objective function increases follow with the value increasing of structure parameter, and negative value means sensitive degree increases follow with the value reducing. The sensitive relationship of structure parameters can be seen from Fig. 51.1.

In Fig. 51.1, there have 10 series global parameters be chosen to sensitivity analysis. Absolute values of sensitive distribute from 0.73 to 0.04, and composed by 3 negative values and 7 positive values. The responsive relationship of sensitive analysis can be seen that P1 is the most sensitive parameter for the displacement on sealing surface and its value of sensitivity is −0.87, its means that the total deformation should increases with reduces of P1. The sensitivities of P5 and P3 are

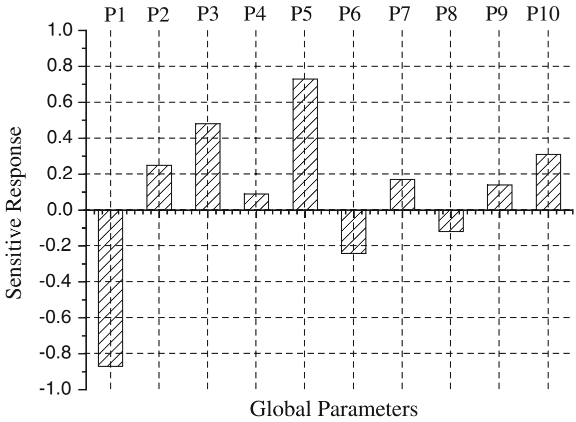

Fig. 51.1 Sensitive relationship of structure parameters

0.73 and 0.48 that are less than P1. The sensitivity of P4 is 0.04 that is the minimum value than the others and it means the P4 can be neglected in optimized process. To modify more sensitivity parameters in the process of design and total deformation can be improved obviously, and this project should be used at design firstly.

In Fig. 51.2, the responsive figure is three-dimensional space range that is constituted by P1, P5 and maximum total deformation on sealing surface of the GVTP. It is shown that maximum total deformation is greater following with the increase of P1 and P5. The maximum equivalent stress is minimum value while P1 is 164.5 mm and P5 is 211.4 mm, and its value is 7.7×10^{-2}mm less than 10×10^{-2} mm that is the maximum deformation of allowable sealing, and maximum total deformation is reduced by 21 %, so the series parameters should be taken into account in design process. The design parameters can interfere each other and lead to counting error, so the change arrange of design parameters should

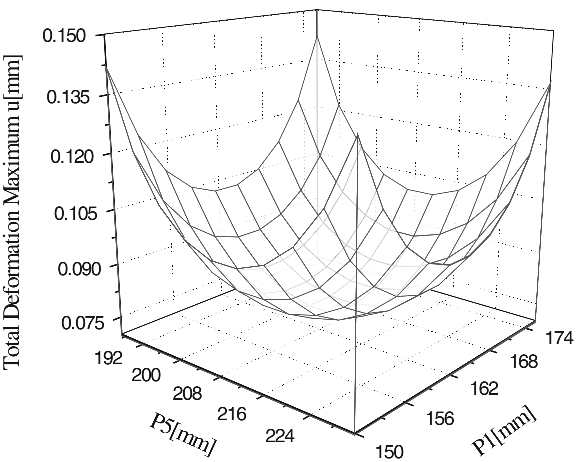

Fig. 51.2 Optimized result of total deformation and parameters

no more than 15 %. It has not extreme values in the optimizing process at some times and the choosing method of noninferior solution on multiobjective optimization is important.

51.5 Conclusion

The sealing performance of the GVTP is hard to amend for concerning with a large number of global and operation parameters. By the sensitivity analysis, the number of the parameters is decreased to 10, and the displacement on the surface of the GVTP is affected directly by these major parameters for deciding with sensitivity analysis. It is shown that P1,P3 and P5 are the higher sensitivity than others, and correcting the parameters can enhance the sealing performance. The number of sampling is decreased by 35 % and maximum total deformation is reduced by 21 %.

As usually, the way of improving sealing performance of the GVTP is strengthen the local place out of leaking point. By using the sensitivity analysis, there has higher pertinence in the process of optimized, the quantity of design variable is reduced obviously. Improving the global parameters of higher sensitivity which leads to leaking, the sealing performance of the GVTP is optimized and the safe degree of power system is ensured.

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Chapter 52
Study on Application of Logistic Curve Fitting and Forecast from Inbound Tourist Market

Wei-qi Tan

Abstract The rising of logistic curve basically coincides with the development and growth of the tourist market. It has great advantages in improving forecast precision to use the logistic growth curve to fit the developing trend of the tourist market and to make forecast. The calculation method of K value is proposed in the paper according to the characteristics of curve symmetry. Based on this, a and r parameter values can be calculated and the logistic curve model of China's inbound market can be fitted by using the method of general curve regression. By the test of χ^2, fitting logistic curve regression meets the requirements. So logistic curve regression can be used as a general method for forecasting the tourist market.

Keywords Advantage · Characteristics · Fitting · Logistic curve · Parameter

52.1 Introduction

In the recent 30 years, tourist industry is treated as pillar industry of national economy development in our country. We hope to increase the economy and promote the proportion of the third industry with the development of tourism so as to optimize the industrial structure. However, tourism economy has significant volatility with the influences of natural factors, worldwide social economic factors, and so on. The volatility of the growth in tourism economy makes tourism investment a high risk one. So it's an important means of reducing the risk of tourism investment to improve the prediction quality of the tourist market. The quantitative forecast method mainly uses historical data to build a quantitative model and then use the model to forecast the development and clinic, psychology

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E. Qi et al. (eds.), *The 19th International Conference on Industrial Engineering and Engineering Management*, DOI: 10.1007/978-3-642-38391-5_52,

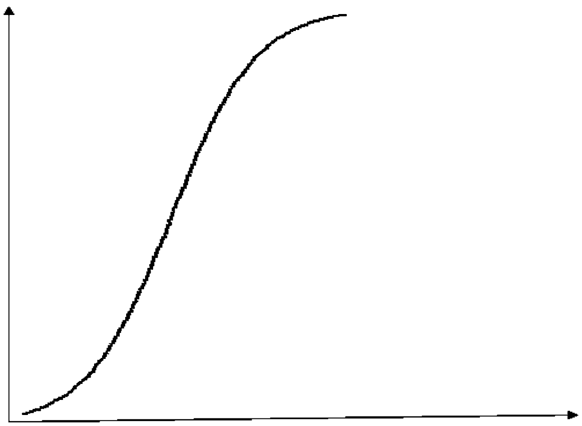

Fig. 52.1 A logistic vurve

and marketing (Huang et al. 2009). With the influences and restrictions from the growth rate, environmental restrictions and time, the logistic growth curve begins to slow down. Once it reaches the critical point, it grows rapidly but never indefinitely. When it gets saturated, the growth speed slows down because of intense competition for resources. The growth curve is slightly elongated as an "S" which is shown in Fig. 52.1: changes in future. Based on time series, there are various of quantitative methods that can be used to predict. According to mathematical principles, there are two kinds: autoregressive conditional heteroskedasticity model and stochastic volatility model. But the two methods are naturally limited in predicting tourist market with greater volatility. This paper is going to introduce the fitting and forecast of the logistic curve to tourist market in order to improve the quality of the forecast (Wand et al. 2009).

52.2 Research Background

52.2.1 The Application and Research of Logistic Curve Equations

Logistic curves are derived from the study process of population growth. They have been widely used in the field of natural science and social science. The curve equations can be shown as follows:

$$y = \frac{k}{1 + ae^{-rt}} \qquad k > 0, a \in R, r > 0 \tag{52.1}$$

Among the letters, k represents the environment or resource limitation, a is an undetermined constant, r for growth and t for time. It has revealed the law of changes in growth rate, environmental restrictions and time. The similar relationship between them widely exists in natural science and social science. The curve has been widely used in the field of natural science and social science. Nowadays, the logistic regression is a commonly used analysis and forecast method in social science.

52.2.2 The Application of Logistic Curve Equations for Tourism Industry

The logistic curve model is applied to fit and forecast the population growth, economic development and life cycle of tourism areas, which has significant effects (see Hu 2011; Huang et al. 2011; Li 1993; Yang 2008, 2009).

Based on the study of logistic curve equations, a Canadian scholar Butler combined them with changes of tourist destinations and put forward the theory of life cycle of destination in 1980. He divided the tourist destinations into 5 different growth stages: the exploration stage, the involvement stage, the development stage, the consolidation stage and the stagnation stage. From then on, many scholars did researches on the theory of life cycle of destination. Although there are different views on it, scholars all agreed that the law of life cycle exists in developing tourism products and tourist areas. This law is of important theoretical and practical significance in forecasting the tourist market. Due to our growth tourist market, the trend of tourist market development increases sharply when we use regression analysis method to forecast, which cannot reflect the medium-term and long-term trend of the development in the tourist market. Logistic curve equations are established on the basis of the trend in growth forecast, so they can overcome the defects and are of great significance to the prediction of the tourist market (Zhang and Xue 2009).

52.3 Characteristics and Advantages of Logistic curves

There are exponential function curves, logarithm function curves, power function curves, hyperbolic function curves, sigmoid curves, and so on. They can be used to fit curves, analyze and predict according to the scatter plots. Scholars have conducted extensive research on the logistic curve fitting. Several methods are used to determine the parameters : the search method, the Gauss–Newton method, the improved Gauss–Newton–Marquit method, and so on. Since the coupling problem between the parameters cannot be solved in the process of solving the problems which need alternate iterations, the selection of initial iteration value is always the key point of being successful during the solving process (Huang et al. 2011). The determination of parameters of the logistic curve equation is closely connected with the characteristics of the curve. We need to conduct research on the characteristics of logistic curve equations to find more scientific and reasonable methods for parameter estimation. Besides the logistic curve shown in Eq. (52.1), there is another curve equation (52.2):

$$y = \frac{k}{1 + e^{a-rt}} \qquad k > 0, a \in R, r > 0 \tag{52.2}$$

Among the letters, k represents saturated level and r for growth factor. The e^a in formula (52.2) can be regard as a in formula (52.1). In this way, (52.1) and (52.2) are coincident in essence. This article uses the curve shown in formula (52.1).

52.3.1 Characteristics of the Logistic Curve

1. Asymptotic lines

$$\lim_{t\to-\infty} \frac{k}{1 + ae^{-rt}} = 0, \ \lim_{t\to+\infty} \frac{k}{1 + ae^{-rt}} = k,$$

We can see from (Jin 2010) that the logistic curve has two asymptotic lines: y = 0 and y = k

2. Monotonicity
   The speed function from the growth process of the logistic curve can be formed by working out the first-order derivative of the logistic curve.
   Since $y' = \frac{kare^{-rt}}{(1+ae^{-rt})^2} > 0$, the logistic curve is monotonically increasing.
3. Three key points
   If we want to work out the second-order derivative of the logistic curve, we can have $y'' = \frac{kare^{-rt}(are^{-rt}-r)}{(1+ae^{-rt})^3}$. Make it equal to 0, we have $t = \frac{\ln a}{r}$. When $t < \frac{\ln a}{r}$, $y'' > 0$, the curve is concave; when $t > \frac{\ln a}{r}$, $y'' < 0$, the curve bulges. If we want to work out the third-order derivative of thelogistic curve, we can have $y''' = \frac{kar^3e^{-rt}(1-4are^{-rt}+a^2e^{-2rt})}{(1+ae^{-rt})^4}$. Make it equal to 0, we have $1 - 4are^{-rt} + a^2e^{-2rt} = 0$. Solve the equation we have $t_1 = \frac{\ln a-1.317}{r}$, $t_2 = \frac{\ln a+1.317}{r}$. In this way, there are three key points in the logistic curve: $t_1 = \frac{\ln a-1.317}{r}$, $t_2 = \frac{\ln a}{r}$, $t_2 = \frac{\ln a+1.317}{r}$.

52.3.2 Advantages of the Logistic Curve

The curve can be divided into four growth stages.

1. Formative period: $0 \sim t_1 = \frac{\ln a-1.317}{r}$, the market has just formed and grows slowly.

2. Growth period: $t_1 = \frac{\ln a - 1.317}{r} \sim t_2 = \frac{\ln a}{r}$, the market has developed and grows rapidly.
3. Mature period: $t_2 = \frac{\ln a}{r} \sim t_2 = \frac{\ln a + 1.317}{r}$, the market continues to grow but the growth speed has decreased.
4. Degenerating stage: $t_2 = \frac{\ln a + 1.317}{r} \sim +\infty$, the growth speed continues to fall and eventually saturates. We can see from the above analysis that the logistic curve and the process of tourism market development are basically consistent. In this way, using the logistic growth curve to fit and forecast the development of tourist market has great advantages (Yang 2009).

52.4 The Parameter Estimation in Logistic Curves

52.4.1 General Methods for the Fitting Curve

The curve fitting refers to the process of conducting curve regression analysis with two variable data to get a significant curve equation. Usually there are three steps: (1) Choose appropriate curve type according to the exact relationship between variable X and Y. (2) As for the selected curve type, configurate linear regression equation with least square method after linearization and test significantly. (3) Convert linear regression equation into the corresponding curvilinear regression equation and make inference on the related statistical parameters. The logistic curve has k, r, a the three selected parameters, so the general curve fitting can't determine the parameters (Yang 2008)

52.4.2 The Determination of Parameters in the Logistic Curve

52.4.2.1 The Determination of Parameter

Choose three time points willfully, make it meet $t_2 = \frac{t_1 + t_3}{2}$, we have:

$$\begin{cases} y_1 = k/(1 + ae^{-rt_1}) \\ y_2 = k/(1 + ae^{-rt_2}) \\ y_3 = k/(1 + ae^{-rt_3}) \end{cases}$$

Then,

$$k = \frac{y_2^2(y_1 + y_3) - 2y_1y_2y_3}{y_2^2 - y_1y_3} \tag{52.3}$$

Once k is determined, the value of a and r can be determined according to the general methods for the curve fitting (Wu and Huang 2004).

52.4.2.2 The Estimate of Parameters

Take the logarithm from both sides in Eq. (52.1), then

$$\text{In}\left(\frac{k-y}{y}\right) = \text{In}\, a - rt \tag{52.4}$$

If $y' = \ln\left(\frac{k-y}{y}\right)$, then we get the linear regression equation:

$$\widehat{y}' = \text{In}\, a - rt$$

Parameters a and r can be determined by Eq. (52.5), of which

$$\left.\begin{array}{l} -r = SP_{y't}/SS_t \\ \text{In}\, a = \bar{y}' + r\bar{t} \\ a = e^{\text{In a}} \end{array}\right\} \tag{52.5}$$

$$SP_{y't} = \sum (t_i - \bar{t})^2 = \sum t_i^2 - \frac{1}{n}\sum t_i^2;$$

$$SS_t = \sum (t_i - \bar{t})(y_i' - \bar{y}') = \sum t_i \bar{y}_i' - \frac{1}{n}\left(\sum t_i\right)\left(\sum y_i'\right)\bar{t} = \frac{1}{n}\sum t_i \bar{y}_i' = \frac{1}{n}\sum y_i'$$

52.4.3 Parametric Test

Since the logistic regression equation curve still contains parameter k besides regression parameters a and r, we need to discuss the testing method for goodness-of-fit (Lie and Zeng 2002). The related coefficients are as follows:

$$\boldsymbol{R^2 = 1 - \frac{\sum\limits_{i=1} (y_i' - \hat{y}')^2}{\sum\limits_{i=1}^{n} (y_i' - y')^2} = \frac{SSR}{SST} = \frac{1}{1 + \frac{SSE}{SSR}}}.$$

The SST is for total sum of square, the SSE for residual squares and the SSR for sum square within groups. There are two types of distribution: $\frac{SSE}{\sigma^2} \sim \chi^2(1)$ and $\frac{SSR}{\sigma^2} \sim \chi^2(n-1)$. We use distribution $\chi^2(n-1)$ for goodness-of-fit test. Look up the data in chart χ^2, if we take $\alpha = 0.05$ and have $\chi^2 < \chi^2_{0.05}(n-1)$, the equation

Table 52.1 China's inbound tourist numbers from 1978 to 2009 (unit: one hundred million)

The particular year	1978	1979	1980	1981	1982	1983	1984	1985
t	1	2	3	4	5	6	7	8
Inbound tourist numbers	0.18092	0.42039	0.57025	0.77671	0.79243	0.9477	1.28522	1.78331
The particular year	1986	1987	1988	1989	1990	1991	1992	1993
t	9	10	11	12	13	14	15	16
Inbound tourist numbers	2.28195	2.69023	3.16948	2.45014	2.74618	3.33498	3.81149	4.15269
The particular year	1994	1995	1996	1997	1998	1999	2000	2001
t	17	18	19	20	21	22	23	24
Inbound tourist numbers	4.36845	4.63865	5.11275	5.75879	6.34784	7.27956	8.34439	8.90129
The particular year	2002	2003	2004	2005	2006	2007	2008	2009
t	25	26	27	28	29	30	31	32
Inbound tourist numbers	9.79083	9.16621	10.90382	12.02923	12.49421	13.18733	13.00274	12.64759
The particular year	2010							
t	33							
Inbound tourist numbers	13.37622							

Source National Bureau of Statistics of China & National Tourism Administration of the People's Republic of China performs well in fitting, which means the expected value is mainly fit with the actual value. The statistics of χ^2 can be described in the equation below:

$$\chi^2 = \sum \frac{(y_i - \hat{y}_i)^2}{\hat{y}_i} \tag{52.6}$$

52.5 The Fitting Logistic Curve of China's Inbound Tourist Market

52.5.1 Source of the Data

The data in Table 52.1 were collected from the original data provided online from National Bureau of Statistics of China and National Tourism Administration of the P.R.C.

52.5.2 The Determination of Parameters

Substitute the data of t = 16, 17, 18 and calculate K according to formula (52.3), then k = 14.257.

By using dfittool matlab, we get r = 0.189, lna = 3.822. Put SSE: 3.183, R-square: 0.9711, Adjusted R-square: 0.9701 in goodness-of-fit test and the results showed that the line fit well. Calculate lna = 3.822 and we have a = 45.6955. And we can get the logistic regression curve equation of China's inbound tourism:

$$\hat{y} = \frac{14.257}{1 + 45.6955e^{-0.189t}} \tag{52.7}$$

52.6 Conclusion

The rising of logistic curve basically coincides with the development and growth of the tourist market. It has great advantages in improving forecast precision to use the logistic growth curve to fit the developing trend of the tourist market and to make forecast. The growth patterns of China's inbound tourist market follow the logistic curve equations which can be used to fit and forecast China's inbound tourist market. There are many kinds of tourist markets in China. We can consider using logistic curve equations for regression forecast provided that their growth scatter plots are similar to the sigmoid curves.

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Chapter 53
Study on Decision Mechanism Choosing by Cost Model for Projectized Organization

Hua-ming Zhang

Abstract The cost of making decision in enterprise differs when they have different decision mechanism. So decision mechanism choosing is very important. A model for calculating the cost of projectized organization is designed in this article with the parameters of the organization information and the relationship among projects. The cost of projectized organization is analyzed under different decision mechanism, on the base of which some tactic is advanced for projectized organization to choose decision mechanism.

Keywords Decision mechanism · Organization structure · Projectized organization

53.1 Introduction

Organization is a collaboration system in which we consciously coordinate two or more persons' activity or capacities (Barnard 1948). The objective of organization is to organize the activities of members inside the system, confirm the best purpose of operation and to rule the assignment of the members and their relationship (Brown and Duguid 1991). By building organization structure, we can easily manage system destination so that it can be realized (Joseph et al. 1999). The goal of organization structure contains division of labor, group of labor and activity collaborate (Stephen and Timothy 1997). When establish organization structure, we should think about activity specialization, activity departmentalization, command chain, span of management, centralization and separation of powers and normalization (Gang and Sun 2006).

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E. Qi et al. (eds.), *The 19th International Conference on Industrial Engineering and Engineering Management*, DOI: 10.1007/978-3-642-38391-5_53,

In projectized organization, project departments are independent to a certain degree (Stephen and Timothy 1997; Project Management Institute 2000). Each project department has its own technician and administration framework. It keeps weak touch with matrix enterprise by phased progress report. Some enterprises give detailed discipline about finance, human resource and administration. But some enterprises leave all the duty and power to project departments (Harold 2002; Xing 2003).

According to the distinction of centralization degree of the enterprise and the competitive relationship and coordinate relationship between the project departments, the decision mechanism can be sorted as follow (Masahiko et al. 2001).

Classical mechanism is the simplest decision mechanism. The enterprise decides the working capacity of the departments on the enterprise information and the department information. The functional departments carried out the work.

In separation mechanism functional departments decide the work capacity on its predicted department information but enterprise information.

In information assimilation mechanism, functional departments decide the work capacity on the same predicted enterprise information but their own information. They undertake the enterprise responsibility together.

In horizontal mechanism, functional departments decide the work capacity on its predicted department information and the same predicted enterprise information.

In information decentralization mechanism, functional departments decide their work capacity by its predicted enterprise information and predicted department information.

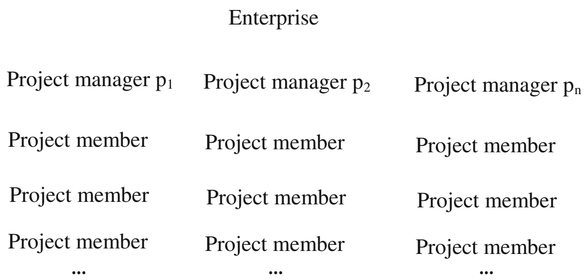
Information dissimilation mechanism is similar to assimilation mechanism. Functional department decide their work capacity on its predicted enterprise information. The difference between the two mechanisms is that in the former the enterprise information is different for departments but in the latter the enterprise information is same.

53.2 Modelling

When building the model, we hypothesize that the enterprise decides its work capacity to minimize expected cost. The objective of building the model is to analyze how the decision mechanism affect expected cost and which mechanism is suitable to projectized organization. So that advice can be drawn for enterprise to choose decision mechanism.

For the convenient of studying, the number of project departments in the enterprise is represented by parameter n. The projectized organization can be described in Fig. 53.1, (Lian and Fu 2007). In this kind of organization there may be functional departments in the enterprise, but they can not affect project. And executive of the enterprise directly control project manager.

Fig. 53.1 Projectized organization



To build the cost model of projectized organization, we suppose parameter α as the factors that affect both project departments such as project alteration or break off. We call them system oscillation. The parameter $\gamma_i(i = 1, 2)$ means the information changing which occurs in project departments such as machine stoppage or tool damage and can only affect one project department. We call them individual oscillation. Both the average of α and γ are 0, and variance are ζ_i and ζ_i. They are random variable.

With the increase of the number of projects, it is inevitable that the relationship of competition and coordination emerge between project departments. They compete for capital and human resource in enterprise. The parameter B represents the competition level between departments. The parameter D represents coordination level. They are treated as constant. The relationship between parameter B and D represents the relationship of competition and coordination between functional departments.

The work capacities of project departments is represented by variable yi(i = 1, …, n), yi $\geqq$ 0.

The operating cost of the enterprise can be conducted as follow.

$$
\begin{aligned}
c = \bar{c} - \sum_{1}^{n} (\alpha + \alpha_i) y_i + \frac{1}{2} \sum_{i=1}^{n} \sum_{j=i+1}^{n} B\left(y_i + y_j\right)^2 \\
+ \frac{1}{2} \sum_{i=1}^{n} \sum_{j=i+1}^{n} D\left(y_i - y_j\right)^2
\end{aligned}
\quad (53.1)
$$

Project department decides the value of yi on the information ψ_i (i = 1, …, 2) given by enterprise, the constitution of which is decided by on the decision mechanism of the enterprise. The expected operating cost is as follow.

$$
E\left[
\begin{aligned}
\bar{c} - \sum_{1}^{n} (\alpha + \alpha_i) y_i + \frac{1}{2} \sum_{i=1}^{n} \sum_{j=i+1}^{n} B\left(y_i + y_j\right)^2 \\
+ \frac{1}{2} \sum_{i=1}^{n} \sum_{j=i+1}^{n} D\left(y_i - y_j\right)^2
\end{aligned}
\right]
\quad (53.2)
$$

53.3 Decision Mechanism Analyzing

In classical mechanism, all decision-making power concentrates upon enterprise level. So the decision criterion is that choose suitable yi so that expected operating cost is minimum. When partial differentials of yi are all equal to zero, expected cost is minimum.

By solving these equations can get a conclusion that when $y_1 = y_2 = \cdots = y_n = 0$ minimum c is $\overline{c}$.

Under separation decision mechanism, variable $\psi_i^{DH} = \alpha_i + \varepsilon_i$ refers to the information project departments decided on.

The variable ε_i is the prediction error. It fit normal distribution with average zero and variance $\sigma_\varepsilon{}^2$. The prediction error of department fit the same distribution. And they are mutual independent. We also hypothesize that the distribution of system oscillation individual oscillation and prediction error are mutual independent. AS cost function is quadratic and the random variables related to it fit to normal distribution, decision criteria is linear equation about ψ_i. y_i^{DH} Can be defined as

$$y_i^{DH} = k + t\psi_i \tag{53.3}$$

Substituting (53.3) into cost function (53.2) can get minimum value of cost function.

Decision criteria of separation mechanism is

$$y_i^{DH} = \frac{Q^{DH}\psi_i^{DH}}{B+D} \cdot \frac{1}{n-1} \tag{53.4}$$

The minimum of expected cost is

$$C^{DH} = \overline{C} - \frac{Q^{DH}\sigma_{\alpha'}{}^2}{B+D} \cdot \frac{n}{2(n-1)} \tag{53.5}$$

The parameter Q^{DH} is defined as $Q^{DH} = \frac{\sigma_{\alpha'}{}^2}{\sigma_{\alpha'}{}^2 + \sigma_\varepsilon{}^2}$.

The parameter Q^{DH} is the proportion of necessary information α_i in the information ψ_i^{DH} of i department which has prediction error. It reflects the accuracy departments processing information. Bigger value indicates information accurately processed and smaller minimum value of expected enterprise cost. It is easy to get the conclusion that the cost of separation mechanism is smaller than classical mechanism.

In information assimilation mechanism all the project departments ignore individual information oscillation. They consider the same system information which has prediction error ε_0. The variance ε_0 is independent to α. It obeys normal distribution with average zero and variance $\sigma_\varepsilon{}^2$. The system information can be defined as: $\psi^{AI} = \alpha + \varepsilon_0$.

Decision mechanism is

$$y^{AI} = \frac{Q^{AI}\psi^{AI}}{2B} \cdot \frac{1}{n-1}$$

Minimum value of expected cost function is

$$C = \overline{C} - \frac{Q^{AI}\sigma_\alpha{}^2}{2B} \cdot \frac{n}{2(n-1)} \tag{53.6}$$

The parameter Q^{AI} in the equation is defined as follow.

$$Q^{AI} = \frac{\sigma_\alpha{}^2}{\sigma_\alpha{}^2 + \sigma_\varepsilon{}^2}$$

Similar to Q^{DH} in separation mechanism, Q^{AI} reflects the accuracy enterprise processing information. Bigger value indicates information accurately processed and smaller minimum value of expected enterprise cost. At the same time the cost is relative to system oscillation $\sigma_\alpha{}^2$, parameter B and the number of projects. The cost will increase with the decrease of $\sigma_\alpha{}^2$ and an increase of parameter B and n. If system oscillation is very big assimilation mechanism is efficient.

In horizontal mechanism project departments consider the same system information $\alpha + \varepsilon_0$ and its own predicted individual oscillation $\gamma_i + \varepsilon_i$. The sum of system information and individual oscillation can be defined as $\psi_i{}^{HH}$.

$$\psi_i{}^{HH} = \alpha + \varepsilon_0 + \alpha_i + \varepsilon_i$$

Minimum value of expected cost function is

$$C = \overline{C} - \frac{Q^{HH}(\sigma_\alpha{}^2 + \sigma_{\alpha'}{}^2)}{(B+D) + (B-D)Q^{HH}\frac{\sigma_\alpha{}^2+\sigma_\varepsilon^2}{\sigma_\alpha{}^2+\sigma_{\alpha'}{}^2}} \cdot \frac{n}{2(n-1)} \tag{53.7}$$

Decision mechanism is

$$y^{HH} = \frac{Q^{HH}\psi_i{}^{HH}}{(B+D) + (B-D)Q^{HH}\frac{\sigma_\alpha{}^2+\sigma_\varepsilon{}^2}{\sigma_\alpha{}^2+\sigma_{\alpha'}{}^2}} \cdot \frac{1}{n-1}$$

The parameter Q^{HH} in the equation is defined as follow.

$$Q^{HH} = \frac{\sigma_\alpha{}^2 + \sigma_{\alpha'}{}^2}{\sigma_\alpha{}^2 + \sigma_{\alpha'}{}^2 + \sigma_\varepsilon{}^2}$$

The parameter Q^{HH} reflects the accuracy processing information. Bigger value indicates lower minimum value of expected enterprise cost. At the same time the cost is relative to the sum of system oscillation and individual oscillation. It is also relative to parameter B and parameter D and n. The cost will increase with the decrease of $\sigma_\alpha{}^2 + \sigma_\gamma{}^2$ and the increase of n, B + D and B − D. Horizontal mechanism would be suitable when system oscillation and individual oscillation is very big. When individual oscillation is very small its cost is approximate to that of assimilation mechanism.

In decentralization mechanism project departments consider different system information and different predicted individual oscillation. The sum of system information and individual oscillation can be defined as ${\psi_i}^{DI}$.

$$ {\psi_i}^{DI} = \alpha + \alpha_i + \varepsilon_i $$

Minimum value of expected cost function is

$$ C = \overline{C} - \frac{Q^{DI}({\sigma_\alpha}^2 + {\sigma_{\alpha'}}^2)}{(B+D) + (B-D)Q^{DI}\frac{{\sigma_\alpha}^2}{{\sigma_\alpha}^2 + {\sigma_{\alpha'}}^2}} \cdot \frac{n}{2(n-1)} \tag{53.8} $$

Decision mechanism is

$$ y^{DI} = \frac{Q^{DI}{\psi_i}^{DI}}{(B+D) + (B-D)Q^{DI}\frac{{\sigma_\alpha}^2}{{\sigma_\alpha}^2 + {\sigma_{\alpha'}}^2}} \cdot \frac{1}{n-1} $$

The parameter Q^{DI} in the equation is defined as follow.

$$ Q^{DI} = \frac{{\sigma_\alpha}^2 + {\sigma_{\alpha'}}^2}{{\sigma_\alpha}^2 + {\sigma_{\alpha'}}^2 + {\sigma_\varepsilon}^2} $$

The parameter Q^{DI} reflects the accuracy processing information. Bigger value indicates lower minimum value of expected enterprise cost. At the same time the cost is relative to the sum of system oscillation and individual oscillation. It is also relative to parameter n, parameter B and parameter D. The cost will increase with the decrease of ${\sigma_\alpha}^2 + {\sigma_\gamma}^2$ and the increase of n, B + D and B − D.

In dissimilation mechanism what departments consider is ${\psi_i}^D$ which is defined as ${\psi_i}^D = \alpha + \varepsilon_i$.

Minimum value of expected cost function is

$$ C = \overline{C} - \frac{Q^D {\sigma_\alpha}^2}{(B+D) + (B-D)Q^D} \cdot \frac{n}{2(n-1)} \tag{53.9} $$

Decision mechanism is

$$ y^D = \frac{Q^D \psi_i^D}{(B+D) + (B-D)Q^D} \cdot \frac{1}{n-1} $$

The parameter Q^D in the equation is defined as follow.

$$ Q^D = \frac{{\sigma_\alpha}^2}{{\sigma_\alpha}^2 + {\sigma_\varepsilon}^2} $$

The parameter Q^D reflects the accuracy processing information. Bigger value indicates lower minimum value of expected enterprise cost. At the same time the cost is relative to the sum of system oscillation and individual oscillation. It is also relative to parameter B and parameter D. The cost will increase with the decrease of ${\sigma_\alpha}^2$ and the increase of B + D and B − D. So dissimilation mechanism is suitable when system oscillation is very big.

53.4 Comparative Analysis of Decision Mechanism

From the result conducted by the model, conclusion can be easily made as follow.

When the number of projects in the enterprise is not large the appropriate decision mechanism is in connection to the proportion of individual oscillation or system oscillation in all information.

In the fields that have rapid changing environment the system oscillation will be large. If the individual oscillation in the project departments is very small and can be neglected the efficiency of the four decision mechanisms in the front would be equal. But the information processed in horizontal mechanism and decentralization mechanism is more than that of assimilation mechanism and dissimilation mechanism. In consideration of the cost for processing information it is proper to choose assimilation mechanism and dissimilation mechanism.

In the fields that have mature technology and stable environment system oscillation is relatively small and individual information is relatively large. The cost of assimilation mechanism, dissimilation mechanism, horizontal mechanism and decentralization mechanism is equal. The cost of separation is the lowest. So it is more appropriate than the other mechanisms.

If the system oscillation and individual oscillation are all very large and cannot be neglected horizontal mechanism and decentralization mechanism process more information than other mechanism. So they are more efficient. But they are also different. If the competitive factor in among projects is larger than coordination factor decentralization mechanism will be more efficient. And horizontal mechanism will be more efficient on the contrary.

With the increase of the number of projects in enterprise the competition among projects would increase rapidly and the coordination among them would decrease rapidly. If the number increase to a certain degree competition factor would be far larger than coordination factor and the coordination can be neglected. The cost function of the enterprise would increase with the increase of the number of projects in the enterprise. If the number is large the expected cost would be large. The extreme condition is that the number is infinite. The minimum of expected cost will be $\overline{c}$. At this time projectized organization would not be efficient. The reason is that when the number of projects in enterprise is small the competition among projects is small and can be solved by project managers. But with the increase of the number in enterprise project managers can no longer solve the competition by themselves. It is necessary to add new department to manage the resource that all projects compete for. They are functional departments.

53.5 Conclusion

In this paper cost model established with parameter defined as competition relationship and coordination relationship and the number of projects in the enterprise. The cost of projectized organization is analyzed under different decision mechanism. Selection strategy is proposed on choosing decision mechanism for projectized organization. So it is feasible to analyze the cost of projectized organization quantitatively. But it is not enough to analyze organization only from the perspective of cost. Operating efficiency and performance should also be analyzed. These work remains to be further studied.

Acknowledgments This work is supported by Jiangsu Education Department Grant #2010SJB 630038 to Hua-ming Zhang.

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Chapter 54
Study on Impact of Investor's Herd Behavior on Corporation Investment Behavior

Hai-ming Wang and De-ming Zeng

Abstract From the perspective of investor irrationality, this paper empirically analyzes the effect of investors' herd behavior on corporate investment behavior. The empirical results show that the buyer's herd behavior has positive effect on the level of corporate investment, and the seller's herd behavior has inhibitory effect on the level of corporate investment. The degree of influence on corporate investment varies between the buyer's herd behavior and that of the seller's.

Keywords Corporate investment behavior · Equity financing · Herd behavior · Investor irrationality

54.1 Introduction

Corporate investment behavior refers to corporations invest financial resources to expect for future returns. Traditional finance theory implied a hypothesis that investors are rational. However, with the appearance of some abnormal financial phenomenon which could not be explained by traditional financial theory, scholars began to pay attention to the influences of investors' irrational behavior on corporate investment behavior and tried to research corporate investment behavior in the consideration of the influence of capital market (Baker et al. 2003; Baker 2009). However, it is very difficult to measure the investors' irrational degree directly in fact. A lot of researchers indirectly measured the irrational degree by measuring the impacts of investors' irrational behavior on stock price. As there are different types of investors irrationality such as herd behavior, over-confidence and so on, current researches still could not explain what specific influences would

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E. Qi et al. (eds.), *The 19th International Conference on Industrial Engineering and Engineering Management*, DOI: 10.1007/978-3-642-38391-5_54,

various investors' irrational behaviors have on corporate investment. Therefore, it is valuable and meaningful to study the influences of investors' specific irrational behavior on corporate investment behavior.

Since the 1980s, as one aspect of irrational manifestations of investors, investors' herd behavior has attracted more and more attention from scholars. Herd behavior is the behavior that investors follow each other into and out of the same securities or follow themselves into and out of the same securities within some period ignoring the value of private information. Keynes (1936) mentioned this concept first, and used the beauty contest game to illustrate such a phenomenon. Later, scholars made a large number of empirical studies. The literature about herd behavior of investors could be divided into two branches. First, Wermers (1999) and Sias (2004) studied the buy and sell decisions of investors based on the results of Lakonishok et al. (1992). Second, Christie and Huang (1995), and Chang et al. (2009) derived a time series based on the distribution of returns around the market to measure herd behavior of investors. These researches showed the existence of herd behavior in securities market. Li et al. (2010), Chun et al. (2011), Li and Li (2011) found that investors' herd behavior exists generally in Chinese securities market, and there were some differences between individual investors' herd behavior and institutional investors'. After then, scholars further researched the effect of investors' herd behavior on stock price. Most scholars argued that herd behavior would aggravate stock price fluctuation and destroy market stability (Chiang and Zheng 2010; Lao and Singh 2011; Maug and Naik 2011); while other scholars believed that herd behavior would reduce stock price fluctuation and stabilize the stock market (Wu et al. 2004).

To sum up, existing studies generally agreed on that investors' herding behavior exists in the securities market and investors' herd behavior would affect the stock price and its volatility, but few studied whether investors' herd behavior impact corporate investment and what the effects are. Considering the existence of herd behavior universally in Chinese securities market, this paper tries to research the influence of investors' herd behavior on corporate investment by relaxing the assumptions of traditional financial theory.

54.2 Hypothesis Development

As the subject of the economic behavior in securities market, investors will make investment decisions in accordance with the information they obtained. What they pursue is the maximum returns with fixed risks or the minimum risk with the fixed returns. However, due to information asymmetry in reality, most investors will follow others' to make investment decisions leading to herd behavior happen. Buying-in or selling-out the same stock of most investors at the same time will greatly aggravate the fluctuation of the stock price, then cause the stock price to be overestimated or underestimated, and finally affect corporate investment behavior. This kind of influence can be divided into two situations as follows.

On one hand, in order to maximize the basic value and pursue the goal of doing better and bigger, the corporate operator needs to increase investment and implement projects with positive net present value. The buyer's herd behavior means that most investors buy a large number of the same stock during the same period, and indicates that most investors are optimistic about the development of corporate. This will result into the rise of stock price, which deviates from its inner value. And then it will ease financing constraint and financing costs accordingly, providing an important guarantee for the smooth implementation of projects with positive net present value in terms of financing. Therefore, the corporate operator will invest more projects with positive net present value, and then expand the scale of the corporate. On the contrary, the seller's herd behavior means most investors sell the same stock during the same period, which indicates that most investors are not optimistic about the development of corporate. This will cause the stock price to fall, which deviates from its inner value. And then it will increase financing constraint and financing costs accordingly, influencing the implementation of projects with the positive net present value. Therefore, the corporate operator will give up some projects with the positive net present value to avoid getting into financial dilemma when they are making investment decisions.

On the other hand, the corporate operator will take the corresponding measure to maximize the stock price according to the stock price fluctuation. The buyer's herd behavior gives rise to the overestimated stock price, which is consistent with the goal of the corporate operator. In order to maintain the high stock price, the corporate operator will improve the level of investment to cater for the majority of investors' expectations. The seller's herd behavior leads to the underestimated stock price, which goes against the purpose of operators. In order to go through the worse situation, the corporate operator will consider share repurchase at the appropriate time. Share repurchase requires a large amount of cash, which imposes restrictions on the corporate investment.

Therefore, the paper proposes the following hypotheses based on the above analysis:

Hypothesis 1: the higher the degree of buyer's herd behavior is, the higher the level of corporate investment is.

Hypothesis 2: the higher the degree of seller's herd behavior is, the lower the level of corporate investment is.

54.3 Research Design

54.3.1 Sample Selection and Data Sources

Considering Chinese securities market has undergone tremendous changes since the split-share reform, we select all A-share firms listing on the Shanghai Stock Exchange (SHSE) and the Shenzhen Stock Exchange (SZSE) over the period from 2007 to 2011 as the research samples.

Considering the availability of the data, we use the open-end funds as the representative of investors. As the main force of the investors, the open-end funds' herd behavior can be used to measure the herd behavior of investors to achieve the empirical requirement of this paper. The original data of the investors' herd behavior is the open-end funds' shareholding details of the annual report data. We compare the number of shareholding stock i of the open-end funds in the period t annual report with the number of shareholding the same stock in the period $t-1$ annual report. If the number of shareholding increased compared with the last period, we call the open-end funds of stock i in the t period as net buying. On the contrary, we call it as net selling. Further, we can get the number of investors who are the net buyers or sellers of stock i in period t by data statistics. In order to guarantee the validity, we eliminate abnormal sample data which the sum of the net buying and net selling is less than five and the number of net buying or net selling is zero. Then, we exclude the ST group, PT group, and companies whose net assets are negative and financial data is missing. At last, we get 3049 observations.

All the data comes from the CSMAR database.

54.3.2 Variables Definition

There exists phenomenon of manipulating profits by asset impairment in Chinese capital market, but it is more difficult to manipulate the data in the cash flow statement. Therefore, this paper chooses the cash which is used to pay for construction of fixed assets, intangible assets and other assets divided the final total assets to measure the level of corporate investment.

We amend the LSV model constructed by Lakonishok et al. (1992) to measure the herd behavior degree of investors. The LSV model can measure the degree of deviation between the stock trading in the same direction transaction and the stock trading in the independent transaction during the same period. The LSV model is as follows:

$$HM_{i,t} = \left|P_{i,t} - E(P_{i,t})\right| - AF_{i,t}, \tag{54.1}$$

where HM_t represents the herd behavior degree of investors, $P_{i,t}$ is the proportion of number of investors who are the net buyers of stock i to the number of investors who are all trading of stock i; $E(P_{i,t})$ is the expected value of $P_{i,t}$; $AF_{i,t}$ is an adjustment factor.

The LSV model calculation steps are as follows:

Firstly, the calculation formula of $P_{i,t}$ is as follows:

$$P_{i,t} = \frac{B_{i,t}}{B_{i,t} + S_{i,t}}, \quad (54.2)$$

where $B_{i,t}$ is the number of investors who are the net buyers of stock i during period t, $S_{i,t}$ is the number of investors who are the net sellers of stock i during period t.

Secondly, according to the study of Lakonishok et al. (1992), we use the proportion of all stock trades which are purchased by investors during period t. The specific calculation formula is as follows:

$$P_t = \frac{\sum_{i=1}^{i=N_{i,t}} B_{i,t}}{\sum_{i=1}^{i=N_{i,t}} B_{i,t} + \sum_{i=1}^{i=N_{i,t}} S_{i,t}}, \quad (54.3)$$

Thirdly, the calculation formula of $AF_{i,t}$ is as follows:

$$AF_{i,t} = E\left|P_{i,t} - E(P_{i,t})\right| = E\left|P_{i,t} - P_t\right|, \quad (54.4)$$

where $E|P_{i,t}–P_t|$ is calculated under the null hypothesis $B_{i,t}$ following a binomial distribution with parameter P_t. Thus,

$$P\left\{B_{i,t} = k\right\} = C_{N_{i,t}}^{k} P_t^k (1 - P_t)^{N_{i,t}-k}, \quad (54.5)$$

we can figure out $AF_{i,t}$ by substituting Eq. (54.5) into Eq. (54.4).

Fourthly, we calculate the herd behavior degree of buyers and sellers. Given that the degree of herd behavior is different when buying and selling stocks, its impaction on corporate investment will also be different. Therefore, according to "buy herding measure" and "sell herding measure" proposed by Wermers (1999), in this paper HM_t is defined as follows: if $HM_t > 0$, then HM_t represents the buyer's herd behavior; if $HM_t < 0$, then HM_t represents the seller's herd behavior. Values of HM_t significantly different from zero are interpreted as evidence of herd behavior. The greater the absolute value of HM_t is, the more serious the investors' herd behavior is.

On the basis of previous studies, in this paper we select some control variables. Specific definitions are in Table 54.1.

Table 54.1 The control variable definition

Variable	Definition
$SIZE_t$	The natural logarithm of asset
$CASH_{t-1}$	The cash flow from operations in period $t-1$
$CASH_t$	The cash flow from operations in period t
$SHARE_t$	The holding ratio of largest shareholder against second-largest shareholder
LEV_{t-1}	The ratio of total liabilities to total assets
$GROWTH_t$	The revenue growth rate
RET_t	The stock market-adjust returns
$YEAR$	Year dummy variables

54.3.3 Model Design

In order to verify the above hypothesis, we construct the model as follows:

$$I_t = c + \beta_1 HM_t + \beta_2 SIZE_t + \beta_3 CASH_{t-1} + \beta_4 CAHS_t + \beta_5 SHARE_t + \beta_6 LEV_{t-1} + \beta_7 GROWTH_t + \beta_8 \mathrm{R}ET_t + \beta_9 \sum YEAR + \varepsilon_1, \quad (54.6)$$

where I_t is the level of corporate investment, HM_t is the herd behavior of investors, others are control variables.

54.4 Empirical Results

The results of regression results of model (54.6) are shown in Table 54.2.

The coefficient of investors' herd behavior degree is significantly positive at the 95 % confidence level, suggesting that the higher the degree of buyer's herd behavior is, the higher the level of corporate investment is; and the higher the degree of seller's herd behavior is, the lower the level of corporate investment is. Hypothesis 1 and hypothesis 2 are verified.

As the regression results of control variables, the larger the corporate scale is, the higher the level of corporate investment is. This may be due to the domestic listed corporation, especially large corporate tend to invest more to achieve the goal of doing better and bigger. The greater the cash flow of previous period in corporate is, the higher the level of corporate current investment is. The initial cash

Table 54.2 The total sample regression results

Variable	Coefficient	t-value	p-value
(Constant)	-0.1423^{***}	−6.8546	0.0000
HM_t	0.0205^{**}	2.2188	0.0266
$SIZE_t$	0.0086^{***}	9.0456	0.0000
$CASH_{t-1}$	0.1216^{***}	9.3180	0.0000
$CASH_t$	0.0985^{***}	7.3498	0.0000
$SHARE_t$	-0.0001^{**}	−2.5652	0.0104
LEV_{t-1}	−0.0069	−1.0828	0.2790
$GROWTH_t$	−0.0001	−1.1787	0.2386
RET_t	−0.0011	−0.8638	0.3878
YEAR		Control	
Adjusted R^2		0.1041	
F-statistics		36.3991	
		(0.0000)	
Durbin-Watson		1.9702	

Note The superscript ** indicates obvious herd behavior at the level of 5 %, and the superscript *** indicates obvious herd behavior at the level of 1 %

Table 54.3 Two subsamples regression results

Variable	The buyer's herd behavior Coefficient	The seller's herd behavior Coefficient
(Constant)	−0.1557***	−0.1101***
HM_t	0.0277**	0.0211*
$SIZE_t$	0.0092***	0.0074***
$CASH_{t-1}$	0.1347***	0.1022***
$CASH_t$	0.0865***	0.1163***
$SHARE_t$	−0.0001**	−0.0001*
LEV_{t-1}	−0.0043	−0.0074
$GROWTH_t$	0.0000	−0.0024***
RET_t	−0.0030*	−0.0020
YEAR	Control	Control
Adjusted R2	0.1094	0.1000
F-statistics	20.6365	21.1208
	(0.0000)	(0.0000)
Durbin-Watson	2.0457	1.7991

Note The superscript * of HM_t indicates obvious herd behavior at the level of 10 %, the superscript ** indicates obvious herd behavior at the level of 5 %, and the superscript *** indicates obvious herd behavior at the level of 1 %

flow is a kind of expression of the level of previous investment. Since corporate investment has some continuity, the level of previous investment has certain effects on current corporate investment. Consequently the initial cash flow has positive effects on the level of corporate investment. The greater the current cash flow is, the higher the level of current investment is. As corporate ownership is more concentrated, the corporate operator will be more cautious for investing, so the level of investment will be lower. In general, control variables are basically consistent with the actual situation.

In order to eliminate the interaction of the data and explore the similarities and differences of the influence which the buyer's herd behavior and the seller's have on the level of corporate investment, regarding the data of the buyer's herd behavior and the seller's as two subsamples, we make regression analyses respectively. The results are shown in Table 54.3.

After controlling the scale of corporate, the cash flow, equity structure, leverage, revenue growth, stock return and annual factor, the regression coefficient of buyer's herd behavior is 0.0277, p value is 0.0415, which means that the coefficients is significantly positive at the 95 % confidence level, so the hypothesis 1 is confirmed. While the regression coefficient of seller's herd behavior is 0.0211, p value is 0.0984, which means that the coefficient is significantly positive at the 90 % confidence level, so the hypothesis 2 is confirmed.

Further, comparing the regression coefficients of buyer's herd behavior with the seller's, we can conclude that the buyer's herd behavior has a greater impact on corporate investment. The possible reason is that the buyer's herd behavior is more serious than the seller's in securities market.

54.5 Conclusion

Research results show that, the buyer's herd behavior can significantly improve the level of corporate investment; and the seller's herd behavior has significant inhibiting effect on the level of corporate investment. What's more, the impact of the buyer's herd behavior on corporate investment is greater than the sellers'.

Acknowledgments This work was supported by the National Social Science Foundation of China (07AJL005), Program for Changjiang Scholars and Innovative Research Team in University (IRT0916), and Science Fund for Innovative Groups of Natural Science Foundation of Hunan Province of China (09JJ7002).

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Chapter 55
Study on the Evaluation Framework of Enterprise Informationization

Qing-wen Yuan, Shu-wei Yu, Yuan-yuan Huo and Dan Li

Abstract Evaluation of enterprise informationization (EI) is an important part of EI construction and applications, which has direct impact on the effect of the acquisition of information technology, investors confidence and the healthy development of following steps. This paper attempts to establish a systematic evaluation framework of EI, analyze the process of that evaluation, and especially build the corresponsive applied model, offering relative references for the work of EI evaluation.

Keywords Application stage · Benefit evaluation · Enterprise informationization (EI) · Evaluation model

55.1 Introduction

Enterprise informationization is a evolutionary process in which an enterprise, by focusing on two objectives, the economic efficiency and the competitiveness of enterprises, and by using the modern information technology, develops and uses

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E. Qi et al. (eds.), *The 19th International Conference on Industrial Engineering and Engineering Management*, DOI: 10.1007/978-3-642-38391-5_55,

corporate information resources effectively and improves its own operation and management and the abilities of research and development, meanwhile strengthening its core competitiveness (Ke and Li 2007).

In the process, the evaluation of EI is an important part of the informationization construction and application. The quality of the evaluation directly influences the effects of the EI application as well as the development in following step. However, the current work on matter on the theory or on application has not formed a mature and practical system, which is an obstruction on the healthy development of informationization work. To sort out the evaluation of EI, forming a certain constructive ideas to provide a reference for the preparation or being implemented information technology companies is the purpose of this article.

Evaluation of EI is not only a guide to build enterprise informationization, but also scales to measure the level of enterprise informationization. The evaluation not only can guide enterprises to understand accurately the connotation of information technology and to clear the purpose of information technology, but also guide enterprises to correctly formulate the information technology strategy and to protect the implementation of the informationization project. EI evaluation can not only improve the overall quality, the sustainable development ability, and the international competitiveness of enterprises, but also promote local economy and social development. It is obvious that for improving the efficiency and the profitability of EI process the evaluation work come into spotlight.

55.2 Evaluation and Significance of the EI

The evaluation of EI is the important part of the construction and application of informationization. It is a comprehensive measurement and metrics to the EI infrastructure, information resources, human capital, technology, transaction costs, resource consumption, competitiveness and innovation capability and other aspects, finding out the relationship between the enterprise information and business performance and corporate value, and establishing the evaluation index system so as to determine the level of corporate information technology and its benefits. Measuring the EI, should not only reflect the level, but also reflects the effectiveness and efficiency, should not only reflect the direct benefits, but also to reflect the development potential and value.

Evaluation of EI is not only a guide to build enterprise informationization, but also scales to measure the level of enterprise informationization. The evaluation not only can guide enterprises to understand accurately the connotation of information technology and to clear the purpose of information technology, but also guide enterprises to correctly formulate the information technology strategy and to protect the implementation of the informationization project. EI evaluation can not only improve the overall quality, the sustainable development ability, and the international competitiveness of enterprises, but also promote local economy and

social development. It is obvious that for improving the efficiency and the profitability of EI process the evaluation work come into spotlight.

55.3 The Content of Evaluation of EI

Evaluation of EI basically includes two aspects: the level evaluation of EI and benefit evaluation of EI.

The evaluation of the level of EI is to measure from the stage of the EI and basic indicators of information measure to the representation of the physical and chemical form of indicators, including the infrastructure in terms of information diffusion, information resources development and utilization of information system applications, and from the organizational structure, quality of personnel as well as corporate IT investment accounted for the proportion of fixed investment.

Construction of enterprise information has both economic benefits and social benefits, meaning that it can not only product direct benefits, but also generate indirect benefits. Its effectiveness and overall business performance are inseparable. Therefore, to judge and evaluate the effectiveness of information technology, it cannot simply treat informationization as a common project investment which is viewed in isolation, but should start from the improvement of the overall corporate performance, according to their differing stages, to comprehensively evaluate. In the evaluation of enterprise information, because of the diversity of its evaluation level and main body, the product of benefits has invisibility, stealth, lag, long-term, accelerated increments and other features which make great difficulties to the set of informationization evaluation index, determination of index weight, and the choice of evaluation methods. This is one of the reasons for the formation of the easy operation of the accepted system of scientific evaluation system.

55.4 Analysis on the Evaluation of EI

55.4.1 Framework of EI Evaluation

The evaluation of EI is a systematic work to analyze the factors ofi nternal resources and capabilities, external environment, in the case of considering the matching of the enterprise strategy and information strategy to clear the application stage and establish two main evaluation systems which is the level of evaluation and effectiveness evaluation of the EI (Wang and Liu 2007). EI evaluation framework diagram is shown in Fig. 55.1.

To carry out the evaluation of EI, it firstly should be in conjunction with the division of the enterprise information application stage to define the enterprise information. The application stage of division is to facilitate the level of

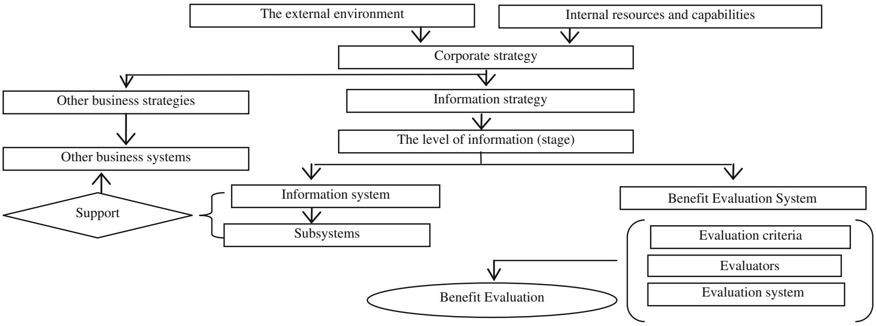

Fig. 55.1 EI evaluation framework diagram

evaluation. For benefit evaluation as a precondition to fully consider the level of evaluation and effectiveness evaluation of convenience, applicability, systemic and operational evaluation of characteristics, we must consider the purpose of the application of information technology, the characteristics and the purpose of the evaluation of information technology, rather than just consider the evaluation division stage.

Secondly, it should be combined with the purpose of the evaluation to make the indicator selection and settings, the choice of evaluation methods, and the level of evaluation and effectiveness evaluation in a phased manner. This process is a dynamic process, indicating that in the different stages of the evaluation, with the different purposes, the selected indicators, weights and evaluation methods should change accordingly.

55.4.2 The Problems of EI Evaluation

55.4.2.1 Moderate Informationization, Emphasizing the Strategic Matching

EI strategy is an important supporting part of the overall business strategy, on the basis of the analysis on the internal and external environment of EI, to make the scientific assessment for the ability of EI it is the planning and decision which is made the strategy and implementation steps for EI.

The formulation and implementation of EI strategy not only need to match with the corporate strategy, emphasizing the unity of purpose to meet the needs of enterprise development, but also to standardize and restrict the direction and content of EI construction and the application. It needs the modest investment and emphasizes on building applications effectiveness to achieve the maximum returns on investment, avoiding the aimlessness and disorder of informationization construction.

The matching of moderate informationization strategy needs to consider the influencing factors of external environment, competitive strategy, competitiveness, industry characteristics, EI demand and other factors, and to make the overall consideration and analysis of these factors (Wen 2010).

55.4.2.2 Do Well the Phases of Work on the EI with the Evaluation

The phasing of EI is the early work on the evaluation of EI. For the evaluation of EI work (Liu et al. 2004), the appropriate information phasing can play a multiplier effect on the smooth development of information technology evaluation.

In order to carry out the work of stage division, we need to choose the phasing basis suitable for EI evaluation under the principle of phasing and to master the main features of each stage.

Under the normal circumstances, the phasing of EI should follow three principles: (*a*) between each level it should have continuity which can reflect the gradual process of development and trend. (*b*) Each phase should have significant and easily described characteristics. (*c*) The phase characteristics identified should reflect the change of the enterprise as soon as possible.

Under the three principles of framework above, the writer conducts the system analysis about the stage research of local and foreign enterprise information application, and makes sure the main stage division by mainly using the following information both at home and abroad: information system input and effective (Nolan); the role of information (Synnott); information technology application (Mische); IT application mode (Boar); outside, the efficiency of benefit, dispersion, comprehensive (Edwords). These serve as the reference of classifying the informationization evaluation stage (Nolan 1975; Churchill et al. 1969; Synnott 1987; Mische 1995; Edwards et al. 1991).

55.5 Rour-Stage Application Model Adapted for the Evaluation of EI

The evaluation of EI is a multi-stage dynamic process, and before the benefit evaluation of the informationization, it's important to confirm the application stage of the enterprise and to confirm that the application stage should integrate the level of EI. The evaluation level of EI and the benefit evaluation of EI is continuous process on the same level.

Refer to the research result of Mische & Boar, we divide EI into three levels four stage according to information technology application and function level. Three levels refer to construction phase, function application level, strategic management level. Among them, infrastructure level corresponding fundamental construction stage, function application levels corresponding internal integration stage, strategic management level corresponding strategic management stage. Strategic management can be divided into process innovation and strategic innovation two stages.

The basic construction phase is the early step of the beginning and technical application, and it mainly consists informational network, data-base construction and local application with an emphasis on the complete function of information. The informationization assessment is carried out as a technical project which aims at the revolution of working format and the improvement of efficiency, thus, the main point is not about making strategies and gaining investment income.

After the completion of the basic construction of the informationization, the requirement of the enterprisers on application of information will come to a strategic level. So far, the internal integration phase has been playing an important role for most of the time on the application phase, and this phase is mainly about the application of informational techniques, improving the business.

The assessment to the internal integration phase is mainly about the incomes, as well as a little invisible benefit which occupies a small portion and can be decided according to specific situations of the enterpriser.

The phase of strategic management is gradually developed from the functional application phase. It is a phase when the functional application becomes mature and the informational strategy shows its support. and with the help of the informational support, the enterprise transits from redesigning the internal process to looking for better cooperation and combination with the relative enterprises on supply chains and redesigns the enterprise boundary.

By enhancing the competitiveness of enterprises as well as competitive advantages of products, the informationization strategy becomes a vital part of the enterprise's overall strategy. An informational management department can be founded in which CIO plays an important role on information support in the enterprise's decision making.

The assessment to the strategic management phase is focused on the invisible benefits and strategic benefits while both incomes and invisible benefits are assessed, and it is mainly about the changes of index and the designing of weights.

The four phases of informationization application is suitable for the assessment of informationization. The classification of the four phases is suitable for differentiating and properly setting the indices on both quality and quantity by making the indices more available. Also, it reduces the difficulty of assessing and increases the practicability. What's more, it is suitable for adjusting the indices and weights in different phases which ensures that the assessment is subject and accurate.

55.6 Conclusion

Evaluation of EI is a multi-level and stages dynamic evaluation process. In the evaluation process, the evaluation of EI should combine the application stage to choose the appropriate evaluation index and evaluation method. How to construct the evaluation of EI system depends on the specific industry and enterprise.

Acknowledgments Soft Science Project of Shandong Province. 2011RKGA7066.

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Chapter 56
Supplier Selection Model Based on the Interval Grey Number

Zhi-yong Zhang and Sheng Wu

Abstract Supplier selection plays an important role in the management of purchasing. Decision support tools and methodologies can help managers make more effective decisions. Many tools have been developed with a variety of formal modeling techniques, but these techniques are limited for the reason that they are not available when the criteria value are interval grey numbers. There are many reasons for the criteria values should be expressed by the interval grey numbers. This paper proposes a new approach for the supplier selection which is prepared to deal with the interval grey criteria based on the definition of grey circle/radius and distance degree. The interval criteria value and its whitenization weight function (WWF in shorted) make the model more realistic and accurate. Through a numerical case, on both the theoretical and the practical level, it has been proved that this model is correct and feasible.

Keywords Grey system theory · Grey circle/radius · Interval grey number · Supplier selection

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E. Qi et al. (eds.), *The 19th International Conference on Industrial Engineering and Engineering Management*, DOI: 10.1007/978-3-642-38391-5_56,

56.1 Introduction

Supplier selection is an important part of purchasing management. Usually, the purchase cost could account for the more than 70 % of the total cost of a product. Supplier selection is one of the most important functions of purchasing management (Ghodsypour and O'Brien 1998).

The criteria of supplier selection can be classified as quantitative and qualitative in general. In many cases, the quantitative criteria values of suppliers should be expressed by interval grey numbers. Such as the price, the suppliers always need to define the range of the price interval for bargaining. The range of the price interval is an interval grey number. The profit goal of Ford Motor Company is 15–20 %, so the price is an interval grey number based on target-return pricing. The quality requirement of white carbon black is that PH should between 5 and 8. The delivery performance can be represented by delivery period and quantity. According to international trade sales contract terms, in terms of delivery period, delivery period is always interval grey number. The actual delivery quantity is also interval grey number, because of the human error and unavoidable risk such as natural disasters and damage of cargo etc. So we need a method to select supplier when there are criteria values of interval grey numbers.

The remainder of this paper is organized as follows. Section 56.2 is a literature review of supplier selection methods. The basic concepts and the supplier selection model based on interval grey number are proposed in Sect. 56.3. Then, in Sect. 56.4, an illustrative example presents applying the proposed approach to the supplier selection problem, and then we discuss and show how the method based on the interval grey number is effective. Finally, conclusions are presented in Sect. 56.5.

56.2 Methods of Supplier Selection

Four evaluation models for supplier selection feature prominently in the literature: LW models, the total cost models, the mathematical programming methods and the grey correlation models. Each of these is introduced below.

(1) *Linear-weighting models*: LW models evaluate potential suppliers using several equally weighted factors, and then allow the decision-maker to choose the supplier with the highest total score (Timmerman 1986). Although this method is simple, it depends heavily on subjective judgment. In addition, these models weight the criteria equally, which rarely happens in practice (Min 1994; Ghodsypour and O'Brien 1998).

In contrast to the equal weighting utilized in LW models, AHP is an effective method for providing a structured determination of the weights of criteria by using pair wise comparison to select the best suppliers. Several researchers have used AHP to deal with the supplier selection issues. These include Nydick and Hill

(1992), Barabarosoglu and Yazgac (1997), Tam and Tummala (2001), Bhutta and Huq (2002) and Handfield et al. (2002).

(2) *Total cost of ownership models*: TCO models attempt to include the quantifiable costs that are incurred throughout the purchased item life cycle into the supplier selection model. Monczka and Trecha (1988), Smytka and Clemens (1993), Roodhooft and Konings (1996), Chen and Yang (2003) attempted to integrate the total cost into their evaluation models.

(3) *Mathematical programming methods*: Mathematical programming methods can be used to formulate the supplier selection problem in terms of an objective function to be maximized or minimized by varying the values of the variables in an objective function. Several papers have used single objective techniques to solve the supplier selection issues, these include linear programming (Pan 1989; Ghodsypour and O'Brien 1998), goal programming (Buffa and Jackson 1983; Karpark et al. 1999) or mixed integer programming (Chaudhry et al. 1993; Rosenthal et al. 1995).

(4) *Grey correlation models*: Grey system theory can be used to solve uncertainty problems in cases with discrete data and incomplete information (Deng 2002). It is, therefore, a theory and methodology that deals with poor, incomplete, or uncertain systematic problems. Several papers have used Grey correlation models to select suppliers. These include Tsai et al. (2003), Jadidi et al. (2008) and Yang and Chen (2006).

All the existing methods are effective when the criteria values are real numbers, but it cannot be used for the interval grey number situations. So vendor selection urgently needs a solution for the interval grey criteria. This paper proposes a new model to solve this problem.

56.3 Supplier Selection Based on Interval Grey Numbers

There are many patterns of supplier selections. The pattern in this paper is described as follows: The managers of purchasing department have the criteria value of the ideal referential supplier, the criteria value of ideal referential supplier is called optimum criteria value; we should compare the optimum criteria value with the criteria value of supplier candidates and chose the closest one. We will give some basic concepts and methods for the convenience of the reader to understand.

56.3.1 Basic Concepts

In our research, the value of criteria is an interval grey number, so the criteria value sequences are interval grey sequences.

Definition 1 Liu et al. (2008) if the value ranges is known and exact value is unknown, then this number is called grey number, noted as $\otimes$. If grey number has both upper bound b and lower bound a, then this number is called interval grey number, noted as $\otimes \in [a, b]$.

Definition 2 Zeng et al. (2010) if a sequence is consist of interval grey number, then this sequence is called an interval grey number sequence, noted as

$$X(\otimes) = (\otimes(t_1), \otimes(t_2), \ldots, \otimes(t_n)) \tag{56.1}$$

where

$$\otimes(t_k) \in [a_k, b_k](k = 1, 2, \ldots, n) \tag{56.2}$$

The criteria value with different dimension cannot form comparable criteria value sequence, so criteria value should be transformed to no-dimensional sequence. Standardization method is a mostly-used dimensionless method, and the mean method is better than the former (Guo et al. 2011). But for Interval grey criteria sequence, there are no existing methods that can transform the sequence to no-dimensional sequence.

Now, we give a method as following: we can just transform the midpoint sequence of interval grey criteria value, and the lengths of interval grey number are invariant. The midpoint can be calculated according to (56.3) and be transformed to no-dimensional sequence according to (56.4).

$$m_{ik} = \overline{a}_{ik} + \frac{\overline{a}_{ik} + \overline{b}_{ik}}{2} \tag{56.3}$$

$$m'_{ik} = \frac{m_{ik}}{\bar{m}_k} \tag{56.4}$$

Where $\bar{a}_{ik}$ is the lower bound of criteria k and $\bar{b}_{ik}$ is the upper bound of criteria k. $\bar{m}_k$ is the mean value of the midpoints' value of criteria k.

Definition 3 Liu et al. (2008) if the starting point and endpoint of the function are determined and the graph of the function is left up, right down, this function is called typical whitenization weight function (TWWF in short), see Fig. 56.1.

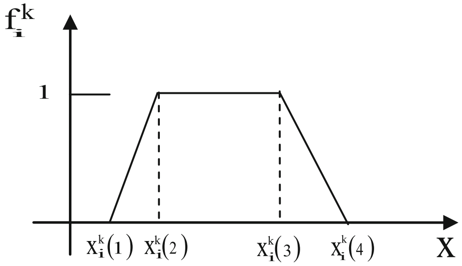

Fig. 56.1 Typical whitenization weight function

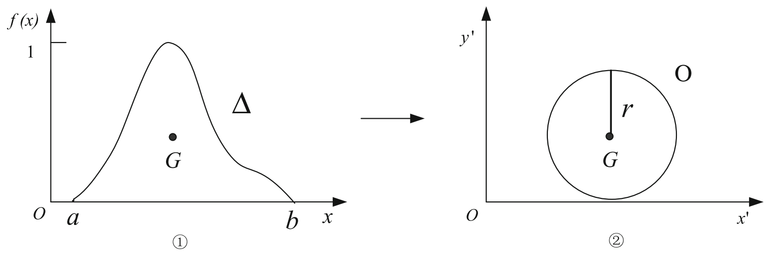

Fig. 56.2 Grey figure/center and grey circle/radius

Where $x_i^k(1)$, $x_i^k(2)$, $x_i^k(3)$, $x_i^k(4)$ are called the turning points of $f_i^k(x)$.

TWWF can be used to describe the probability that the grey interval criteria take values in its range. TWWF of interval grey criteria value can be determined by experience of the purchasing managers.

In order to describe the geometrical characteristic of interval grey criteria value and its TWWF, we proposed the definition of grey figure and grey point as follow:

Definition 4 The figure combined by interval grey line and WWF is called grey figure, noted as △, Grey figure's gravity center is called grey center, noted as G, see Fig. 56.2①. The circle which has the equal area with grey figure is called grey circle, noted as O, it's radius is called grey radius, noted as *r*, see Fig. 56.2②.

56.3.2 Fundamental Idea

The fundamental idea of this paper is that we calculate a grey closeness degree between the compared supplier alternatives set and the ideal referential supplier alternative to determine the ranking order of all alternatives of supplier and to select the ideal supplier based on interval grey numbers.

Firstly, the quantitative criteria should be converted into the proper dimensionless indexes, and regard the dimensionless criteria value of supplier as an interval grey number sequence. Then, map the interval number sequence and its WWF on the rectangular coordinates system, see Fig. 56.3.

We assume that $\Re_i$ is the grey figure sequence of CS_i and $\Re_0$ is grey figure sequence of the ideal referential supplier. The closeness degree between $\Re_i$ and $\Re_0$ is judged based on the similarity level of grey figure and the distance between them. The similarity level of grey figure is represented by the difference between grey radius and the distance between grey figures is represented by the grey point's distance.

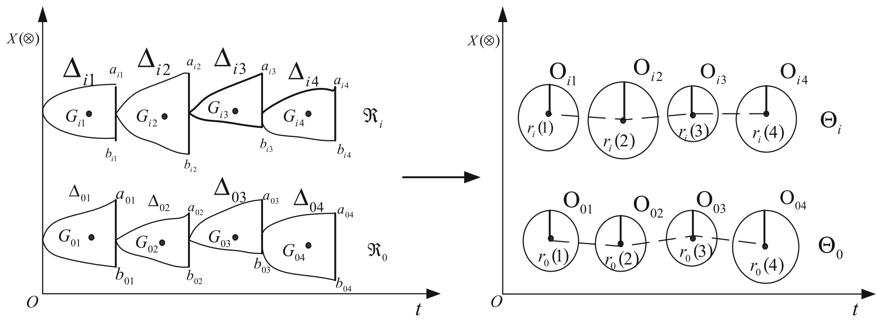

Fig. 56.3 Geometric patterns of interval criteria value

56.3.3 Specific Methodology

The specific methodology of this model is mainly includes the following steps:

Step 1 Calculate the Grey points' horizontal ordinate sequence and vertical ordinate sequence according to (56.5) and (56.6).

$$\bar{x}_i(t_k) = k - \frac{2x_i^k(3) + x_i^k(4) - 2x_i^k(2) - x_i^k(1)}{3[x_i^k(3) + x_i^k(4) - x_i^k(2) - x_i^k(1)]} \tag{56.5}$$

$$\bar{y}_i(t_k) = \frac{\left[x_i^k(4)\right]^2 + x_i^k(3) \cdot x_i^k(4) + \left[x_i^k(3)\right]^2 - \left[x_i^k(2)\right]^2 - \left[x_i^k(1)\right]^2 - x_i^k(1) \cdot x_i^k(2)}{3[x_i^k(3) + x_i^k(4) - x_i^k(2) - x_i^k(1)]} \tag{56.6}$$

Where $x_i^k(1)$ is the turning point of TWWF.

Step 2 Calculate the distance between grey points according to (56.7).

$$d_{0i}(t_k) = \sqrt{[\bar{x_i}\ (t_k) - \bar{x_0}\ (t_k)]^2 + [\bar{y_i}\ (t_k) - \bar{y_0}\ (t_k)]^2} \tag{56.7}$$

Where $\bar{x_i}\ (t_k)$, $\bar{y_i}\,(t_k)$ are the grey points' horizontal ordinate and vertical ordinate of supplier candidate i, $\bar{x_0}\ (t_k)$, $\bar{y_0}\,(t_k)$ are the grey points' horizontal ordinate and vertical ordinate of ideal referential supplier.

The longer of the grey points distance the smaller the similarity of different sequence. So the distance degree (noted as D_{i0}) is calculated according to (56.8).

$$D_{0i}(t_k) = \left[\sum_{i=1}^{m}\sum_{k=1}^{n} d_{i0}(t_k) - \sum_{k=1}^{n} d_{i0}(t_k)\right] - d_{i0}(t_k) \tag{56.8}$$

Step 3 Calculate the weight that reflects the difference of the circle's radius which has the equal area with grey figure according to (56.9) and (56.10).

$$\omega'_{0i}(k) = \frac{1 - \sigma'_{0i}(k) \Big/ \sum_{k=1}^{n} \sigma'_{0i}(k)}{n-1} \tag{56.9}$$

$$\sigma'_{0i}(k) = \left| \sqrt{\frac{x_i^k(3) + x_i^k(4) - x_i^k(1) - x_i^k(2)}{2\pi}} - \sqrt{\frac{x_0^k(3) + x_0^k(4) - x_0^k(1) - x_0^k(2)}{2\pi}} \right| \tag{56.10}$$

Step 4 Compute the weighted sums of grey point's distance by use of the weight in step 3.

56.4 Case study

In this section, we will concentrate on how to apply the new supplier selection method based on interval grey number to evaluate vendors. It is not our intention to develop an evaluation model with considering all criteria as mentioned above. Therefore, this paper will only provide a feasibility study on the new model for vendor evaluations.

56.4.1 Selection of Criteria

In a review of earlier research, Dickson (1966) identified 23 different criteria as having been used in the supplier selection process—including quality, delivery, price, technical capability, and financial position. A review of 74 supplier selection articles by Weber et al. (1991) founds that cost, product quality, delivery performance, and supply capacity were most frequently used as selection criteria. The five criteria select by Amir et al. (2010) were product quality, delivery performance, price, technical capability and tenacity. Four criteria are accepted by most researchers, there are price, product quality, delivery performance and technical capability.

56.4.2 The Application of Supplier Selection Method Based on Interval Grey Number

Before using the new method, quantitative criteria should be converted into the proper dimensionless indexes. The processed information of five candidate suppliers is present in Table 56.1. The turning point of WWF is present in Table 56.2

Table 56.1 Processed information of candidate suppliers

CS	Criteria			
	Price	Quality	Delivery performance	Technical capability
1	[75,81]	[88,93]	[28,32]	[96,98]
2	[81,85]	[92,96]	[25,31]	[92,96]
3	[78,80]	[79,81]	[40,46]	[89,92]
4	[90,94]	[91,95]	[33,40]	[82,88]
5	[85,88]	[84,88]	[25,27]	[78,83]

Table 56.2 Turning point of processed information of candidate suppliers

Turning point of CS	Criteria			
	Price	Quality	Delivery performance	Technical capability
1	(78,81)	(89,92)	(29,32)	(97,98)
2	(81,83)	(94,95)	(25,30)	(94,94)
3	(79,79)	(79,80)	(42,44)	(90,91)
4	(92,94)	(93,93)	(35,38)	(84,86)
5	(86,87)	(86,88)	(26,26)	(80,83)

Step 1 Purchasing department (PD in short) determines the optimum interval grey value of criteria, and the processed data is presented in Table 56.3. The turning points of the optimum interval grey criteria value's WWF function are present in Table 56.4.

Step 2 Calculate the distance between grey points.

Firstly, calculate the grey point's horizontal ordinates and vertical coordinates, see Tables 56.5 and 56.6.

Then, calculate the distance and distance degree between grey points of the optimum criteria value and the suppliers' criteria value respectively, see Tables 56.7 and 56.8.

Table 56.3 Processed optimum criteria

Criteria			
Price	Quality	Delivery performance	Technical capability
[76,80]	[89,93]	[30,33]	[96,98]

Table 56.4 Turning point of whitenization weight function

	Criteria			
	Price	Quality	Delivery performance	Technical capability
Turning point	(78,80)	(90,92)	(32,32)	(96,97)

Table 56.5 Grey points horizontal ordinates

CS	Horizontal ordinate			
	Price	Quality	Delivery performance	Technical capability
CS1	0.556	1.542	2.542	3.556
CS2	0.533	1.6	2.515	3.667
CS3	0.667	1.556	2.583	3.583
CS4	0.556	1.667	2.567	3.583
CS5	0.583	1.556	2.667	3.542
PD	0.556	1.556	2.667	3.556

Table 56.6 Grey points horizontal ordinates

CS	vertical ordinate			
	Price	Quality	Delivery performance	Technical capability
CS1	78.667	90.5	30.238	97.222
CS2	82.556	94.2	27.758	94
CS3	79	79.778	43	90.5
CS4	92.444	93	36.5	85
CS5	86.5	86.444	26	80.958
PD	78.444	91	32.667	96.778

Table 56.7 Distance between grey points

CS	Distance $d_{i0}(t_k)$			
	Price	Quality	Delivery performance	Technical capability
CS1	0.223	0.500	2.432	2.049
CS2	4.112	3.200	4.911	3.359
CS3	0.567	11.222	10.333	6.581
CS4	14	2.003	8.834	11.942
CS5	8.056	4.556	6.667	15.948

Step 3 calculates the weight that reflects the difference between the area of the optimum grey figures and compared figures, which are noted as $\omega_{PD\cdot CS_i}(k)$, see Table 56.9.

Step 4 Compute the weighted sums of grey point's distance by the use of weights in step 3.

$$\mathrm{SC1} = 109.834 \quad \mathrm{SC2} = 96.666 \quad \mathrm{SC3} = 81.762$$
$$\mathrm{SC4} = 78.022 \quad \mathrm{SC5} = 73.193$$

So, candidate supplier 1 is selected

Table 56.8 Distance degree between grey points

	Distance degree $D_{i0}(t_k)$			
	Price	Quality	Delivery performance	Technical capability
CS1	111.33	111.053	108.553	109.505
CS2	96.411	97.767	95.725	97.608
CS3	88.584	78.151	79.151	82.546
CS4	71.865	83.862	82.365	73.909
CS5	73.707	77.207	74.761	68.816

Table 56.9 Weights that reflects the grey figure difference

	$\omega_{PD \cdot CS_i}(k)$			
	Price	Quality	Delivery performance	Technical capability
CS1	0.290	0.107	0.269	0.333
CS2	0.333	0.22	0.255	0.191
CS3	0.203	0.243	0.253	0.3
CS4	0.333	0.252	0.279	0.135
CS5	0.292	0.333	0.143	0.232

56.5 Conclusion

The ultimate goal of supplier selection is to select appropriate suppliers that can provide faster delivery, lower cost and better quality, and further to increase the corporate competitiveness. But the information of delivery, prize, quality and technical capability is usually uncertain, and the criteria values might be interval grey numbers. This problem could not be solved by the existing methods. So we put forward a new method based on the interval grey number.

The method, in this paper, could deal with the supplier selection problem in an uncertain environment. Though it was demonstrated that the new method, which is used to select the best supplier, it is a good means of evaluation. The proposed model has two disadvantages.

(1) The interval grey value of criteria is not easy to obtain in practice. Because the suppliers' information which existing evaluation methods needed is real number, there is little interval grey information in hand.

(2) There is no existing scientific method to determine the WWF of the interval grey criteria value. Most WWFs could only be determined by the experience of the managerial and/or the technical staffs.

Our suggestions are, Firstly, establish an interval grey information system for the supplier selection of your department. Secondly, study the appropriate method for determining the interval grey criteria value's WWF.

After all, the new model should be widely applied for supplier selection in practices. In comparison with other models, this model is more applicable and effective.

Acknowledgments This research is supported by Beijing Municipal Education Commission (SZ 201010037015) and partly supported by the Researching Platform of Logistics management and Engineering of Beijing Wuzi University.

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Chapter 57
The Accuracy Improvement of Numerical Conformal Mapping Using the Modified Gram-Schmidt Method

Yi-bin Lu, De-an Wu, Ying-zi Wang and Sha-sha Zheng

Abstract In this paper, a method to improve the accuracy of numerical conformal mapping is considered. This method calculates new charge points using a generalized eigenvalue problem, the matrix of which is calculated using the modified Gram-Schmidt method. We illustrate the efficiency of the proposed method by some numerical results.

Keywords Generalized eigenvalue problem · Modified gram-schmidt method · Numerical conformal mapping · Vandermonde matrix

57.1 Introduction

Conformal mapping theory has been widely applied in the fluid dynamics and many other fields with a strong vitality. Computing conformal mapping is a very difficulty question. Amano et al. have achieved many numerical results on the studies of the charge simulation method for conformal mappings (Amano 1987, 1988a, b, 1994) in which the charge points is often gained by experience. On the other hand, Sakurai and Sugiura proposed a numerical method for conformal mappings by using Padé approximation (Sakurai and Sugiura 2002), allows the

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E. Qi et al. (eds.), *The 19th International Conference on Industrial Engineering and Engineering Management*, DOI: 10.1007/978-3-642-38391-5_57,

charge points to be computed automatically. High accuracy of numerical conformal mappings can be gained through a few charge points by using Padé approximations, but numerical accuracy is degraded when exceeding a certain number of charge points.

A numerical method is proposed for conformal mapping in this paper that resolves this accuracy issue. First we introduce how to compute charge points using the charge simulation method and the Padé approximations. We then construct the generalized eigenvalue problem using two diagonal matrices and a vandermonde matrix for obtaining new charge points (Niu and Sakurai 2003a, b). A highly accurate orthonormal matrix is constructed for solving the generalized eigenvalue problem using the modified Gram-Schmidt method (Golub and Van Loan 1996; Saad 2003). The numerical accuracy of conformal mapping is improved. Some numerical results are presented to demonstrate the efficiency of the proposed method.

57.2 Computing Charge Points

There is a conformal mapping from a domain D exterior to a closed Jordan curve C in the z plane onto the exterior of the unit disk $|w| > 1$ in the w plane. Without lose generality, we assume that the origin $z = 0$ lies in D and $f(0) = 0$. Then the mapping functions

$$f(z) = \frac{z}{\gamma}\exp(g(z) + ih(z))$$

are uniquely determined by the normalization conditions $f(\infty) = \infty$ and $f'(\infty) > 0$ (Amano 1988a), and $g(z)$ is the solution of the dirichlet problem of exterior

$$\begin{cases} \nabla^2 g(z) = 0, & z \in D \\ g(z) = \log\gamma - \log|z|, & z \in C \\ g(\infty) = 0 \end{cases}$$

where γ is the radius of mapping and $h(z)$ is conjugate harmonic function of $g(z)$ in D. The charges $q_1, \ldots, q_N$ can be calculated at the charge points $\zeta_1, \ldots, \zeta_N$ arranged inside the boundary C and the collocation points $z_1, \ldots, z_N$ arranged on the boundary C by

$$\begin{cases} \sum_{j=1}^{N} q_j log|z_i - \zeta_j| = log|z_i| - log\Gamma\,(i = 1, 2, \ldots, N) \\ \sum_{j=1}^{N} q_j = 0 \end{cases}$$

in the charge simulation method, where Γ is an approximation to γ (Amano 1988a).

Let $E(z)$ be the rational expression

$$E(z) := \sum_{j=1}^{N} \frac{q_j}{z-\zeta_j} = \tilde{\mu}_1 z^{-1} + \tilde{\mu}_2 z^{-2} + \cdots,$$

the residue theorem implies that

$$\tilde{\mu}_k = \sum_{j=1}^{N} q_j \zeta_j^{k-1}, k = 1, 2, \cdots. \tag{57.1}$$

Application of the Padé approximations yields $E(z) \approx A(z)/B(z)$, where $A(z) = a_0 + \sum_{j=1}^{n-1} a_j z^j$ and $B(z) = \sum_{j=0}^{n-1} b_j z^j + z^n$.

Let $\tilde{H}_n$ be the $n \times n$ Hankel matrix

$$\tilde{H}_n := [\tilde{\mu}_{j+k+1}]_{j,k=0}^{n-1}, \tag{57.2}$$

then the coefficient vector $x = [b_0, b_1, \ldots, b_{n-1}]^{\mathrm{T}}$ of $B(z)$ can be obtained by solving $\tilde{H}_n x = m$ in (Stewart 1973), where $m = -[\tilde{\mu}_{n+1}, \tilde{\mu}_{n+2}, \ldots, \tilde{\mu}_{2n}]^{\mathrm{T}}$.

The zeros of $B(z)$ can be regarded as new charge points calculated by using Padé approximations when a high accuracy result of the charge simulation method is gained. Thus the charge points are computed automatically. This numerical method for conformal mappings using the charge simulation method and the Padé approximations was originally proposed by Sakurai and Sugiura (2002). When increasing the number of charges n gained by Padé approximations, the solution x is not accurate because $\tilde{H}_n$ is ill conditioned (Tyrtyshnikov 1994). Then the zeros of $B(z)$ can not be calculated accurately.

57.3 Improving the Accuracy

In this section, the problem of computing new charge points is transformed to solving the generalized eigenvalue problem, in which an orthonormal matrix Q is calculating by using the modified Gram-Schmidt method.

Let $\tilde{H}_n^{<}$ be the $n \times n$ shifted Hankel matrix

$$\tilde{H}_n^{<} := [\tilde{\mu}_{j+k+2}]_{j,k=0}^{n-1}. \tag{57.3}$$

Note, in the formula above, that the elements of $\tilde{H}_n^{<}$ are defined via (57.1). Thus from (57.2) and (57.3), new charge points can be gained by calculating the generalized eigenvalue problem $\tilde{H}_n^{<} x = \lambda \tilde{H}_n x$, instead of calculating the roots of $B(z)$ (Kravanja et al. 1999, 2003; Sakurai et al. 2003).

Let V be the $N \times n$ Vandermonde matrix

$$V := \begin{bmatrix} 1 & \zeta_1 & \zeta_1^2 & \cdots & \zeta_1^{n-1} \\ 1 & \zeta_2 & \zeta_2^2 & \cdots & \zeta_2^{n-1} \\ 1 & \zeta_3 & \zeta_3^2 & \cdots & \zeta_3^{n-1} \\ \vdots & \vdots & \vdots & \ddots & \vdots \\ 1 & \zeta_N & \zeta_N^2 & \cdots & \zeta_N^{n-1} \end{bmatrix},$$

$$D_N := \mathrm{diag}(q_1, q_2, \ldots, q_N),\ Z_N := \mathrm{diag}(\zeta_1, \zeta_2, \ldots, \zeta_N). \tag{57.4}$$

Then, from (57.1) it can be verified that

$$\tilde{H}_n = V^T D_N V,\ \tilde{H}_n^< = V^T D_N Z_N V. \tag{57.5}$$

Here, V can be expressed as

$$V = \tilde{Q}\tilde{R} = [Q, Q'] \begin{bmatrix} R \\ O \end{bmatrix} = QR \tag{57.6}$$

for QR decomposition, where $Q \in \mathrm{C}^{N\times n}$, $Q' \in \mathrm{C}^{N\times(N-n)}$. $\tilde{Q} \in \mathrm{C}^{N\times N}$ is an unitary matrix, and $\tilde{R} \in \mathrm{C}^{N\times n}$ is expressed as

$$\tilde{R} = \begin{bmatrix} R \\ O \end{bmatrix}.$$

In the matrix above, $R \in \mathrm{C}^{n\times n}$ is an upper triangular matrix and $O \in \mathrm{C}^{(N-n)\times n}$ is a zero matrix.

Note that V is the Vandermonde matrix constructed by the mutually distinct charge points $\zeta_1, \ldots, \zeta_N$, thus the numbers of linearly independent rows and columns of V are N and n, respectively. Therefore we have

$$\mathrm{rank}(V) = n. \tag{57.7}$$

By comparing the rank of various matrices via (57.6), it follows that

$$\mathrm{rank}(V) = \mathrm{rank}(QR) \le \mathrm{rank}(R). \tag{57.8}$$

Since R is the $n \times n$ matrix, then

$$\mathrm{rank}(R) \le n. \tag{57.9}$$

From (57.8) and (57.9), we can verify that

$$\mathrm{rank}(R) = n. \tag{57.10}$$

Therefore the upper triangular matrix R is a regular matrix. Then the eigenvalues can be described as the following theorem.

Theorem *The eigenvalues of* $\tilde{H}_n^< - \lambda \tilde{H}_n$ *are equal to the eigenvalues of* $Q^T D_N Z_N Q - \lambda Q^T D_N Q$.

Proof From (57.5), it can be obtained that

$$\det(\tilde{H}_n^{<} - \lambda \tilde{H}_n) = \det(V^T D_N Z_N V - \lambda V^T D_N V).$$

Then it follows from (57.6) that

$$\begin{aligned}\det(\tilde{H}_n^{<} - \lambda \tilde{H}_n) &= \det(R^T Q^T D_N Z_N QR - \lambda R^T Q^T D_N QR)\\ &= \det(R^T (Q^T D_N Z_N Q - \lambda Q^T D_N Q)R)\\ &= \det(R^T)\det(R)\det(Q^T D_N Z_N Q - \lambda Q^T D_N Q).\end{aligned}$$

Since R is the regular matrix via (57.10), then

$$\det(R^T) \neq 0,\ \det(R) \neq 0.$$

Therefore, it can be verified that

$$\det(\tilde{H}_n^{<} - \lambda \tilde{H}_n) = 0$$

and

$$\det(Q^T D_N Z_N Q - \lambda Q^T D_N Q) = 0 \tag{57.11}$$

have identical eigenvalues. Thus the theorem is proved.

The theorem implies that the eigenvalues $\lambda_1, \ldots, \lambda_n$ can be gained by (57.11). We obtain the following algorithm for numerical conformal mapping from the discussions in this section. The approximate charge points of Padé approximations are obtained by solving (57.11). Then the mapping functions can be calculated through the use of $\lambda_1, \ldots, \lambda_n$ by calculating the charge simulation method.

Algorithm

1. Give the charge number n of the Padé approximations and the charge number N of the charge simulation method, the collocation points $z_1, \ldots, z_N$, and the charge points $\zeta_1, \ldots, \zeta_N$.
2. Calculate the charges $q_1, \ldots, q_N$ by using the charge simulation method.
3. Calculate diagonal matrices D_N and Z_N by (57.4).
4. Construct the matrix Q.
5. Calculate the eigenvalues $\lambda_1, \ldots, \lambda_n$ of the pencil $Q^T D_N Z_N Q - \lambda Q^T D_N Q$.
6. Calculate conformal mapping by the charge simulation method regarding $\lambda_1, \ldots, \lambda_n$ as charge points.

It is necessary to obtain Q in step 4 to calculate the generalized eigenvalue problem in the algorithm. The modified Gram-Schmidt method is considered for construction of Q (Table 57.I). Here V is constructed as

$$V = [u, Z_N u, Z_N^2 u, \ldots, Z_N^{n-1} u],$$

where $u = [1, 1, \ldots, 1]^T$. In the Krylov subspace

Table 57.1 Construction of Q

$r_{11} = \|\|u\|\|,\ q_1 = u/r_{11},\ p = u$
for $k = 2, 3, \ldots, n$
$p = Z_N p$
for $j = 1, 2, \ldots, k-1$
$r_{jk} = (p,\ q_j), \quad p = p - r_{jk} q_j$
end
$r_{kk} = \|\|p\|\|,\ q_k = p/r_{kk}$
end

$$k_n(Z_N,\ u) = \mathrm{span}(u, Z_N\ u, Z_N^2\ u, \ldots, Z_N^{n-1}\ u)$$

is expressed using column vectors of V with the construction of $Q = [q_1, q_2, \ldots, q_n]$.

57.4 Numerical Example

In this section, we provide the numerical example of the charge simulation method and the proposed method. We draw a comparison between the proposed method and the charge simulation method. The algorithm of the charge simulation method is denoted by M0. In contrast, the proposed algorithm by using the modified Gram-Schmidt method is referred to as M1. On a Microsoft Windows operating system, the calculations were performed by using Matlab. The numerical error is defined as the maximal distance from the point which is the map of the point on the boundary C in the z plane, onto the circumference of the unit circle in the direction of radius in the w plane. Here the eigenvalues of $Q^T D_N Z_N Q - \lambda Q^T D_N Q$ were calculated by using the eig command in Matlab.

Example Exterior of trochoid: the boundary is given by

$$\begin{cases} x = 0.9\cos t + 0.1\cos 3t \\ y = 0.9\sin t - 0.1\sin 3t \end{cases}.$$

Collocation points and charge points in the charge simulation method are placed by (Watanabe 1984).

In Fig. 57.1, the error curves of the conformal mappings by various numerical calculation methods are shown. The results of charge simulation with $N = 200$ were used for the calculation of (57.1). The accuracy of M1 is superior to M0. M1 gained the best accuracy at $n = 29$. Figure 57.2 showed the locations of the charge points for M1 at $n = 29$. From the results of example, we see that the accuracy of

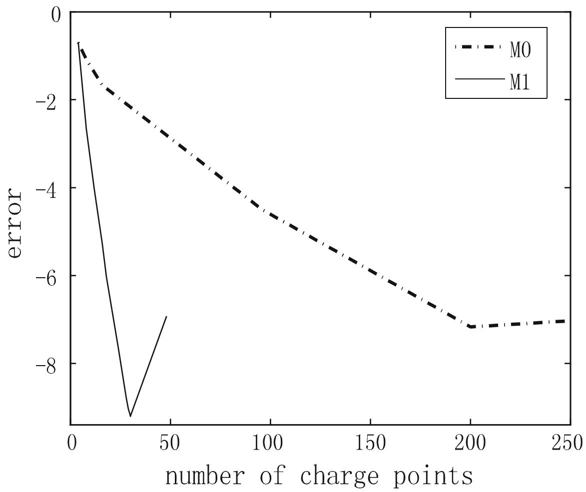

Fig. 57.1 Errors of conformal mappings

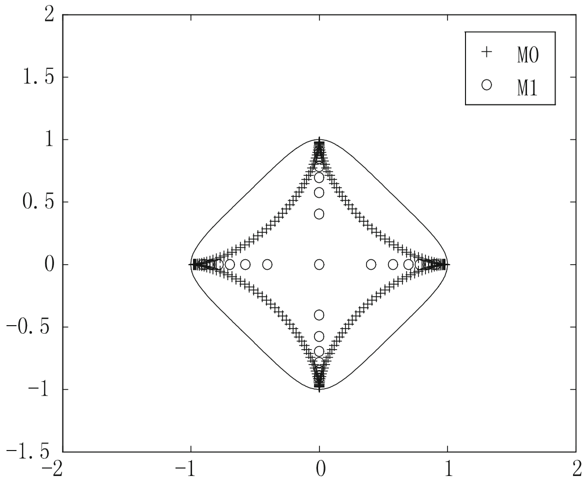

Fig. 57.2 Locations of charge points ($N = 200$, $n = 29$)

M1 is superior to M0. Figure 57.3 shows the exterior of the trochoid. The conformal mapping of Fig. 57.3 computed by M1 at $n = 29$ is shown in Fig. 57.4. From the result of M1 in Fig. 57.4, we see that the boundary of the trochoid is well mapped onto the unit circle.

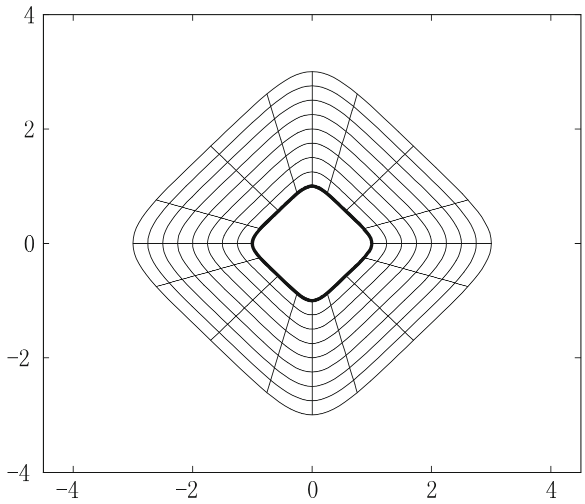

Fig. 57.3 Exterior of trochoid

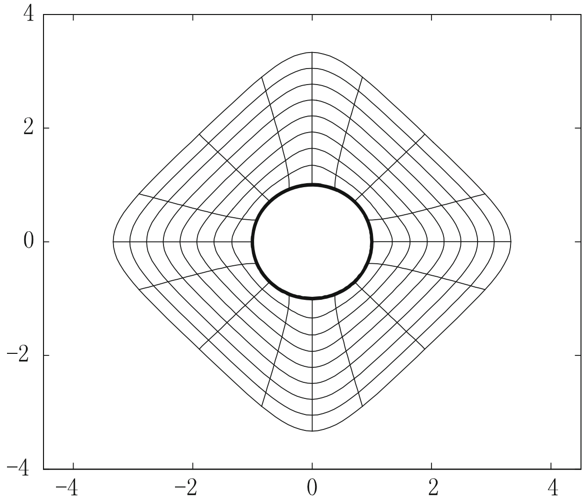

Fig. 57.4 Conformal mapping of fig. 57.3 (M1)

57.5 Conclusions

In this paper, a numerical method using the modified Gram-Schmidt method has been proposed for improving the accuracy of conformal mapping. The applicability of our method has been demonstrated with numerical results. The accuracy of conformal mapping by the proposed method is better than achievable by the charge simulation method. The error analysis for the proposed method will be investigated in the future.

Acknowledgement This work is supported by Yunnan Provincial Natural Science Foundation of China under Grant No. 2011FZ025, and Fundamental Research Funds for the Central Universities of China, No. ZYGX2010J111

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Chapter 58
The Application of AHP in Biotechnology Industry with ERP KSF Implementation

Ming-Lang Wang, H. F. Lin and K. W. Wang

Abstract This research focused on the production of Phalaenopsis, particularly in its implementation of enterprise resources planning, dimensions and the adoption of AHP (Analytical Hierarchy Process). The importance of assessment index and its attributes were reviewed. The results from this research have shown that factors that led to the incorporation of ERP Key Success Factor in the Biotechnology Industry (KSF) were employees' training, the full support from executives in ERP system integration, communication with company, assistance in training and technology transfer, real-time and system accuracy and efficiency and flexibility in resources allocation. The results from this study will benefit the Biotechnology industry in understanding the important factors that contributed to the success of ERP, and thus is instrumental for the development of products and marketing strategies. It serves as a reference for breaking into the renovation market.

Keywords Enterprise resource planning (ERP) · Key success factor (KSF) · Analytical hierarchy process (AHP)

58.1 Introduction

The application of ERP system is very complex and relies on background and motivation. Performance management and analysis of the KSF are required to ensure successful application of the ERP system in the biotechnology industry (Wong and Keng 2008). To cope with the competitive orchid market in Taiwan in

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E. Qi et al. (eds.), *The 19th International Conference on Industrial Engineering and Engineering Management*, DOI: 10.1007/978-3-642-38391-5_58,

the future, it is necessary to reduce capital, increase profit and enhance competitiveness. The objective of this study is to explore enterprise resource planning in the KSF-Biotechnology industry for effective integration of ERP system (Li et al. 2007). A clear picture of ERP implementation will promote biotechnology industry's market.

Based on the above mentioned research backgrounds and motives, this sturdy is intended for realizing the following purposes: (1) To consolidate and summarize the literature of KSF of ERP SYSTEM implementation; (2) To understand the KSF of ERP SYSTEM implementation; (3) To understand the difficulties and obstacles encountered at each stage of ERP system implementation and solution to overcome.

58.2 Literature Review

58.2.1 Enterprise Resource Planning System

ERP is short for Enterprise Resource Planning, conceptualized by the Gartner Group in the early 1990s. Davenport (1998) had viewed ERP as a technology for enterprise information integration with a simple database as its core. The database pools and processes various commercial activities within the enterprise according to the functions, department and regions. Through the internet it creates a network for data sharing and supports application modules to comply with policies, organizational characteristics and corporate culture. The integration of ERP system can maximize efficiency in planning, management, control and utilization of corporate resources.

58.2.2 Key Success Factor

Daniel (1961) was one of the first to propose the concept of Key Success Factor (KSF) or critical success factor. It was highlighted that the success of most industry is determined by three to six factors, such are known as the KSF. KSF after which economist Commons (1974) referred to as the "limiting factor" and had the concept applied in economy management and negotiation. Thereafter Barnard (1976) applied the concept in management decision making theory. He considered the analysis required for decision making was essentially looking at "strategic factors". In addition, Tillett (1989) applied the concept of strategic factors to dynamic system theory. He viewed that the ample resources of an organization was the key factor. Policies were established to maintain and ensure maximum utilization of resources. In addition, they were important in resources forecast. KSF is the top priority in industrial analysis. It is important in the management of control variables, as well as the source of competitive advantage.

In recent years, policy management has overtaken "information system management" which was the main focus in earlier research. KSF has thus being applied in areas beyond information system management.

58.2.3 The Blue Gold of Biotechnology Industry: Phalaenopsis

Taiwan is known as the kingdom of orchids. The suitable climate, environment and along with government policies and effort in related measures have placed Taiwan's orchid industry in a pivotal position in the international arena. The sales of Phalaenopsis, Oncidium and Paphiopedium (from Xinxing) rank first in the world. The production process of Phalaenopsis is divided into three stages. The upstream development involves development and species identification, breeding, propagation; the middle stream carries out domestication, small seedlings, medium seedling, large seedling, growing and harvesting; while logistics, marketing and branding are steps in the downstream pathway. The application of key technology and its importance varies among the three production stages. At upstream, the value-added of breeding and seedling is higher than development, identification and seedlings. In the middle stages, the value-added of the flowering and seedling stages is higher than growing, harvesting and domestication. While in the downstream stage, the value-added of logistics, channels, brand and marketing is higher than cash flow and information flow (Huang et al. 2008).

With government guidance, the production of Phalaenopsis has moved toward mass production. The stringent computerized monitoring on production and cultivation management, in addition a large demand from the domestic and international market has led to the expansion of the production lines across cities and nation-wide. Apart from "Taiwan Orchid bio Park", the national orchid industry has also established the Taiwan Orchid Growers Association (TOFA), which aims to promote production and sale of orchids, to develop domestic and foreign markets, to improve marketing strategy and to assist Taiwanese government in policy making for the flora industry.

58.3 Methodology

58.3.1 Brief Description and Purpose of AHP

The purpose of AHP analysis is to simplify complex problems into elementary hierarchy system. It gathers scholars, experts and decision makers at all levels for comparison between pairs of elements, also known as Pair wise Comparison. Upon quantization, comparative matrix pairs (Pair wise Comparison Matrix) is established according to the matrix of eigenvectors (Eigenvector). Thereafter the elements of the vector are employed to establish a hierarchy of priorities and thus finding the largest eigenvalue. This value provides a reference point for policy makers in decision making by assessment of the relative strength between the Pair wise Comparison Matrix consistency indexes. The consistency index is made up of at least two levels, while AHP links all levels in deriving the AHP hierarchy among the various factors of relative priority and strength. This is followed by AHP connecting all the Consistency Index and Consistency Ratio before the final evaluation of the high and low levels consistency of the hierarchy.

58.3.2 Hypothesis of AHP

In "The features and application of hierarchy analysis method" by Deng Zhengyuan, Zeng Guoxiong (1989), it was mentioned that the basic assumptions of AHP analysis included 9 of the following:

(1) A system can be broken down into a number of classes or components to form a network-level structure.
(2) Each level is assumed independent within the hierarchy.
(3) The factors within each level make use some of or all of the factors in the level above for assessment and evaluation.
(4) Absolute values can be converted to a Ratio Scale in comparative assessment.
(5) Regular matrix can be employed after Pair wise Comparison.
(6) Preferential relations satisfy transitivity.
(7) Consistency level needs to be measured in case of transitivity.
(8) The degree of advantage of factors is evaluated by the Weighting Principle.
(9) For elements that appear in the class structure, they are considered and assessed as a whole structure (regardless of their strength), rather than of independent of review class structure.

58.3.3 Design of a Questionnaire

To study the KSF and their role in ERP implementation, the questionnaire was divided into two parts:

(1) *First Stage Questionnaire*: (1) Target audience: the junior and middle management level of companies involved in ERP system; (2) The company's key success factors of ERP.
(2) *Second Stage Questionnaire*: (1) Target audience: the junior and middle management level of companies involved in ERP system; (2) The part was based on the first part and had the factors that contributed to the success of ERP analyzed.

(3) *The aim was to seek the relative importance of KSF*: (1) the motive behind companies in ERP implementation; (2) The second level as the measurement index: the four dimensions: internal factors, ERP system features, ERP software support, results followed by ERP implementation; (3) Third level gauged the KSF of second level indexes.

58.3.4 Research Structure

See Fig. 58.1.

58.4 Results

58.4.1 Analysis and Results of First Stage Questionnaire

This section covered the first stage of the analysis. Its target audience was the junior and middle management level of the companies that was involved in successful ERP system integration. Out of the total of 20 questionnaires issued, 14 were received. Of those received 13 were valid questionnaires after omitting one that was incomplete (70 % completed). Likert's five-point level score system was used for data mining. The reliability of this study was summarized by Cronbach' s α coefficients where the reliability α of the four dimensions in ERP implementation fell within the range of $0.50 < \alpha < 0.90$. It is thus a good indicator of the research's reliability and value (Wang 2004).

58.4.2 Analysis and Results of Second Stage Questionnaire

(1) Subjective measurement of AHP analysis

Consistency ratio (C.R.) was subjected to ensure questionnaire answers lie within the valid range in a consistent manner. The measurement of the consistency ratio in each level was found to be less than 0.1 in all the levels, whether as a whole factor (first level), internal factor (second level), ERP system features (third level) or the ERP software support. The C.R values were listed in Table 58.1 Results has shown the factors within the hierarchy were closely related and consistent. Since there were only two factors for comparison in the second level, it was found to be consistent (A > B or A < B) and hence no calculation was required. In conclusion, C.R was not applicable in the results of ERP implementation.

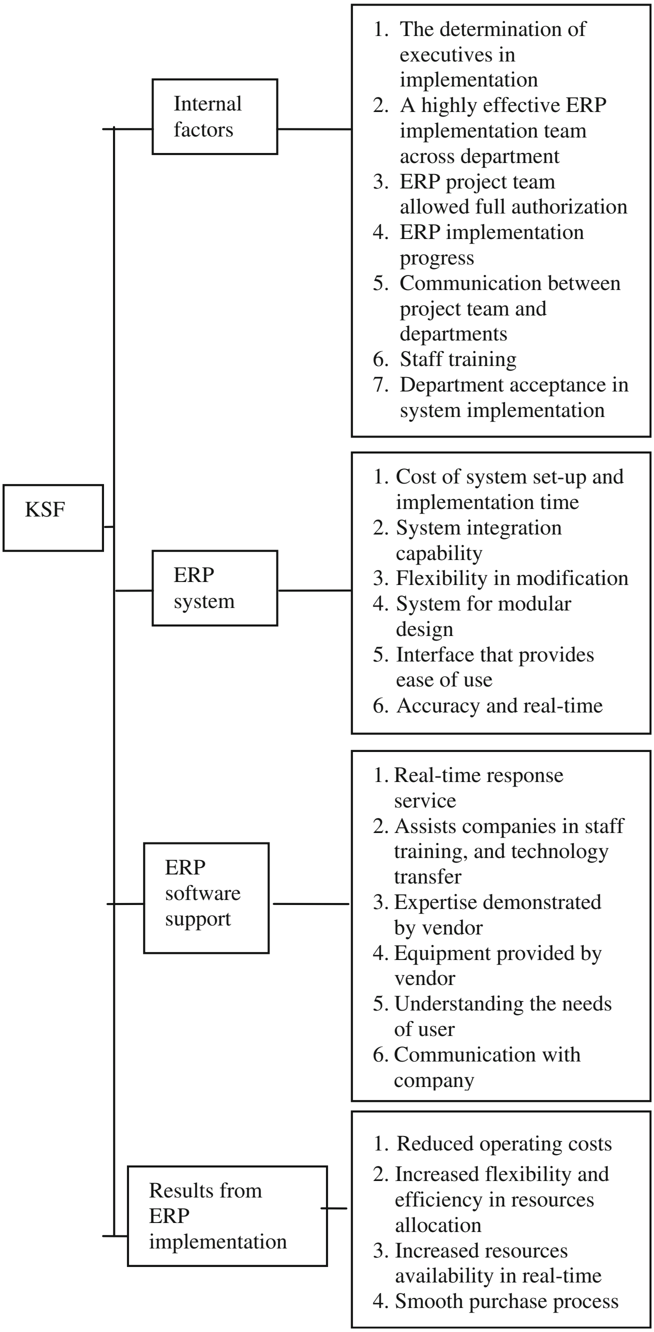

Fig. 58.1 Research structure

Table 58.1 The consistency ratio in second stage of questionnaire

Dimension	Consistency ratio (C.R.)
Whole factor	0.0413
Internal factor of the company	0.9459
ERP system features	0.0400
ERP software support	0.0337
Results from ERP implementation	Consistency not required

(2) Compound weight analysis

In "KSF research on the chain of cafés" (Qin 2002), it was mentioned that hierarchy weighing is also known as local priority which refers to relative comparison of weight between each level. The overall weight is known as Global Priority, which is the weight of the level above (second level) multiplied by the factors in the current level (third level). This is to display the impact of the factors in the current level (third level) has on the entire evaluation. Therefore based on the results from the four dimensions, the compound weights were listed in Table 58.2 and ranked in order of importance. For better clarity, the values were multiplied by 100. For example: compound weight (c) = second level weight (a) * third level weight (b) *100 %.

58.5 Conclusion

The main focus of this study was to identify the Key Success Factors and its level of importance in ERP implementation. This was carried out successfully through AHP analysis as well as the survey from questionnaire which was designed based on interviews and literature review. The factors of ERP implementation in the company were consolidation in Table 58.3.

In recent years a number of 4 ~ 6 KSF was usually considered by most researchers. Therefore, in this case study, the focuses were placed on the first 6 KSF (Yang et al. 2007).

(1) Staff training and education: As the company in this case study is a traditional industry, the employees were not as highly educated and most did not possess computer skills. Therefore the company had invested a considerable amount of time in conducting training courses. Their staff training and education were divided into two main stages; (1) The team of E- training. They were mainly responsible for system maintenance, program modifications, and as training instructors. In addition to basic knowledge, the E- team was required to work with the ERP software vendors in training courses; (2) The company was responsible for part of their training courses. The courses were planned in conjunction with the ERP implementation. A 30-hour course was planned according to the work system. The E- team members served as lecturers and all system users were required to undergo training in a classroom setting during non-working hours. The course

Table 58.2 Compound weight analysis of KSF From ERP implementation

(Second level)		(Third level)		Compound weight (%) (c) = (a)*(b)*100 %	Importance
Level/dimension	Weight (a)	Question (Index)	Weight (b)		
Internal factor	0.381	Determination of executives in ERP implementation	0.340	12.954	2
		A highly effective ERP implementation team across department	0.070	2.667	11
		Progress of implementation team	0.119	4.534	7
		Staff training and education	0.392	14.935	1
ERP system features	0.139	Cost of system set-up and implementation time	0.150	2.085	12
		System integration capability	0.279	3.878	9
		Accuracy and real-time	0.372	5.171	5
ERP software supply	0.249	Real-time response service	0.163	4.059	8
		Assist company in staff training and technology transfer	0.286	7.121	4
		Communication with company	0.342	8.516	3
Results from ERP implementation	0.097	Reduced operating cost	0.320	3.104	10
		Increased flexibility and efficiency in resources allocation	0.498	4.831	6

aimed to resolve issues encountered and provide solutions. It also provided an opportunity to understand and improve the ERP system. At present, the company continues to conduct staff training and assessment. The assessment would serve as an encouragement for the staff and accelerate their learning curve. The company's executives estimated an additional year is required for staff training and full ERP system integration. It remains one of the company's future goals to have everyone familiarized with the operating system.

(2) Determination of executives in implementation. The company first implemented the ERP system in 2000. The decision to implement was proposed by the executives through meetings. However, due to lack of support from the senior management and hence lack of funding by the company, the project was shelved. In 2001, Taiwan officially became a member of WTO in the 144th meeting. The influx of large scale manufacturing companies and consulting firms in Taiwan had led to a perspective change. To enhance competitiveness, the senior management of the company had decided to reincorporate the ERP system with the full support of budget.

Table 58.3 Factors of ERP implementation

KSF		Level/dimension
(A6)	Staff training and education	Internal factor
(A2)	Determination of executives in ERP implementation	Internal factor
(C6)	Communication with company	ERP software support
(C2)	Assist company with staff training and technology transfer	ERP software support
(B6)	Accuracy and real-time	ERP system features
(D2)	Increased flexibility and efficiency in resources allocation	Results from ERP implementation
(A4)	Progress of implementation team	Internal factor
(C1)	Real-time response service	ERP software support
(B2)	System integration capability	ERP system features
(D1)	Reduced operating cost	Results from ERP implementation
(A2)	A highly effective ERP implementation team across department	Internal factor
(B1)	Cost of system set-up and implementation time	ERP system features

(3) Under the impetus of the executives, staffs were trained to work with the new system. Staffs that refused change had to be let go. With full budget support and authorization given by the top management, E-team was able to focus on all steps and methods of implementation and had complex issues resolved. Therefore the support from the executives was the main crucial success factor.

(4) Communication between the ERP software vendor and company. The company in this case study differs from other manufacturing industries. It had to rely on customized software. The company spent almost a year working with the software vendor in building a customized ERP system. Meetings were held between the parties of the E-team members, representatives from every department and the ERP software vendor. Every one to two weeks pre and during the implementation period, meetings were held. The meetings were changed to once a month upon implementation and finally to only emergency situations. ERP software vendors to assist companies in training and technology transfer. From the factor of ERP software vendor features, the company in this case study has placed less priority on the training and technology transfer. The services provided by the ERP software vendor were as follows: (1) To provide professionals in staff training and to arrange training in system conversion. Tailor training courses to meet customers' needs; (2) To carry out an assessment on the old system before determining the means of data transfer (The system requires Windows 2000 Server operating systems, server software: Tomcat, programming languages: Java, database: Oracle 9i). The E-team was responsible for data transfer operations which was followed by data integration data into the ERP system by the software vendors.

(5) Accuracy and real-time system. The progress of the ERP system implementation could be monitored through network and video systems (cameras).

Through real-time monitoring, effective quality control and work progress could be ensured. Officials could also depend on the system database to identify problems should they occur during construction.

(6) Flexible and efficient allocation of resource. One of the biggest results upon ERP implementation was the increased flexibility and allocation of resources, hence more efficient business operations.

58.5.1 Limitations

(1) The company in this case study is a single case company. The key factors for implementation mentioned here may not apply in the non-construction industry. Therefore, there may be limitation on the scope of the findings. The similar research method is applicable to another industry (e.g., semiconductor industry) to find any same or distinct conclusions.
(2) This study was not able to widen its scope of survey from a larger pool of employees due to time, manpower, and financial constrains. This might have an impact on the results and analysis.

58.5.2 Suggestions and Directions for Follow-up Research

The analysis of this research was based primarily on the csompany in this case study. It is recommended that subsequent research to be carried out on companies of difference portfolios in order to compare results and discussion. This will be a good source of reference for companies and organization considering ERP implementation.

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Chapter 59
Application of Gray Correlation Method in the Employment Analysis of Private Enterprises

Bao-ping Chen

Abstract In recent years, the private enterprises have made outstanding contributions to China's employment issue and become the main channel to assimilate labors. However, the private enterprises in various regions of China are developing unevenly, resulting in the very big difference in the number of employment. With the gray correlation method, this paper takes the number of employment of the private sector in 7 industries in 21 provinces, municipalities and autonomous regions as the evaluation index to calculate the corresponding relative correlation, absolute correlation and comprehensive correlation, look for the major industries affecting the employment of the private sectors, and analyze the effective way to expand the employment space in the backward areas. The results show that this method can comprehensively considerate the various factors of the evaluation problem, which not only avoids the subjectivity of the single factor but also makes the analysis process more reasonable and objective. Also the analysis results can accurately reflect the differences between various factors.

Keywords Gray correlative analysis · Compositive correlative degree · Private enterprises · Employment

59.1 Introduction

At present the reform and opening up, China's private enterprises have been developing vigorously from small to large and from weak to strong and become an important economic growth point in China's national economic development (Liu 2005). Since the mid-1990s, the employment of the private sector has been

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E. Qi et al. (eds.), *The 19th International Conference on Industrial Engineering and Engineering Management*, DOI: 10.1007/978-3-642-38391-5_59,

developing substantially in scale and growth speed and gradually become the absolute subject to solve the employment issue in our society, which provides an important guarantee for China's social stability. At the same time, it can be seen that the private enterprises in all regions are developing unevenly in employment and the number of employment varies greatly (Feng et al. 2010). Then, the private enterprises in which industries play a leading role in employment? Many scholars have studied the development of the private sector, such as Feng Tainli's An Empirical Study on Political Capital and the Accession to Loan from State-owned Banks of Chinese Private Enterprises (Song and Dong 2011), Song Qicheng's On the Relationship between Development of Private Enterprises and Employment (Zhang 2004), etc. However, there has been relatively little research conducted on the degree of impact of the private enterprises in various industries on employment.

Gray correlation analysis method is one method to quantitatively describe as well as compare the trend of the development and change of a system (Dang et al. 2009)·. Through the determination of the similarity degree of the geometrical shapes between the reference data column and several comparative data columns, the closeness of the correlation is estimated and the correlation degree of curves also is reflected. In the development process of one dynamic system, the major influential factors can be analyzed through the sequencing of the correlation degrees. Among them, a low correlation degree means there is no or less influence from this factor while a high correlation degree means this factor is the major one influencing the development of the system.

According to the number of employment of the private enterprises in 7 industries in 21 regions of China given by *China Statistical Yearbook* (2010), this paper applies the grey correlation analysis to reveal the major sectors impacting employment and analyze its causes. The empirical studies have shown that: the use of this method can evaluate the degree of impact of the private enterprises in various industries on employment more systematically, objectively and accurately, which has a certain reference value to solve the employment problem of China.

59.2 Procedures of Grey Relation Analysis

Grey correlation method has a low requirement on the sample size and its regularity. It can be applied to the evaluation study with few statistical data, large data grey, great data fluctuation or non-typical distribution regularity. Grey correlation method based on the gray system theory is a multi-factor analysis technique which uses grey correlation to describe the strength, degree and sequence of the correlation between the factors through the calculation of the grey correlation degree. The specific procedures are as follows.

Step 1: determine the reference sequence and comparative sequence. On the basis of the qualitative analysis, determine one dependent variable and multiple independent variables. For m indexes which have n evaluation objects, according to the historical statistics, the reference sequence X_0 which reflects the corresponding condition of the things and the comparative sequence which describes the corresponding situation of m factors are given. Among them:

Reference sequence:

$$X_0 = (x_0(1), x_0(2), \ldots, x_0(m)) \tag{59.1}$$

Comparative sequence:

$$X_i = (x_i(1), x_i(2), \ldots, x_i(m))(i = 1, 2, \ldots, n) \tag{59.2}$$

Step 2: calculate the absolute correlation degree. Set the length of Xi is same as that of Xj and Xi0 and Xj0 are their respective initial point zero images.

$$X_i^0 = (x_i(1) - x_i(1), x_i(2) - x_i(1), \ldots, x_i(m) - x_i(1)))(\mathrm{i} = 0, 1, 2, \ldots, \mathrm{n}) \tag{59.3}$$

Calculate the grey absolute correlation degrees of X_i and X_j with formula:

$$\varepsilon_{ij} = \frac{1 + |s_i| + |s_j|}{1 + |s_i| + |s_j| + |s_i - s_j|} \tag{59.4}$$

Among them:

$$|s_i| = \left| \sum_{k=2}^{n-1} x_i^0(k) + \frac{1}{2} x_i^0(n) \right| \tag{59.5}$$

Step 3: calculate the relative correlation degree. Set the length of X_i is same as that of X_j and their initial values are not equal to zero. X_i' and X_j' are respectively the initial value images of X_i and X_j. Take ε_{ij}', the absolute correlation degree of X_i' and X_j' as the grey relative correlation degree of X_i and X_j. Note as $r_{ij.}$ Among them:

$$X_i' = X_i / x_i(1), \tag{59.6}$$

$$X_j' = X_j / x_j(1), \tag{59.7}$$

$$r_{ij} = \frac{1 + |s_i'| + |s_j'|}{1 + |s_i'| + |s_j'| + |s_i' - s_j'|} \tag{59.8}$$

Step 4: solve the comprehensive correlation degree. Set the length of X_i is same as that of X_j and their initial values are not equal to zero. There is no positive correlation between ε_{ij} (the absolute correlation degree of X_i and X_j) and r_{ij} (the relative correlation degree of X_i and X_j). Comprehensive correlation degrees take both the absolute change and relative change of the data sequences into consideration and at the same time satisfy 4 Axiom of grey correlation degree. Note ρ_{ij} as the grey comprehensive correlation degrees of X_i and X_j. Among them:

$$\rho_{ij} = \theta\varepsilon_{ij} + (1-\theta)r_{ij} \quad (59.9)$$

The value of θ represents the emphasis on the absolute correlation degree ε_{ij} and relative correlation degree r_{ij}. Generally, the value of θ is 0.5. When θ is set, grey comprehensive correlation degree is unique. However, this kind of conditional uniqueness does not affect the analysis on the problem.

Step 5: utilize the calculated comprehensive correlation degree analysis ρ_{ij} to analyze the correlation sequence.

59.3 Analyze the Number of Employment of the Private Enterprises with Grey Correlation Method

Since the reform and opening up, the private enterprises has mushroomed in the rapid speed and become the basic force to promote the national economic development as well as an important guarantee to realize the interests of the people. The development of the private enterprises plays an important role in optimizing our resources, increasing the employment rate and promoting the national economic growth (Wang et al. 2011; Fang et al. 2011; Zhang et al. 2011). However, the private enterprises develop unevenly in different provinces and cities of China with a great difference. This paper tries to explore the main reasons causing the difference with the gray correlation method and find ways to solve the problem so as to achieve common development and avoid the decline of the overall level affected by individual backward areas.

Divide the provinces, cities and districts in the country into three parts: the eastern area includes Beijing, Hebei, Liaoning, Shanghai, Jiangsu, Zhejiang, Shandong, Guangdong, etc.; the central area includes Shanxi, Heilongjiang, Henan, Hubei, etc. the western area includes Guangxi, Xinjiang, etc. According to the number of employment of the private enterprises in 21 regions in 2010 given by *China Statistical Yearbook* (2010), this paper selects the total employment as the reference sequence and the number of employment in seven industries, namely, manufacturing, construction, transportation, wholesale and retail, accommodation and catering, leasing and business services and others as the main assessment index. Table 59.1 is the relevant data of 21 cities in 2010.

From Table 59.1, the reference sequence can be obtained:

X_0 = (323.2, 123.3, 294.1, 170.7, 216.0, 511.4, 247.3, 293.9, 343.1, 1297.3, 758.8, 397.4, 278.4, 247.5, 636.6, 375.2, 451.8, 372.7, 1233.1, 241.5, 79.8, 43.2, 48.6, 132.4)

Comparative sequence is:

$$X_i = (x_i(1),\ x_i(2),\ x_i(3), \ldots,\ x_i(21))(i = 1, 2, \ldots, 21) \quad (59.10)$$

Table 59.1 The number of employment of the private enterprises in 7 regions in 2010 [million people]

Cities	Total	Manufacturing	Construction	Transportation	Wholesale and retail	Accommodation and catering	Leasing and services	Others
Beijing	323.2	11.5	8.7	6.6	88.7	21.0	46.8	15.4
Tianjin	123.3	33.4	5.4	5.5	39.8	4.6	10.1	4.7
Hebei	294.1	59.4	9.6	10.2	136.2	20.2	9.2	19.6
Shanxi	170.7	16.1	4.0	3.3	94.1	15.6	5.9	17.1
Neimenggu	216.0	24.4	7.6	10.8	94.9	23.1	9.1	19.2
Liaoning	511.4	87.5	27.0	46.5	193.9	31.0	24.2	32.0
Jilin	247.3	31.5	27.3	10.3	102.5	21.4	7.7	20.0
Heilongjiang	293.9	34.2	8.8	11.3	114.0	28.4	12.6	52.6
Shanghai	343.1	53.5	25.9	13.6	121.5	16.4	45.1	12.0
Jiangsu	1297.3	475.3	109.5	29.3	408.4	52.5	57.9	57.6
Zhejiang	758.8	259.7	34.0	15.6	269.8	36.1	44.8	38.4
Anhui	397.4	57.5	11.0	6.7	190.7	37.0	13.5	34.4
Fujian	278.4	65.4	8.6	5.1	115.1	16.1	19.7	16.6
Jiangxi	247.5	53.3	4.0	10.2	108.8	22.1	6.6	19.2
Shandong	636.6	144.0	30.3	19.9	279.3	36.0	39.1	35.7
Henan	375.2	61.9	12.5	6.1	186.9	28.8	17.8	27.7
Hubei	451.8	71.5	19.4	15.1	207.6	32.6	20.1	35.2
Hunan	372.7	39.4	12.5	10.1	162.9	20.9	56.2	23.0
Guangdong	1233.1	293.3	30.3	24.4	523.9	71.3	83.9	67.5
Guangxi	241.5	34.7	5.2	11.3	120.5	18.5	12.2	14.7
Hainan	132.4	16.3	4.8	5.4	56.7	14.6	8.2	11.4

Step 1: Calculate the absolute correlation degree. Take manufacturing calls for example, through the initialization operation (settled as 1-time interval sequence of equal length), we can obtain:

$X_1 = (11.5, 33.4, 59.4, 16.1, 24.4, 87.5, 31.5, 34.2, 53.5, 475.3, 259.7, 57.5, 65.4, 53.3, 144.0, 61.9, 71.5, 39.4, 293.3, 34.7, 4.4, 5.2, 5.2, 16.3)$

Through the operation of initial point zero images on X_0 sequence and X_1 sequence, we can obtain following sequences:

$X_0 = (0.00, -199.91, -29.19, -152.58, -107.24, 188.19, -75.98, -29.30, 19.89, 974.05, 435.53, 74.10, -44.88, 5.71, 313.34, 51.96, 128.57, 49.41, 909.88, -81.79, -190.89)$

$X_1 = (0.0, 21.85, 47.91, 4.55, 12.85, 75.98, 19.97, 22.66, 41.97, 463.82, 248.16, 45.99, 53.91, 41.84, 132.47, 50.43, 60.02, 27.84, 281.76, 23.20, 4.75)$

Calculate the values of $|s_0|$, $|s_1|$ and $|s_1 - s_0|$, Among them:

$$|s_0| = 2252.91,\ |s_1| = 1679.64,\ |s_1 - s_0| = 573.27,$$

Thus, according formula (59.4), the absolute correlation degree of manufacturing calls can be calculated and its value is 0.5676. Similarly, the absolute correlation degrees of all the factors can be calculated. Namely:

$$\begin{aligned} &\varepsilon_{01} = 0.8728,\ \varepsilon_{02} = 0.5501,\ \varepsilon_{03} = 0.5310, \\ &\varepsilon_{04} = 0.8926,\ \varepsilon_{05} = 0.5290,\ \varepsilon_{06} = 0.5917, \\ &\varepsilon_{07} = 0.5560 \end{aligned}$$

Step 2: Calculate the relative correlation degree. Take the manufacturing calls for example. After the initialization operation, calculate the initial value images of X_0 sequence and X_1 sequence. Namely:

$X_0 = (1.0, 0.38, 0.91, 0.52, 0.66, 1.58, 0.76, 0.90, 1.06, 4.01, 2.3, 1.22, 0.86, 0.76, 1.96, 1.16, 1.39, 1.15, 3.81, 0.74, 0.4095)$

$X_1 = (1.0, 2.89, 5.16, 1.39, 2.11, 7.60, 2.73, 2.96, 4.64, 41.30, 22.56, 4.99, 5.68, 4.63, 12.51, 5.38, 6.21, 3.41, 25.48, 3.01, 1.41)$

Calculate the initial point zero images of X_0' and X_1'. Namely:

$X_0' = (0.0, -0.61, -0.09, -0.47, -0.33, 0.58, -0.23, -0.09, 0.06, 3.01, 1.34, 0.22, -0.13, -0.23, 0.96, 0.16, 0.39, 0.15, 2.81, -0.25, -0.59)$

$X_1' = (0.0, 1.89, 4.16, 0.39, 1.11, 6.60, 1.73, 1.96, 3.64, 40.30, 21.56, 3.99, 4.68, 3.63, 11.51, 4.38, 5.21, 2.41, 24.48, 2.01, 0.4)$

The values of $|s_0|$, $|s_1|$ *and* $|s_1 - s_0|$ can be obtained.

$$|s_0| = 6.96, |s_1| = 145.96, |s_1 - s_0| = 138.99$$

Thus, according formula (59.8), the relative correlation degree of manufacturing calls can be calculated and its value is 0.5255. Similarly, the relative correlation degrees of all the factors can be calculated. Namely:

$r_{01} = 0.5255$, $r_{02} = 0.6418$, $r_{03} = 0.6735$, $r_{04} = 0.6828$, $r_{05} = 0.9475$, $r_{06} = 0.9007$, $r_{07} = 0.7218$

Step 3: Calculate the comprehensive correlation degree. Utilize the above absolute correlation degree and relative correlation degree and formula (59.9) and at the same time set $\theta = 0.5$, the comprehensive correlation degrees of all the factors can be calculated. Namely:

$$\rho_{01} = 0.73,\ \rho_{01} = 0.66,\ \rho_{01} = 0.91,\ \rho_{01} = 0.56,$$
$$\rho_{01} = 0.76,\ \rho_{01} = 0.90,\ \rho_{01} = 0.82$$

Step 4: Result analysis.

The result is:

$\rho_{03} < \rho_{06} < \rho_{07} < \rho_{05} < \rho_{01} < \rho_{02} < \rho_{04}$, Namely:

$X_3 < X_6 < X_7 < X_5 < X_1 < X_2 < X_4$.

It can be seen from the above analysis that X_5 is the optimal factor. In other words, the main factors that affect employment are wholesale and retail, followed by business services, accommodation and catering, manufacturing, others and transportation; the construction industry has the minimal impact, which is consistent with the reality. From the point of view of economic development, the economic growth will largely promote the employment of the private sector. Meanwhile, the gradient difference in economic development is consistent with the gradient level of employment. China has a vast territory and the levels of economic development in the East, center and west are different, which promotes the gradual expansion of the difference in the number of employment in the private enterprises in various regions. It can be seen from Table 59.1 that provinces and cities with the high employment rate such as Shanghai, Beijing, Liaoning, Zhejiang, Jiangsu and Guangdong are mainly concentrated in the east area; the employment rate in the central and western areas is relatively low. The employment rates of Shanxi, Guangxi, Gansu, Inner Mongolia and other provinces rank bottom. If provinces and cities with the low employment rate want to improve the employment rate of the private sector, the key is to accelerate the economic development, because the income gap of residents is a key factor to affect the employment of the private sector in China. Meanwhile, the local governments take more proactive policies within the scope of authority to regulate the charge order, provide the employment, such as: wholesale and retail, business services, accommodation and catering and manufacturing, appropriately reduce and exempt certain taxes and provide certain tax grace period. They should also actively address the financial problem of the private enterprises during the development, give more support and create the development environment encouraging the private entrepreneurship, which will have a great pull on the employment of the private enterprises.

59.4 Conclusions

Grey comprehensive evaluation method is a comprehensive evaluation method which combines the qualitative analysis and quantitative analysis (Liu et al. 2009). This method can not only solve the problems of evaluation indexes well that the evaluation indexes are difficult to quantify and accurately statistic, but also exclude the effects of personal factors. All these make the evaluation results more accurate. Gray correlation analysis method adopts the correlation degree to quantitatively describe the strength of the influences between things. The calculated value of the correlation degree falls on the interval. The larger the value is, the stronger the influence between things is. The geometric significance of the correlation degree is the difference degree of the geometrical shapes between curves which represent different things or factors (Sun 2011). If the correlation degree of certain index is high, it means this index is one major factor affecting things. On the contrary, if the correlation degree of certain index is low, it means this index has a low influence. Applying grey correlation method into the principal component analysis to seek the major influential factors can take several factors into consideration comprehensively, which avoids the subjectivity of the single factor. In this way, the analysis process can be more reasonable and objective and the analysis results can accurately reflect the differences between various factors. The above case shows that gray correlation analysis method has a low requirement on the regularity of the original data and definite objectivity and scientificity. Besides, it is simple for use, not time consuming and easy to understand.

Acknowledgments Project supported by the Science Research Projects of the Colleges and Universities in Inner Mongolia (NO.NJZY11106) and the Natural Science Foundation Project in Inner Mongolia (NO.2010 MS1007).

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Chapter 60
The Design of Three-Dimensional Model for the Economic Evaluation of the Coal Enterprise Informationization

Qing-wen Yuan and Shu-wei Yu

Abstract According to the coal enterprise characteristics and the current coal enterprise informationization construction circumstance, the author designed a three-dimensional model for the economic evaluation of the coal enterprise informationization with a low demand for data and great practicability, so as to direct the construction of the coal enterprise informationization, and to evaluate the economic returns.

Keywords Coal enterprise · Economic evaluation · Informationization · Three-dimensional model

60.1 Introduction

In China, the enterprise informationization is defined as the utilization of information technology, the application of information system, and the development and utilization of the information resources in all aspects, all levels and various areas in production, operation, and management, which aims at constantly improve the efficiency and level of production, operation, management, decision-making and services, so as to improve the enterprise economic benefits and its competitiveness.

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E. Qi et al. (eds.), *The 19th International Conference on Industrial Engineering and Engineering Management*, DOI: 10.1007/978-3-642-38391-5_60,

Coal enterprise informationization is a complex systematic project, which needs a huge investment, a long cycle, and a high demand for technology. This causes a dramatic difference between the actual results and the expected results on the informationization application. Thus, there is an urgent demand for the objective and fair approach to evaluate the economic returns of the informationization.

60.2 The Construction of a Three-Dimensional Model for the Economic Evaluation of the Coal Enterprise Informationization

60.2.1 The Description of a Three-Dimensional Model for the Economic Evaluation of the Coal Enterprise Informationization

The three-dimensional model for the economic evaluation of the coal enterprise informationization (hereafter referred to as the three-dimensional model) is shown below as Fig. 60.1. The three-dimensional coordinates are delineated in Fig. 60.1. The volume of the cube that is surrounded by the dimensions in the three-dimensional model can be calculated by the coordinates quantification and undimensionalization, and it can be used as a reference for the economic evaluation of the coal enterprise informationization.

60.2.2 The Definition of the Dimension Coordinate Axses in the Three-Dimensional Model

(1) X-axis: Supporting Capacity of the Current Coal Enterprise Informationization Condition

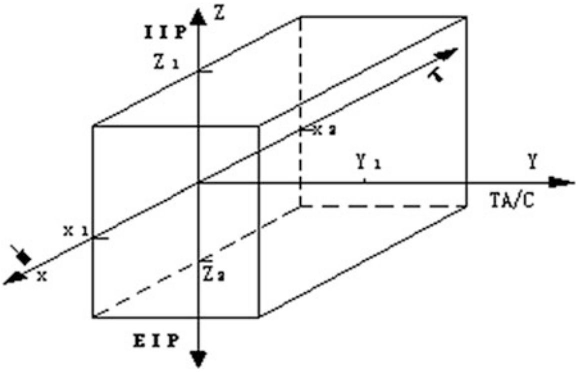

Fig. 60.1 The three-dimensional model for the economic evaluation of the coal enterprise informationization

Supporting capacity is the capability of current coal enterprise technology and management for ensuring the developing information system can be on normal operation and achieve expected results. The axis can be divided into technology and management in two directions, and formulates the technology and management bi-domain model (Zhong 2004). The management domain defines the current internal organizational management status of the enterprise and the technology domain defines current informationization of the coal enterprise.

(2) Y-axis: The Ratio of Tangible Assets to Implementation Cost of the Coal Enterprise Informationization

The Y-axis is defined as the ratio of tangible assets to implementation cost. Here is the formula:

$$R(Y) = Tangible\,Asset(TA)/Implementation\,Cost(C) \tag{60.1}$$

The cost of informationization investment consists of two aspects. One is the investment in the system hardware and software at the beginning of the coal enterprise, and the other one is the cost on the operation, maintenance, and personal expenditures of the informationization implementation. The tangible assets are the economic returns that can be measured in currency, and can be calculated by profit and cost.

(3) Z-axis: The Internal and External Invisible Earnings of the Coal Enterprise Informationization

The invisible earnings refer mainly to the improvements of the efficiency of the coal enterprise, and they are difficult to measure in currency.

Based on economist Galbraith's theory, and the opinions of Edivinsson and Malone, the coal enterprise informationization is a complex systematic project. It not only affects the internal organization and staff in the coal enterprise, but also plays a role of great importance on the upstream and downstream firms (Edvinsson and Malone 1997).

In this paper, the author defines the invisible earnings in the coal enterprise as intellectual capital, and the intellectual capital can be divided into organizational capital, market capital and human capital.

Considering that the invisible earnings caused by informationization in the coal enterprise can be regarded as the increase of intangible assets, the author sets the Z-axis origin as the center, and defines the left interval as the increase of the internal invisible earnings, which consists of organizational capital and human capital, and the right interval is defined as the increase of the external invisible earnings, which is formed by the market capital (KaPlan and Norton 1996; Stewart 1994; Bharadwaj 2000).

60.2.3 The Dimension Coordinate Axses Quantification in the Three-Dimensional Model

(1) X-axis: The Technology Domain Quantification and Management Domain Quantification of the Informationization Supporting Capacity

(a) The Technology Domain Quantification—The Supporting Capacity of the Coal Enterprise Informationization

The enterprise informationization supporting capacity of the technology domain of the X-axis in the bidomain model can be evaluated by measuring current information system supporting capacity of the developing information system of the enterprise.

In recent years, there have been a lot of information system vcs in the coal enterprise, and they are available in production, operations, and management. Network technology plays an important role in the coal enterprise informationization application by using advanced coal mining methods, techniques, and equipment. This results in the change from site control to process control. The control and management data can be shared by the integration of the device layer, control layer and information layer of the production field. Also, the application and implementation of the ERP management informationization system software can integrate the management informationization system and production automatic system, together with the intensive integration of the detect ability and control ability of the system.

The author deems the information systems to have the following relations after intensive study of the technology foundation, data source, system compatibility, and function component of each system.

Suppose A, B, and C are different information systems, and C is a lower system than A and B, then the relations between A and B are shown as below:

(1) If $A \in B$, then A is a subsystem of B, and the supporting capacity of A to B is the maximum value
(2) If $C \in A$, $C \in B$, and $C/A > C/B$, then C is a lower system than A and B, and the supporting capacity of A to B should be less than the supporting capacity of B to A.
(3) If $C \in A$, $C \in B$, and $C/A < C/B$, then C is a lower system than A and B, and the supporting capacity of A to B should be greater than the supporting capacity of B to A.
(4) If A and B are not related, then the supporting capacity of A to B is 0.

(b) The Management Domain Quantification—the Supporting Capacity of Management

The coal enterprise management informationization is the integration of management and the advanced digital management technology. In this paper, the X-axis management domain quantification has differences on the system classification, organization classification.

Table 60.1 Coal enterprise informationization cost reduction

Cost reduction	Calculation method
Coal development cost reduction	Geological exploration cost reduction + the layout of mining area cost reduction + mine construction cost reduction
Coal production cost reduction	Mainly contains the cost reduction of material, purchased fuels, staff salaries, depreciation, upkeep, etc
Coal safety cost reduction	The safety of information, safety accidents reduction (information disclosure, gas accidents, water leakage accidents, etc.)
Inventory cost reduction	The decrease of inventory capital × capital funds
Marketing cost reduction	Advertising cost reduction + the decrease of marketing staff × salaries
Transaction cost reduction	Paper documents reduction + the capital increase × capital funds

(2) Y-axis: The Ratio of Tangible Assets to Implementation Cost

(a) The calculation of information system implementation cost.

The information system implementation cost (*C*) can be divided into development cost (*C1*) and maintenance cost (*C2*). And both can be subdivided by the objects of cost. The cycle used in the calculation depends on the information system, and the cost can be amortized over from 1 to 3 years. The formula of the cost is as below:

$$C = C1 + C2 \tag{60.2}$$

(b) The calculation of tangible assets.

The profit of the coal enterprise informationization can be achieved by improving management efficiency, and using labor and materials sparingly. The tangible assets mainly come from the cost reduction (*TA*). The whole cost reduction equals the sum of the development cost reduction, production cost reduction, safety cost reduction, inventory cost reduction, and transaction cost reduction of the informationization application.

All the formulas are shown in the Table 60.1 (Li 2005, 2009, 2010).

From the above information we can figure out:

$$R(y) = \frac{P}{C1 + C2} \tag{60.3}$$

(3) Z-axis: The Quantification of the Internal and External Invisible Earnings.

The invisible earnings that are achieved by informationization can be measured by the definition and classification of the coal enterprise. The coal enterprise can create a self-evaluation table based on human capital, organizational capital, and market capital. The result of calculation is the quantification of the domains of the Z-axis.

60.2.4 The Dimensions Coordinates Undimensionalization of the Three-Dimensional Model

The quantification of coordinate axses are delineated above, but can not be calculated directly because of the differences among dimensions. In this paper, the author uses mathematical methods for the undimensionalization.

The catastrophe points are not available in the three-dimensional model, neither are the sample data; therefore, the mathematical undimensionalization method is simple and accurate.

The higher value of the coordinates in the three-dimensional model means the better performance of the informationization. The valuation of X-axis and Z-axis are the results of formula 60.4. The valuation of the Y-axis is already dimensionless and does not need to be calculated.

The undimensionalizaiton formula is shown as below:

$$R(i) = \frac{i - i_{\min}}{i_{\max} - i_{\min}} \qquad i_{\min} \le i \le i_{\max} \tag{60.4}$$

60.2.5 The Calculation of Economic Evaluation in the Three-Dimensional Model

The coordinates of the dimensions can be figured out through the definition, quantification and undimensionalization.

As is shown on Fig. 60.1, the valuation of *X1* is the result of the undimensionalization of enterprise management domain. The valuation of *X2* is the result of the undimensionalization of technology domain. The valuation of *Y1* is the ratio of tangible assets to informationization cost. The valuation of *Z1* is the internal invisible earnings of the coal enterprise informationization, and *Z2* is the external invisible earnings.

The volume that is surrounded by the three dimensions is the economic evaluation of the coal enterprise informationization, and the formula is shown as below.

$$B = X \times Y \times Z \tag{60.5}$$

X, Y, Z are the undimensionalization results, and *B* is the undimensionalization of the coal enterprise economic benefits.

60.3 Conclusions

The three-dimensional model has great practicability, a low demand for data and is easier to evaluate the economic returns compared with the index synthetic evaluation.

The three-dimensional model maintains the supporting capacity of the coal enterprise informationization, and emphasizes the relativity and conditionality of the enterprise informationization economic returns.

This model can not only be used for evaluating the economic returns of the developing information system, but also can be used as a reference for choosing an information system, and plays a role of great importance in the coal enterprise informationization construction.

Acknowledgments Soft Science Project of Shandong Province. 2011RKGA7066.

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Chapter 61
The Effects Decomposition of Carbon Emission Changes and Countermeasures in Shandong Province: Based on De Bruyn's Factors Decomposition Model

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Abstract This article calculates the total carbon emission of Shandong Province and the variations in carbon emission of all industries during 1995–2010 term by term. Based on the synchronous data of population and economy, decomposition analysis is applied to decompose the carbon emission of Shandong Province into scale effect, structure effect and technical effect. Then the article analyzes the relations between the average GDP's carbon emission, the total amount of carbon emission, the per capita of carbon emission and these effects by use of de Bruyn's model. Results show that: scale effect and structure effect led to the growth of carbon emission; technical effect played opposite role to make the amount of carbon emission lower. The article gives some countermeasures and suggestion according to the results.

Keywords Carbon emission · Countermeasures · Decomposition analysis · Factors decomposition model

61.1 Introduction

In recent years, factors decomposition model has been extensively used in the area of environment research to measure the relative importance of each effects to environmental pollution changes. De Bruyn (1997) believes that economic scale expansion, industrial structure change and population strength change lead the

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E. Qi et al. (eds.), *The 19th International Conference on Industrial Engineering and Engineering Management*, DOI: 10.1007/978-3-642-38391-5_61,

outcome. He called them as follows: scale effect, structure effect and technical effect (Chen et al. 2004). The method of decomposition analysis becomes more and more important because it can effectively separate the effects that lead to the change of population from any possible effects (Stern 2002).

According to the data during 1995–2010, the article will research the effects on the carbon emission of Shandong Province that caused by economic scale, industries structure and technical improvement using de Bruyn's factors decomposition model and Ang's PDM (parametric Divisia methods) (Ang 1994), and then put forward corresponding measures.

61.2 Factors Decomposition Model and Estimation on the Amount of Carbon Emission

61.2.1 Factors Decomposition Model

In this model, C_t is the amount of carbon emission in the t year, Y_t is GDP in the t year, I_t is the strength of carbon emission in the t year. $S_{it} = Y_{it}/Y_t$ is the GDP's proportion of added value for industry i, $I_{it} = C_{it}/Y_{it}$ is the strength of carbon emission for industry i in the t year. So the change of carbon emission's amount can be attributed to the interaction of economic scale, industrial structure and technical improvement. The formula is:

$$C_t = Y_t I_t = \sum_i Y_t \times S_{it} \times I_{it} \tag{61.1}$$

To attribute the change of carbon emission completely to the effects, decomposition of allowances is needed (Sun 1998). The methods used widely now include fixed-weight method, AWD and allowance balance method (Ang and Zhang 2000). The article uses Ang's PDM (parametric Divisia methods) to decompose the carbon emission into three parts as follow:

$$\Delta C_{sca} = (Y_t - Y_{t-1})[I_{t-1} + \beta(I_t - I_{t-1})] \tag{61.2}$$

$$\Delta C_{str} = \sum_i [Y_{t-1} + \beta(Y_t - Y_{t-1})][I_{it-1} + \beta(I_{it} - I_{it-1})](S_{it} - S_{it-1}) \tag{61.3}$$

$$\Delta C_{tec} = \sum_i [Y_{t-1} + \beta(Y_t - Y_{t-1})][S_{it-1} + \beta(S_{it} - S_{it-1})](I_{it} - I_{it-1}) \tag{61.4}$$

In the equations of (61.2–61.4), ΔC_{sca}, ΔC_{str}, ΔC_{tec} represent the improvement of carbon emission amount caused by economic scale, industrial structure and technical improvement in turn. β is an adjustment coefficient. If $\beta = 0.5$, so we can get the contribution rate equations of scale effect, structure effect and technical effect. As follow:

$$R_{sca} = \Delta C_{sca}/C_{t-1} = \frac{(Y_t - Y_{t-1})(I_{t-1} + I_t)}{2Y_{t-1}I_{t-1}} \tag{61.5}$$

$$R_{str} = \Delta C_{str}/C_{t-1} = \frac{\sum_i (Y_t + Y_{t-1})(I_{it} + I_{it-1})(S_{it} - S_{it-1})}{4Y_{t-1}I_{t-1}} \tag{61.6}$$

$$R_{tec} = \Delta C_{tec}/C_{t-1} = \frac{\sum_i (Y_t + Y_{t-1})(S_{it} + S_{it-1})(I_{it} - I_{it-1})}{4Y_{t-1}I_{t-1}} \tag{61.7}$$

In the equations of (61.5–61.7), R_{sca}, R_{str}, R_{tec} represent the contribution rate of scale effect, structure effect and general technical effect. $R_i \geq 0$ means that actor i improve the amount of carbon emission. On the contrary, factor i reduce the amount of carbon emission (Hu et al. 2008).

61.2.2 Carbon Emission's Amount Estimation

The article uses equation of (61.8) to estimate the amount of carbon emission in Shandong Province.

$$C_t = p\left(\sum_i E_{ti} + L_t\right) = p\left(\sum_{ij} F_{tij}M_j + \sum_j L_{tj}M_j\right) \tag{61.8}$$

In the equation of (61.8), C_t is the amount of carbon emission (tc); p is the unit energy's carbon emission coefficient (tC/tce). Development and Reform Commission of China believes $p = 0.67$ tC/tce (Wu 2009). E_{ti} is the amount of energy consumption of industry i (tce). L_t is the amount of energy consumption of resident life (tce). F_{tij} is the amount of energy j's consumption of industry i in the t year (t). L_{tj} is the amount of energy j's consumption of resident life in the t year (t). M_j is the conversion factor between energy j and standard coal.

Based on the data of energy consumption caused by industries and resident life, the article gets the data of total amount of carbon emission, and the carbon emission of the three industries and resident life during 1995–2010. At the same time, the article gets the pertinent data of GDP, the added value of the three industries and the population. The data in Table 61.1 is the base for analysis.

The energy data in this article comes from the part of Shandong Province Energy Balance Sheet (physical quantity) in "China Energy Statistics Yearbook" (2000–2005) and Integrated Energy Balance Sheet in "China Statistical Yearbook" (2011). The data of economic and population comes from "Shandong Statistical Yearbook" (1996–2011) (China's National Bureau of Statistics 2002, 2005; Statistics Bureau of Shandong province 1996).

Table 61.1 Basic data for analysis of carbon emission of Shandong

Years	Amount of carbon emission(10^4 tons)					Population (10^4 persons)	GDP(10^8 yuan)		
	Total	The first industry	The second industry	The third industry	Household consumption		The first industry	The second industry	The third industry
1995	5853	216	4780	542	315	8701	1263.78	2782.73	1942.10
1996	6116	257	5105	450	304	8747	1347.18	3167.87	2184.46
1997	6111	244	5145	461	261	8810	1353.46	3570.49	2500.11
1998	6024	314	4976	429	305	8872	1429.89	4001.46	2780.14
1999	6062	375	4977	388	322	8922	1497.03	4484.03	3038.67
2000	5485	296	4462	406	321	8975	1553.94	5020.78	3355.93
2001	6674	341	5323	544	466	9024	1553.94	5572.56	3732.79
2002	7380	357	6153	469	401	9069	1658.95	6406.20	4139.66
2003	8739	131	7444	718	446	9108	1750.94	7482.45	4609.95
2004	10607	152	9176	809	470	9163	1872.68	8922.83	5177.39
2005	15601	427	12707	1604	863	9212	1963.51	10478.62	5924.74
2006	17928	295	13942	2353	1338	9282	2064.57	12219.93	6785.73
2007	19548	324	15153	2597	1474	9346	2147.04	14145.95	7773.41
2008	20481	344	15781	2772	1584	9392	2255.53	15847.09	8856.99
2009	21721	368	16620	3035	1698	9449	2349.15	18043.87	9849.62
2010	23009	260	18554	2861	1334	9536	2434.41	20346.93	11182.09

Notes the equation of carbon emission amount for industry i: $C_i = pE_i$, It's the product of the unit energy's carbon emission coefficient and the amount of energy consumption of industry i, the price of GDP is according to the GDP of 2005 and the population is household register number

61.3 The Analysis of Carbon Emission Effects in Shandong Province

According to the equations of (61.5–61.7), the article calculates the contribution rate of scale effect, structure effect and technical effect. Table 61.2 and Fig. 61.1 reflect the outcome.

Table 61.2 Contribution of different effects to carbon emission in Shandong

Years	Scale effect (R_{sca})	Structure effect (R_{str})	Technical effect (R_{tec})
1995–1996	11.6454	1.1701	−7.5401
1996–1997	10.5321	1.0257	−10.4468
1997–1998	10.1588	0.8003	−12.6205
1998–1999	9.5920	1.1928	−9.9526
1999–2000	9.3573	0.8643	−19.2023
2000–2001	10.5714	0.5397	8.6138
2001–2002	11.6695	1.9356	−1.3590
2002–2003	13.7051	2.3206	2.5217
2003–2004	15.7992	2.7512	3.2888
2004–2005	17.0911	1.8421	25.3113
2005–2006	14.7321	1.1802	−3.0838
2006–2007	13.8973	0.9678	−5.5482
2007–2008	11.6328	0.1263	−6.6613
2008–2009	11.8451	0.9289	−6.3562
2009–2010	11.9538	0.3628	−3.8932
Average	12.2789	1.2006	−3.1286

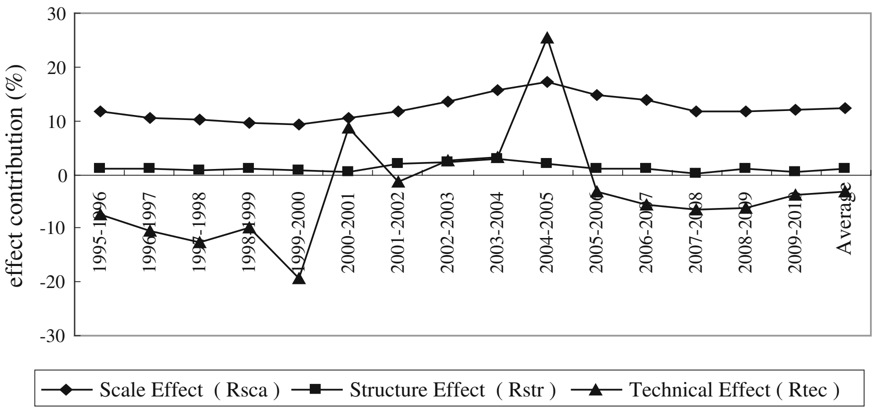

Fig. 61.1 The effects of carbon emission for 1995–2009 in Shandong

61.3.1 Scale Effect

In the research time, the contribution rate of carbon emission scale effect is always above 0 (9–18 %), the average rate is 12.3 %. It means that the enlargement of economic scale improves carbon emission amount. The change path likes an inverted "N" along with the growth of economic (Fig. 61.1). It's basically the same with the economic development of Shandong Province. 1995–2000, and the improvement speed of economic was drop obviously in the background of the Asian financial crisis, the speed dropped from 12.02 % in 1996 to 10.28 % in 2000 and the influence of scale effect became weaker. The improvement speed of economic was straight up in the following 5 years, the influence of scale effect became stronger in this period and it reached the maximum as 15 % in 2005. In the period of The Eleventh-Five, China government adopted the policy of energy-saving and emission reduction, the efficiency of energy consumption was improved clearly in Shandong Province, and the strength of energy consumption dropped 22.1 % than last 5 years. Because of the Global financial crisis in 2008, the speed of economic improvement dropped slowly again and dropped to 12.30 % of 2010, the scale effect became much weaker. The economic improvement path obviously proved the change of scale effect. The by-product (carbon emission) will grow large with the development of economic scale. So, obviously, the press from scale effect of carbon emission will keep long time in the developing Shandong Province even all over China which is a developing country.

61.3.2 Structure Effect

As the same with scale effect, structure effect also improves the amount of carbon emission in the research period, with the numbers between 0–3 %, the average number 1.2 %, and the influence much weaker. It suggested that in the passed 15 years the change of economic structure did not reduce the amount of carbon emission but improved it, although the number is only 10 % of scale effect. In the last 15 years, the structure of industries in Shandong Province is 20.4:47.6:32.0 in 1995 moves to 9.2:54.2:36.6 in 2010. The ratio of added value of the first industry dropped 11.2 % while the second industry and the third industry improved 6.6 and 4.6 % in turn. Although the structure of in industries has improved, the second industry which emits 5–6 times carbon than the first industry and 3–4 times than the third industry became larger in the structure. It directly leads the number of structure effect above 0, becoming the draw power of carbon emission. This situation means the change of structure is important and urgent to carbon emission reduction.

61.3.3 Technical Effect

In the research period, the fluctuation of technical effect was strong, with the contribution numbers between −20 and 26 %. In most of the years the numbers were below 0 except the period from 2000 to 2005, and the average number is −3.1 %. It means that the contribution of technical effect is not quite obviously and has a certain amount of randomness. But in average, the technical effect reduced the amount of carbon emission totally. In fact, the promoted contribution of technical effect comes from the technical improvement of industry units. In the period of Eleven-Five, the policy of energy-saving and emission reduction was executed powerful in Shandong Province. Some specific policies got notable achievements like "eliminating backward production capacity", "developing technical of energy-saving". The efficient of energy-using improved large. These actions led the number of technical effect contribution dropped to −6.7 % in 2008 form 25.3 % in 2005 and retain below 0. The technical effect inhibits the growth of carbon emission efficiently, although the space is still large. So it's an important task to insist for a long time that using energy-saving technology to strength the technical effect, such as "cogeneration of heating and electric power", "waste heat and pressure generate electric power", "new types of motors" and so on.

61.4 Countermeasures and Suggestions

The analysis above shows that among the three mechanisms that effect the changes in carbon emission, scale effect and structure effect enlarge the amount of carbon emission, technical effect inhibits the amount of carbon emission. According to the analysis, the article gives several countermeasures to promote the development of low carbon economic.

61.4.1 Speed up the Adjustment of Industrial Structure, to Change Structure Effect from Positive to Negative

The proportion of the second industry in the industrial structure of Shandong Province is too large, that's why structure effect enlarged the amount of carbon emission. So, the government should take efficient actions to change the industrial structure. First, the government should strengthen the review of energy consumption of all investment projects, and control the development of the industries which cost too much energy. Second, the government should accelerate the upgrade of traditional industries and encourage the development of new strategic industries and new types of service industry. These measures will enable structure effect to change from positive to negative, from enlarging to inhibiting the carbon emission.

61.4.2 Perfect the Policies about Carbon Emission Reduction, Establish and Sound the Market Mechanism

First, the government should establish and sound the finance and taxation policies to encourage energy-saving and emission reduction, enhance financial support to make energy-saving technology industrialization, to develop new energy and environmental industry, and to eliminate and modify high energy-consuming devices. Meanwhile, tax breaks on energy conservation should be implemented to control high energy-using and emission products and consumption. Second, the government should speed up the service industries that are energy-saving, practice marketing methods like "contract manage the energy-using" and "certificate energy-saving products", cultivate a cluster of energy-saving equipment industry, strength the competitiveness of energy-saving products, and build long time mechanism of energy-saving and carbon emission reduction.

61.4.3 Accelerate the Development of Energy-Saving Technology, to Achieve that Technology Dominates Emissions Cuts

The special campaigns about energy-saving and emissions cuts should be continued. By analysis the traits of enterprises and industries with high energy consumption, the government should choose and provide supports for the development, import and absorption of relevant energy-saving technology. Our government should build energy-saving industrial centers and support the industrialization of major energy-saving technology and equipment, which will make a mutual promotion between the development of industry and technology, and enhance inhibiting effect of technological progress on carbon emission.

61.4.4 Determine Energy Consumption Indexes Scientifically, Control the Amount of Energy Emission

The situation of energy supplies should be changed. At the basis of local level of economy, industrial structure, energy structure and the level of energy consumption, the local government ought to determine its target for energy consumption, and control the total amount of energy cost. According to the discipline that economy growing should keep a balance with society, energy consumption indexes system that combines total amount index with strength index of energy consumption should be established, as well as energy efficiency examining mechanism remained by total amount control, and supplemented by strength control.

61.4.5 Strengthen Advocacy and Education, Launch Universal Low Carbon Campaign

Our government should publicize the knowledge about resources environment and climate changes, such as energy-saving and low carbon economy. Base on NGOs and grass-roots communities, launching actions focused on energy efficiency and low carbon widely can help to build low-carbon conception, strength low-carbon awareness, popularize the pathway how to product and consume in a low-carbon way, and launch universal low carbon campaign.

Acknowledgments Supported by Chinese Ministry of Education humanities the social sciences research fund item (NO. 10YJA790199) and Shandong Province Natural Science Foundation Project (NO. ZR2009HM02).

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Chapter 62
The Empirical Research of the Causality Relationship Between CO_2 Emissions Intensity, Energy Consumption Structure, Energy Intensity and Industrial Structure in China

Tao Zhao and Xiao-song Ren

Abstract This paper adopts econometrics methodology to explore the causality relationship among CO_2 emissions intensity, energy consumption structure, energy intensity and industrial structure in China, during the time period 1980–2009. Multivariate cointegration and vecm model are applied to explore the long-term equilibrium and short-term fluctuation. Base on the granger causality test results, it concludes that there exist four group unidirectional causality relationships from CO_2 emissions intensity to energy consumption structure, CO_2 emissions intensity to industrial structure, industrial structure to energy consumption structure and energy intensity to energy consumption structure. In addition, a bidirectional causality relationship running from CO_2 emissions intensity to energy intensity is detected.

Keywords Carbon dioxide emissions intensity · Energy consumption structure · Energy intensity · Industrial structure · Multivariate cointegration · Vecm model

62.1 Introduction

The empirical research of the causality relationship between energy consumption, economic output, carbon dioxide emission and some other variables is a hot topic in the research field of low carbon economy, since the pioneering research of Kraft and Kraft (1978) who explored the causality relationship between economic growth and energy consumption in the United States during the period 1947–1974 (Kraft and Kraft 1978). However, due to diverse countries focused, specific time span selected, various variables used and different econometric methodologies adopted, the conclusions of the causality relationship study are uncertain, and even controversial (Ilhan 2010).

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E. Qi et al. (eds.), *The 19th International Conference on Industrial Engineering and Engineering Management*, DOI: 10.1007/978-3-642-38391-5_62,

Ang used multivariate cointegration and vecm model to explore the dynamic causality relationships between carbon dioxide emissions, energy consumption, and economic growth in France for the period 1960–2000 (James 2007). Zhang and Cheng (2009) adopted the TY-VAR method to discuss the existence and direction of the causality relationship between carbon emissions, economic growth, and energy consumption in China from 1960 to 2007 (Zhang and Cheng 2009). Feng et al. (2009) employed cointegration analysis and Granger causality test to explore the long-run equilibrium relationships, short term dynamic relationships and causality relationships between energy intensity, energy consumption structure and economic structure in China over the time span from 1980 to 2006 (Feng et al. 2009). Halicioglu (2009) used bounds test and Granger causality analysis to explore dynamic causality relationships between economic output, carbon emissions, energy consumption and foreign trade in Turkey for the period 1960–2005 (Halicioglu 2009). Soytas, Sari adopted the TY approach to explore the long run Granger causality relationship between carbon dioxide emissions, economic growth and energy consumption in Turkey (Ugur and Ramazan 2009). Chang detected the causality relationship between carbon dioxide emissions, energy consumption and economic growth in China from 1981 to 2006, applying the vecm model and Granger causality test. Lotfalipour used Toda-Yamamoto method to examine the causality relationships between carbon emission, energy consumption, and economic growth in Iran over the time from 1967 to 2007 (Mohammad et al. 2010). Menyah and Wolde-Rufael adopted the bound test and Granger causality test to analyze the causality relationship between carbon dioxide emissions, economic growth, and energy consumption in South Africa over the time from 1965–2006 (Kojo and Yemane 2010). Chang and Carballo used vecm and var model to explore the cointegration and causality relationships between carbon dioxide emissions, energy consumption and economic growth for twenty countries belong to Latin America and the Caribbean region during the period 1971–2005 (Chang and Claudia 2011). Hatzigeorgiou et al. employed the vecm model to explore the dynamic causality relationship between GDP, CO_2 emissions and energy intensity for Greece during the period 1977–2007 (Emmanouil et al. 2011). Bloch et al. used Johansen multivariate cointegration and vecm model to investigate the causality relationships among carbon dioxide emission, coal consumption and economic output for China (Harry et al. 2012). Jayanthakumaran et al. used the bounds cointegration analysis and the ARDL model to test the long run and short term relationships among carbondioxide emission, economic growth, trade and energy consumption during the time 1971–2007, comparing China with India (Kankesu et al. 2012). Chen used a multinomial logit model to examine the key elements affecting the causality relationships between energy consumption and economic output for 174 samples (Cheng et al. 2012).

Above all, the conclusions derived from these empirical researches are various and even conflicted. It is because that the different data sets are collected, different time spans are selected, different econometric model are applied and different countries are focused. In this paper, we apply multivariate cointegration, vecm model and granger causality test to examine the causality relationship among CO_2

emissions intensity, energy consumption structure, energy intensity and industrial structure for China, over the time period 1980–2009.

The rest parts of this paper are arranged as follows. Section 62.2 presents data source and process. Section 62.3 describes econometric methodologies and models applied in this paper. Section 62.4 reveals the results of the empirical research analysis. Section 62.5 finally puts forward some conclusions and policy suggestions.

62.2 Data Source and Process

We collect and calculate the annual data of CO_2 emissions intensity, energy consumption structure, energy intensity and industrial structure in China during the time period 1980–2009 as research samplings. CO_2 emissions intensity denotes CO_2 emissions per unit of GDP, which is defined as CI. The coal proportion accounting for the primary energy consumption is used to describe energy consumption structure, which is called ECS. Energy intensity denotes primary energy consumption per unit of GDP, which is named EI. The proportion of tertiary industry is used to represent industrial structure, which is denoted as IS. The annual data of GDP is collected from China statistical yearbook of 2010, the primary energy consumption data is from China's energy statistics yearbook of 2010, and the CO_2 emissions data come from the databank of world development indicators.

62.3 Methodology

62.3.1 Unit Root Test

Cointegration analysis claims that the level time series or the same difference time series of variables must be stationary. So it is necessary to test the stationarity of variables using unit root test. ADF test, introduced by Dickey and Fuller, is the most broadly applied root test method. The model is represented as follows.

$$DCI_t = \rho CI_{t-1} + \sum_{i=1}^{k} \lambda_i DCI_{t-i} + \varepsilon_t \tag{62.1}$$

$$DECS_t = \rho ECS_{t-1} + \sum_{i=1}^{k} \lambda_i DECS_{t-i} + \varepsilon_t \tag{62.2}$$

$$DEI_t = \rho EI_{t-1} + \sum_{i=1}^{k} \lambda_i DEI_{t-i} + \varepsilon_t \quad (62.3)$$

$$DIS_t = \rho IS_{t-1} + \sum_{i=1}^{k} \lambda_i DIS_{t-i} + \varepsilon_t \quad (62.4)$$

62.3.2 Multivariate Cointegration Test

If the variables pass the unit root test, we can use cointegration tests to explore the long run equilibrium relationships among the variables, which introduced by Johansen and Juselius. Base on the maximum likelihood procedure, the Johansen co integration test are used to confirm the existence of long run equilibrium relationship among CO_2 emission intensity, energy consumption structure, energy intensity, and industrial structure during the time period 1980–2006. The trace statistic value can be used to ascertain the existence of cointegration. The model is as follow.

$$D\begin{pmatrix} CI \\ ECS \\ EI \\ IS \end{pmatrix} = \alpha\beta' \begin{pmatrix} CI \\ ECS \\ EI \\ IS \end{pmatrix}_{t-1} + \sum_{i=1}^{p-1} \Gamma_i D \begin{pmatrix} CI \\ ECS \\ EI \\ IS \end{pmatrix}_{t-i} + \varepsilon_t \quad (62.5)$$

62.3.3 Vector Error Correction Model

VECM is the cointegrated constraint vector auto regression model, introduced by Sargan, developed by Engle and Granger, and is applied to deal with the cointegration relationship between the non-stationary time series modeling. VECM can comprehensively reflect the long-term equilibrium and short-term fluctuations between carbon dioxide emissions, energy consumption structure, energy intensity and industrial structure. The VECM model can be specified as follow.

$$D\begin{pmatrix} CI \\ ECS \\ EI \\ IS \end{pmatrix} = \alpha ECM_{t-1} + \sum_{i=1}^{p-1} \Gamma_i D \begin{pmatrix} CI \\ ECS \\ EI \\ IS \end{pmatrix}_{t-i} + \varepsilon_t \quad (62.6)$$

Table 62.1 Results of ADF unit root tests

Variables	ADF test	Critical value (1 % level)	Critical value (5 % level)	Critical value (10 % level)	Stationary/ nonstationary
CI	−1.443	−3.689	−2.972	−2.625	Nonstationary
ECS	−0.922	−3.679	−2.968	−2.623	Nonstationary
EI	−0.944	−3.689	−2.971	−2.625	Nonstationary
IS	−1.237	−3.679	−2.968	−2.623	Nonstationary
DCI	−3.199	−3.689	−2.972	−2.625	Stationary**
DECS	−4.190	−3.689	−2.972	−2.625	Stationary***
DEI	−3.379	−3.689	−2.972	−2.625	Stationary**
DIS	−3.837	−3.689	−2.972	−2.625	Stationary***

62.4 Empirical Analysis

62.4.1 Stationarity Test Results

Considering the popularity and practical applicability, Augment Dickey–Fuller (ADF) test is adopted in this paper. The equations of the ADF model all include the intercept terms, but no trend terms. Table 62.1 represents the results of the ADF unit root test in level and first difference time series of these four variables.

From the Table 62.1, we can see that the t statistics value of four variables (CI, ECS, EI, IS) are all larger than the critical values at the 5 % level in the ADF unit root test. It denotes that the null unit-root hypothesis can be accepted at the 5 % level, that is to say, these four variables are all non-stationary in their level time series. DCI, DECS, DEI and DIS are the first differenced variables of CI, ECS, EI and IS. The ADF unit test statistics of the first differenced variables are smaller than the critical values at the 5 % significant level; especially the ADF test statistics of DCI and DEI are smaller than the critical values at the 1 % significant level. After fist difference, these four variables become stationary. It denotes that these four variables are integrated of order one, which implies that there may exist long term cointegration relationships among these four variables.

62.4.2 Multivariate Cointegration Test Results

As reflected in Table 62.2, over the time from 1980 to 2009, the trace test demonstrates that at the 5 % significance level, just one cointegration relationship exists among CO_2 emission intensity, energy consumption structure, energy intensity, and industrial structure. The cointegration equation is represented as follow.

$$CI = 0.201 * ECS + 0.017 * EI - 0.281 * IS \tag{62.7}$$

Table 62.2 Results of Johansen cointegration tests

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical value	Probability **
None *	0.621	43.376	40.175	0.023
At most 1	0.311	16.225	24.276	0.364
At most 2	0.181	5.777	12.321	0.464
At most 3	0.007	0.195	4.130	0.714

The cointegration equation expresses that, in the long term, both energy consumption structure and energy intensity have positive role to CO_2 emission intensity, while industrial structure plays an obvious negative part in CO_2 emission intensity. Supposing that other variables remain unchanged, if the energy consumption structure is improved by 1 %, CO_2 emission intensity will lessened accordingly by 0.201 %. With energy intensity dropping by one percentage, CO_2 emission intensity is cut down by 0.017 %. If the proportion of tertiary industry of the industrial structure goes up in 1 %, CO_2 emission intensity may decrease by 0.281 %.

62.4.3 VECM Results

CI, ECS, EI and IS have one cointegration relationship, so a corresponding error correction model can be constructed to represent the long-term equilibrium and short-term fluctuations in the cointegrating relationship. Carbon dioxide emissions intensity as explained variables, the error correction model equations is represented as follows:

$$\begin{aligned} DCI_t = {} & 0.843DCI_{t-1} + 0.3394DECS_{t-1} - 0.005DEI_{t-1} - 0.049DIS_{t-1} \\ & - 0.39ECM_{t-1} \end{aligned} \tag{62.8}$$

$$ECM_{t-1} = CI_{t-1} - 0.201ECS_{t-1} - 0.017EI_{t-1} + 0.281IS_{t-1} \tag{62.9}$$

The equations of the VECM demonstrate the long run equilibrium and short term fluctuation among CI, ECS, EI and IS. In the short term, compared with ECS and EI, IS has the biggest influence on the volatility of CI, except for the lag term of CI itself. The Eq. (62.8) shows that the coefficient of the error correction term is negative, which is in accord with reverse revision mechanism. When carbon dioxide emissions intensity appears short-term volatility off long-term equilibrium, the system will be adjusted to the stable equilibrium at the 39 % adjustment speed.

Table 62.3 Results of Granger causality tests

Null hypothesis	F-statistic	Prob.	Accept/Reject
ECS does not Granger Cause CI	0.070	0.794	Accept
CI does not Granger Cause ECS	10.985	0.003[a]	Reject
EI does not Granger Cause CI	2.275	0.144	Accept
CI does not Granger Cause EI	3.910	0.059[a]	Reject
IS does not Granger Cause CI	0.288	0.596	Accept
CI does not Granger Cause IS	3.910	0.059[a]	Reject
EI does not Granger Cause ECS	8.445	0.007[a]	Reject
ECS does not Granger Cause EI	0.316	0.579	Accept
IS does not Granger Cause ECS	4.992	0.034[a]	Reject
ECS does not Granger Cause IS	0.252	0.620	Accept
IS does not Granger Cause EI	0.024	0.877	Accept
EI does not Granger Cause IS	3.631	0.068[a]	Reject

[a] Denotes rejection of the hypothesis (X does not Granger cause Y) at the 10 % level

62.4.4 Granger Causality Tests

The result of cointegration test and VECM model denote that there exist some causal relationships among CI, ECS, EI and IS. However, it cannot ascertain the direction and the number of the causal relationships, and then the Granger causality test is used. The result shows as Table 62.3.

If the null Hypothesis is accepted at the 10 % significant level, it denotes that there is not the causality relationship. Table 62.3 reveals that there exist four group unidirectional causality relationships running from CI to ECS, CI to IS, EI to ECS, and IS to ECS. Meanwhile, the bidirectional causality relationship between CI and EI is appeared. The decrease of CO_2 intensity will improve energy consumption structure, which leads to the decrease of coal consumption amount. The decrease of CI also can promote industrial structure improvement, and stimulate the progress of the tertiary industry. Meanwhile, if energy intensity drops, the third industry in the country industrial structure in the total increase will promote the energy structure to be improved.

62.5 Conclusions and suggestions

62.5.1 Conclusion

Through the above analysis this paper gives conclusions as follows.

(1) Four variables (CI, ECS, EI, IS) are stationary in first differences and have one cointegration relationship. In the short term, although China's carbondioxide emissions intensity, energy consumption structure, energy intensity and

industrial structure have the fluctuation relationship, a stable equilibrium relationship exists among them in the long run. In this long term equilibrium relationship, energy consumption structure and energy intensity have a positive impact on boosting the growth of carbondioxide emissions intensity, while the industrial structure plays a negative inhibition effect on carbon dioxide emissions intensity. In comparison, the industrial structure has the strongest impact on the growth of carbondioxide emissions, followed by energy consumption structure, and energy intensity has the least role among them.

(2) In the short term, compare with energy consumption structure, energy intensity, industrial structure has the biggest impact on the volatility of CO_2 emission intensity, except for the lag term of CO_2 emission intensity itself. The coefficient of the error correction term in vecm equation is negative, which is in accord with reverse revision mechanism. When carbon dioxide emissions intensity appears short-term volatility off long-term equilibrium, the system will be adjusted to the stable equilibrium at the 39 % adjustment speed.

(3) There exist four group unidirectional causality relationships from CO_2 emission intensity to energy consumption structure, CO_2 emission intensity to industrial structure, energy intensity to energy consumption structure, and industrial structure to energy consumption structure. In addition, a bidirectional causality relationship running from CO_2 emissions intensity to energy intensity is detected.

62.5.2 Suggestions

(1) To speed up the adjustment of industrial structure of our country, increase the proportion of the third industry. With high economic added value and low energy consumption characteristics, the proportion of third industry has become an important symbol of development of a country's low carbon economy. The industrial structure has the biggest impact on carbondioxide emissions intensity. At present, the proportion of industries with low added value, high energy consumption and high pollution, is too big in national economy of China, this is the main cause carbon of the high dioxide emissions intensity. So our government has to implement strategic adjustment to the national economic structure, eliminate energy-intensive and low production value industries, emphasize on the development of high added value, low energy consumption and high technology industries, try to develop the new service industry, and the new energy industry.

(2) Improve the coal-dominated energy consumption structure. The annual average proportion of coal amounting for the primary energy consumption is 76 % during period from 1980 to 2009. It also determines that China may not change the current energy consumption structure in the short term, but could increase oil and gas consumption proportion, and develop water power, wind,

nuclear energy, solar energy and other clean energy to gradually improve China's energy consumption structure.

(3) Strengthen the low carbon technology innovation and improve energy efficiency. Since the reform and open policy, our country industrialization process gets the rapid development, along with the phenomenon of excessive energy consumption and serious waste. Low carbon technology innovation is an important way to realize national resource conservation and environment friendly development. In order to support low carbon technology innovation, the government can levy resource tax, energy tax and environmental taxes to make subsidies for low carbon technology innovation activities.

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Chapter 63
The Evaluation of China Construction Industry Sustainable Development on DEA Model

Peng-Yang Liu, Jian-Ping Yang and Fan-Fang Wen

Abstract Using the DEA model and based on the panel data of China construction industry between the year of 1995 and 2008, this paper chooses the number of employees, fixed assets and the total power of mechanical equipment as input index, gross output and value added as output index, to conduct an overall evaluation of China construction industry Sustainable Development. Based on the input–output index, the study data shows that China construction industry has been in low level of development, and experienced from dropping to rising and begun to develop well since 2002. Furthermore, according to the results of the element adjustment, the sustainable development of China construction industry can be achieved by optimizing employees' structure and proportion of investment assets, improving the operational efficiency of mechanical equipment and expanding the market actively.

Keywords Construction industry · DEA model · Evaluation · Sustainable development

63.1 Introduction

Driven by rapid economic growth, China construction industry is developing rapidly for more than 30 years of reform and opening up. Therefore, it is particularly important to evaluate the sustainability of China construction industry. We

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E. Qi et al. (eds.), *The 19th International Conference on Industrial Engineering and Engineering Management*, DOI: 10.1007/978-3-642-38391-5_63,

can understand the level of development in the construction industry with evaluation material, and provide a scientific basis for the industrial development policy with the aid of the evaluation results. After collecting and analyzing literatures above, we can find that there are some problems in determining the index weight in the use of evaluation methods (Zhang 2010). Therefore, in this paper, data envelopment analysis (DEA) is applied to evaluate which of the sustainable development of China construction industry, don't need to determine the weight of the index, to avoid subjective factors with the objective validity, which is more objective and effective to the evaluation results of the construction industry's sustainable development. Furthermore, the results are adjusted (Xiao 1994).

63.2 Basic Idea of DEA and Models

63.2.1 Basic Idea of DEA

Data Envelopment Analysis (DEA) is one of the non-parametric methods to evaluate the efficiency of multiple decision-making units and their relative effectiveness, which was first proposed by A. Chames, W. W. Cooper and E. Rhodes. The idea of DEA is based on the concept of relative efficiency, DEA regards each target of evaluation as a decision making unit (DMU) and forms a evaluated group by all the DMUs, according to the DMU data, using the mathematical programming we can analyzes the input–output data comprehensively, calculate the indicators of relative efficiency of each DMU to determine whether each DMU is efficient or not, and find the reason of non DEA efficiency, the direction and extent of improvement by using the projective method. DEA method does not need pre-estimate parameters, so it has the advantage in avoiding subjective factors, simplifying calculation and reducing errors (Lu and Cai 2006).

63.2.2 The Model of C^2R

This paper uses C^2R model of DEA to analyze. The envelopment form of the C^2R model for evaluating DMU_j is as follows:

$$\begin{cases} Min\left[\theta-\varepsilon\left(\sum_{r=1}^{t}s_r^{+}+\sum_{i=1}^{t}s_r^{-}\right)\right] \\ s.t.\ \sum_{j=1}^{n}\lambda_j\,x_{ij}+s_i^{-}-\theta\,x_{ij_0}=0 \\ \sum_{j=1}^{n}\lambda_j\,y_{ij}-s_r^{+}=y_{ij_0} \\ \lambda_j\geq 0,\ j=1,2,\ldots,\ n \\ s_i^{-}\geq 0 \\ s_r^{+}\geq 0 \end{cases} \tag{63.1}$$

where θ is the efficiency score which is unconstrained, $\lambda=(\lambda_1,\ldots,\lambda_n)^T$ is a "structural" variable vector. Suppose we have a set of n peer DMUs consisting of $DMU_j(j=1,\ 2,\ldots,\ n)$, and each DMU_j consumes m inputs $x_{ij}(i=1,2,\ldots,n)$ and generates s outputs $y_{rj}(r=1,2,\ldots,s)$, s_i^{-} (slack of input) and s_r^{+} (slack of output) represent input excess and output shortfall respectively; and ε is a non-Archimedean infinitesimal which is defined to be smaller than any positive number; λ_j, s_r^{+}, s_i^{-} and θ represent the Parameters to be estimated (Li 2007).

In Eq. (63.1), λ_j is a combination proportion reconstructed an effective DMU combination of the j decision unit of DMU combination in relate to DMU_i. n is the number of DMU decision unit; m, t represents respectively the quantity of input index and output index; x_{ij} is the j decision unit for the i type of inputs; y_{rj} is the j decision unit for the r type of output; s_r^{+} (slack of input) and s_i^{-} (slack of output) represent input excess and output shortfall respectively; ε is a non-Archimedean infinitesimal which is generally taken $\varepsilon=10^{-6}$; θ is valid values for the DMU decision unit, that is relative efficiency for the first a decision unit for the input in relate to output. λ_j, s_r^{+}, s_i^{-} and θ represent the Parameters to be estimated (Gong and Zhang 2004).

63.2.3 *The Economic Meaning of* C²R

(1) When considering the factor of "time" in C^2R, making a time i in random, if any $\theta(t-i)<\theta(t)$, the evaluated system is in the good developing track; if $\theta(t-i)=\theta(t)$ existing, the evaluated system is weak less than developing track; if $\theta(t-i)>\theta(t)$ existing, the evaluated system is less than developing track.

(2) For non-effective DMU unit, if $\sum\lambda_i=1$, DMU is efficient to technical efficiency, otherwise, it is valid; supposing $K=1/\theta\sum\lambda_j$, when $K=1$, the returns-to-scale of DMU is prevail, when $K<1$, the return-to-scale of DMU is increasing prevail, otherwise is decreasing prevail (Deng et al. 2008).

(3) If and only if the efficiency score θ is equal to one and all optimal slacks are zero, DMU is called efficient unit, the formation of the efficient frontier for constant returns to scale, and the DMU is technical efficiency and scale efficiency. When θ is equal to one but $s_r^+ \neq 0$ or $s_i^- \neq 0$, DMU is called weak efficient unit; When $\theta < 1$, DMU is inefficient, maybe in technical inefficiency or scale inefficiency (Sheng 1996).

63.3 Empirical Analysis

63.3.1 Data and Selection of Inputs and Outputs

Using the C^2R model, this paper takes the Chinese construction 1995–2008 year for decision unit, selects the calendar year panel data of China construction industry as the analysis data of input and output indicators. The date originates calendar year "Chinese Statistic Almanac" from 1999 to 2009.

From the input–output point of view, the sustainable development of the construction industry includes input subsystem and output subsystem, the key elements of each subsystem are selected as the input and output indicators.

As human, fund, and material are the three types of input elements in the construction industry, input indicators selected in this paper for the number of employees of China construction industry, the fixed assets and total power of its own machinery and equipment at the end of the year, which represent three types of elements as the labor input, capital inputs, machinery and equipment input; output indicators selected for the construction industry output value and added value (Porteous 2002). The construction industry output value can reflect the overall production of the construction industry efficiency better relative to revenue, gross profit, and other output indicators, and value added of construction can reflect the value added capability and space of industry efficiently (Reinhardt 1999).

Therefore, in the DEA model, the input index is determined in this paper for: the number of employees, fixed assets and total power of its own machinery and equipment at the end of the year; output index for: the construction industry output value and added value. So DMU can be defined as 11, it represents the years of 1995–2008; the number of input indexes is 3; the number of output indexes is 2. The data of input and output are included in Table 63.1.

63.3.2 The Calculation of the C^2R Model

Take the input and output data from Table 63.1 into the C^2R model, we can get the solution (Tables 63.2 and 63.3) using Maxdea5.0 software.

Table 63.1 The data of input and output indexes of China construction 1995–2008

Year	Input index			Output index	
	x_1 (10,000 persons)	x_2 (100 millions RMB)	x_3 (10,000 kWh)	y_1 (100 millions RMB)	y_2 (100 millions RMB)
1995	1497.9	1850.76	7056.5	5795.73	1668.64
1996	2121.9	2685.89	9804.8	8282.25	2405.62
1997	2101.5	3083.81	8668.5	9126.48	2540.54
1998	2029.99	3380.89	8656.52	10061.99	2783.79
1999	2020.1	3752.66	9077.77	11152.86	3022.26
2000	1994.3	4204.71	9228.11	12497.60	3341.09
2001	2110.7	4951.31	10251.72	15361.56	4023.57
2002	2245.2	6183.80	11022.52	18527.18	3822.42
2003	2414.3	6548.74	11712.38	23083.87	4654.71
2004	2500.28	7148.85	14584.05	29021.45	5615.75
2005	2699.9	7621.45	13765.56	34552.10	6899.71
2006	2878.2	8395.68	14156.29	41557.16	8116.39
2007	3133.7	9175.82	15579.39	51043.71	9944.35
2008	3314.9	10258	18195.37	62036.81	11911.65

Data source Calendar year "Chinese Statistic Almanac" from 1999 to 2009

63.3.3 The Analysis of the Solution

Using DEA to evaluate the ability of sustainable development of China construction industry, and evaluation results can be known in Table 63.3. From the evaluating results in Table 63.3, the ability of sustainable development of China's construction industry of the DEA appears valid only in 2008, that is, input and

Table 63.2 The C^2R model solution of China construction 1995–2008

Year	θ	$\sum \lambda_i$	s_1^-	s_2^-	s_3^-	s_4^+	s_5^+
1995	0.776	0.140	698.620	0	2929.998	2894.678	0
1996	0.771	0.202	967.150	0	3887.901	4246.407	0
1997	0.709	0.213	783.923	0	2269.228	4104.851	0
1998	0.709	0.234	664.714	0	1885.864	4436.206	0
1999	0.694	0.254	560.000	0	1679.384	4587.307	0
2000	0.684	0.280	434.880	0	1211.137	4903.058	0
2001	0.7	0.338	357.329	0	1028.178	5593.508	0
2002	0.532	0.321	131.403	0	28.670	1380.283	0
2003	0.612	0.391	182.404	0	59.005	1158.224	0
2004	0.676	0.471	128.584	0	1287.775	225.816	0
2005	0.78	0.579	184.763	0	192.436	1382.13	0
2006	0.876	0.681	261.929	363.272	0	713.635	0
2007	0.975	0.835	287.979	382.824	0	747.244	0
2008	1	1	0	0	0	0	0

Table 63.3 Results of trend of China construction industry development capacity 1995–2008

Year	θ	$\sum \lambda_i$	K	Technology efficiency	Operating track
1995	0.776	0.140	0.180	Invalid	–
1996	0.771	0.202	0.262	Invalid	Inferior to track
1997	0.709	0.213	0.300	Invalid	Inferior to track
1998	0.709	0.234	0.330	Invalid	Inferior to track weakly
1999	0.694	0.254	0.366	Invalid	Inferior to track
2000	0.684	0.280	0.409	Invalid	Inferior to track
2001	0.7	0.338	0.483	Invalid	Benign to track
2002	0.532	0.321	0.603	Invalid	Inferior to track
2003	0.612	0.391	0.639	Invalid	Benign to track
2004	0.676	0.471	0.697	Invalid	Benign to track
2005	0.78	0.579	0.742	Invalid	Benign to track
2006	0.876	0.681	0.777	Invalid	Benign to track
2007	0.975	0.835	0.856	Invalid	Benign to track
2008	1	1	1	Valid	Benign to track
Mean	0.750	0.424	0.546	–	–

output results achieve the optimal state, and both scale efficiency and technical efficiency are effective. While, the evaluating results of the DEA is invalid in the years from 1995 to 2007, the relative values of the efficiency fluctuate largely, and change overall from downward to upward with a V-type curve, as shown in Table 63.1. Before 2005, the construction industry develop slowly, and the overall development trend appears declining. In 2005, the efficiency index is lowest, and $\theta = 0.528$, which indicates that if the returns to scale is in a constant state, 46.8 % of the input resources are wasted. In the 14 years, there are 7 % when the efficiency of DEA is effective, there are 5 years when the comprehensive efficiency index is less than 0.7, 6 years when the comprehensive efficiency index is between 0.7 and 0.8, 3 years when the comprehensive efficiency index is more than 0.8, the average efficiency is 0.88 between 1995 and 2007, So we think that development of China's construction industry is lower (Requate 2005).

According to the results of Table 63.2, during the years when the DEA is valid in 2008, the slack variables s_i^- and s_r^+ are both zero, which indicates that China construction industry system runs without sink and deficit, and the input–output has reached its optimal state; Otherwise, during the invalid years of DEA, the input and output present with sink or deficit, which indicates that China construction industry system runs in the invalid state.

In input, there are some years appears oversupplied, 13 years to employees and 10 years to its own machinery and equipment at the end of the year, which indicates that the technology quality of employees and mechanization level of China construction industry is low, the industry is still labor-intensive and rough (Tieterberg 1994). In output, the construction industry output value appear deficient, while the slack variables of added value are zero, which indicates that trends of the added value of China construction industry products are good.

Analyzing from the technology efficiency, when the operating efficiency appears valid in 2008, $\sum \lambda_i < 1$, which indicates the technology efficiency is effective; in other years $\sum \lambda_i = 1$, which indicates the technology efficiency is invalid, and the combination of input–output elements does not reach the optimal state and needs further improvement. The good news is, in the years of non DEA efficiency, technical effectiveness index value shows a rising trend, rising from 0.140 in 1995 to 0.835 in 2007, up to 1 in 2008, which show that the technical level of China construction industry is in the rising phase (World Commission of Environment and Development 1987).

Judging from the scale efficiency, the scale efficiency index $K < 1$, which indicates the scale efficiency is invalid.

Before 2004, $K < 0.5$, scale returns grow slowly, the industry's scale efficiency is low. After 2005, scale efficiency appears to increase, and reaches best in 2008. On the whole, with the advancement of technological level and expansion of the market, China construction industry returns to scale in the rising stage, even in non- DEA efficient year, the scale efficiency appears increasing (Yu et al. 1996).

In addition, from the dynamic operation of China construction industry system (Table 63.3), we can find that the operation does not work on the track before 2002, while, with the improvement of Construction personnel quality, technical level and the prosperity of construction market, China construction industry works on the track after 2002.

After projection and adjustment in the effective plane of non DEA efficiency data in Table 63.3, adjustment results are as shown in Table 63.4. The conclusion is as follows, the development of China construction industry is not only achieved by investing a lot of labor resources and capital, but also consuming a lot of energy, which can be seen from the savings of employees, fixed assets and total power of its own machinery and equipment at the end of the year in the development process (Koopmans 1951).

63.4 Conclusion

According to the analysis results of overall sustainable development of China construction industry above, the paper concluded as follows:

(1) China construction industry has been in low level of development, the efficiency average is only 0.75, which the DEA efficient year accounted for only 7 %, and experienced from dropping to rising and begun to develop well since 2002.

(2) In the process of the development of the construction industry, the technical efficiency is low in most of the year, which is in the invalid state, but the indexes of technology efficiency are always in the increasing trend. The industrial scale is inappropriate, but what the results of the analysis found are the scales are always in the increasing trend.

Table 63.4 DEA projection and adjustment results of China construction industry development

Year	The number of employees savings (10,000 persons)	Fixed assets savings (100 millions RMB)	Its own machinery and equipment at the end of the year savings
1995	1033.496	413.771	4507.607
1996	1452.398	614.233	6130.150
1997	1394.491	895.964	4787.756
1998	1255.275	983.563	4404.205
1999	1179.051	1149.969	4461.185
2000	1064.492	1327.451	4124.504
2001	990.921	1486.317	4105.608
2002	1181.431	2892.032	5183.669
2003	1118.888	2540.226	4602.183
2004	937.446	2312.714	6005.839
2005	779.766	1679.601	3226.065
2006	619.411	1406.058	1758.283
2007	366.249	612.007	389.124

(3) Adjust DEA results show that investments of China construction industry in the number of employees, the fixed assets and machinery and equipment operating efficiency, are all in excess, leading to gross domestic product output deficit. China construction industry is still labor-intensive and rough.

Based on the conclusion of analysis above, from the point of view of enhancing the ability of sustainable development of China construction industry, this article suggests that people should be focusing on optimizing employee's structure and quantity, improving their technical level, allocating the proportion of investment assets rationally, increasing the operating efficiency of the machinery and equipment gradually, reducing invalid investment of productive elements and resources, and expanding the market space actively, in particular, broadening foreign construction market positively.

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Chapter 64
The Prediction of Customer Retention Costs Based on Time Series Technique

Fan Yu, Ji-fang Yang and Ai-wu Cheng

Abstract Customer expenditure is one of the vital factors that impact customer asset, the measurement and prediction of customer expenditure means a lot to the measurement of customer asset (Chen 2006). From the perspective of customer asset, we'd like to study the measurement of customer retention costs—the major component part of customer expenditure. Firstly, we define the components of customer expenditure and explain the connotation of customer retention costs; secondly, using time series technique, we build a prediction model of retention costs, then we predict the customer future costs on the basis of this model. Last, this prediction model is used to the case and the results prove that this model is effective. Besides, this model has reference value to develop the study of the measurement of customer asset.

Keywords Customer retention costs · Expenditure prediction · Time series technique

64.1 Introduction

Customer expenditure, a factor impacting customer value, has been paid attention after the fact that customer value-oriented becomes a generally recognized marketing concept. To achieve the purpose of measuring customer value accurately and objectively, we should focus on the measurement of customer expenditure. However, we lack the theoretical and empirical research about it currently, the reason for which is that it's not an easy task to predict the future costs, considering the uncertainty of future. As a part of customer expenditure, the measurement of future costs is very vital; it will not only impact the measurement of customer

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E. Qi et al. (eds.), *The 19th International Conference on Industrial Engineering and Engineering Management*, DOI: 10.1007/978-3-642-38391-5_64,

expenditure, but also have an effect on evaluating customer value accurately, then impacting the expenditure management and marketing decision (Ness et al. 2001). Therefore, the purpose of this paper is to study the measurement of future costs. Retention costs are its major expression. We will predict the customer retention costs by time series technique and historical data, aiming to provide a suitable way for solving problems of measurement and prediction of customer expenditure.

64.2 The Constitution of Customer Expenditure

Customer expenditure means that enterprises spend some money on attracting and retaining customers (Liu 2003). There are two ways to classify customer expenditure: according to the costs spent in customer expenditure life cycle, it can be divided into costs incurred and future costs; according to the overall process of obtaining and retaining customers, it can be divided into customer retention costs and acquisition costs (Zhao and He 2009). This paper integrates these two ways under the thought of customer life cycle, and believes that retention costs and acquisition costs constitute historical and current costs, retention costs are future costs' major expression. The sum of historical and current costs and future costs is lifelong costs (Yang 2011). So it's very easy to see that we must know acquisition costs and retention costs if we want to measure customer expenditure. Acquisition costs are costs incurred, which are available because we have actual data, while retention costs are future costs, predicted by suitable way, chosen by characters and rules. Obviously, retention costs are more difficult than acquisition costs.

64.2.1 Customer Acquisition Costs

Acquisition costs refers to operating expenditure spent on attracting customers, including visit costs, promotional costs, cost of sales (Fei 2007).

Visiting is the basic way to promote productions in order to attract customers. There are some virtues about this way: flexible, seasonable, bidirectional feedback. Besides, when developing new customers, this method is very useful in products introduction and purchasing encouragement. Repeated visiting is very necessary to build trading relationship when competing for target customers, who have bigger purchasing potential. Visiting costs include expenses of travel, product samples, brochures, technical services.

Promotional costs are the customer expenditure spent on promotional activities, trying to intrigue customers and achieving purchasing goals. When enterprises develop new customers, it's necessary to propagate enterprises and productions for deepening their understandings of us. These promotions should be repeated for the purpose of encouraging them to purchase. Therefore, these costs account for large proportion in acquisition costs.

Costs of sales which happen in the selling process include policy costs and service costs. Costs caused by the differences of sales policy include sales commission costs, costs of push money, and costs of cash discounts and so on. Service costs in completing purchasing include order processing costs, packaging costs, cargo handling costs, etc.

64.2.2 Customer Retention Costs

Customer retention costs are the spending to retain existing customers. They include customer sales service costs and customer management costs (Jiang 2006).

Customer after-sales service costs are comprised of several parts: Sales technical support, training costs, maintenance service costs and product upgrades costs. After-Sales Service is one of the key marketing policies to improve customer satisfaction, especially for complex products of high technicality. Whether companies provide after-sales service has become a basic requirement to retain customers. Favorable after-sales service can develop corporate image and strengthen willingness to repeat their purchasing behaviors. But, we have to admit the fact that it is not a small spending, which is related directly to production environment, technology and the quality of personnel.

Customer management costs include customer account management costs and relationship maintenance costs. Customer account management costs are accounts receivable management costs caused by credit business. They include wages caused by managing accounts receivable, travel expense caused by collecting accounts receivable, bad debt losses and bad debt processing fee. This fee has been on increase because of the sincere competition and the rise of credit business.

Relationship maintenance costs are emotional investment costs caused by retaining purchasing relationship with existing customers; including regularly visiting costs, presenting gifts costs, support costs of customers and long-term relationship redeem costs, etc.

From above we can see acquisition costs are costs incurred, we have current data, so it's not a tough task. Retention costs are future costs, characterized by uncertainty. They are predicted by suitable way chosen by characters and rules. Therefore, we must know customer retention costs in order to obtain lifelong costs. That's why we write this paper.

64.3 The Choice of the Way to Predict Retention Costs

From above, we know many parts of retention costs and factors which impact it are relevant with customers themselves. These factors' varieties make customer expenditure uncertain. So, we must consider their effects on retention costs, if we want to establish prediction model. But, there are too many factors, it's impossible to analyze every factor and build models. Besides, their effects have been shown in the time series of past and current time. In a word, this paper will use time series technique to build prediction model of customer retention costs.

The basic idea of time series technique is that we should find regularity that appearance changes over time from historical data. Besides, we assume that this regularity will continue to the future. We can predict the future data according to this regularity. We use single-element time series in this paper. The purpose of building the model is to use historical data and random errors to predict the change of variable. Generally, we assume that random errors ε_t at different times are statistically independent and normally distributed random variables. There are three steps when using time series technique: pretreatment of time series, the establishment of model, short-term forecasts of customer costs (Wang 2008).

There are two parts of the pretreatment of time series: the judgment of stationary nature and pure randomness testing. At first, we should judge the stationary nature of time series by drawing timing diagram. If the time series is not of stationary nature, we should do zero mean and difference stationary processing of series. If they are of stationary nature, we should do pure randomness testing. Pure randomness series are also called white noise sequences; they are the series that the past behaviors will not impact the future development. The series can be divided into different types. Every type has a method to analyze (Guo et al. 2006).

There are three phases of the model building: order determination, parameter estimation and adaptive test. There are three ways to do order determination: ACF order determination, PACF order determination, residual variogram order determination method, the best criterion function order determination method. What should be noticed is that if we adopt the first method, the order we judge is not the certain result, the exact order can be obtained by other ways.

When we finish this step, the next is parameter estimation: build ARMA (p, q) model by a set of sample data sequence, judge the order (p, q) and parameter. There are three ways to estimate parameter: moment estimation, maximum likelihood estimation, least squares estimation. Least squares estimation is more accurate because it uses information at utmost (Cheng and Li 2007).

After the establishment of the model, we will do adaptive test to ensure whether we get enough information. The null hypothesis is: residuals series are white noise sequences. If we refuse null hypothesis, which means residuals has relevant information, fitting model is not significant. If not, that means the model is significant.

After two steps, we can apply the model to predict customer retention costs.

This paper will use SAS to build ARMA (p, q) model.

64.4 Case Study

A company is a high-tech enterprise, which produces power monitoring and measurement system, power energy-saving technology and other commercial electronic trading products. We select company's cost of five customers from first

Table 64.1 The results of white noise testing

To Log	χ^2	DF	Pr > χ^2	………Autocorrelations……				
6	39.50	6	<0.0001	0.702	0.373	0.294	0.362	0.265

quarter of 2001 to second quarter of 2010. We take customer A for example and show its data processing. Other companies have the same data processing.

In the judgment of stationary nature, the results show that retention costs of this customer are sequential; fluctuations are in smooth and have a certain periodicity. We judge it the stationary time series.

Next, we do pure randomness testing.

The results of white noise testing shown in Table 64.1.

The results are: P values of LB test statistic are very small (<0.0001). Therefore, we are sure that (confidence level >99.999 %) customer retention costs series are smooth non-white noise sequences.

Thirdly, we experience order determination. We adopt ACF order determination, PACF order determination. We can see that all autocorrelation coefficients decay to two times of the standard deviation range of fluctuations. It shows that sequences obviously are short-term related. But the sequence of significant non-zero correlation coefficient of attenuation for the little finger volatility process is quite continuous and slow, the autocorrelation coefficient can be regarded as not cut tail. In addition, it also shows that delayed two-order partial autocorrelation coefficient are significantly greater than two times the standard deviation, the other partial autocorrelation fluctuate in two times the standard deviation range of the random of small value. The process of attenuating from non-zero correlation coefficient to small value fluctuations is very prominent coefficient. Partial autocorrelation coefficient can be regarded as two order censored. Therefore, we consider using model AR (2) $x_t = \frac{\varepsilon_t}{1-\phi_1 B-\phi_2 B^2}, \varepsilon_{t\sim \mathrm{N}\left(0,\sigma_\varepsilon^2\right)}$ to Fit the values of the observed sequences.

Through further model fitting and optimization, in an ARMA (p, q) model where moving average delay of the order is less than or equal to five, BIC relative minimum amount of information is an ARMA (2, 0), so we are certain that the model is model AR (2). Then we use least squares method to do parameter estimation of model AR (2). Results show that mean MU and other parameters are significant, (t test statistic P values are less than 0.0001).

So Sample data fitted model is $x_t = 1.16163x_{t-1} - 0.66487x_{t-2} + \varepsilon_t$.

Next step is the adaptive test of the model. Results show that P values of LB statistic, delayed orders are significantly greater than α. The fitted model is significantly available.

Last, we use the model to predict the customer expenditure. Sample data is extended to the second quarter of 2011. We can get the retention costs of third, Fourth quarter of 2010 and first, second quarter of 2011. The retention costs of future four quarters are 246015. Using the same way, we get the results of the retention costs in a year: 203178, 313482, 235837 and 173109.

64.5 Conclusion

As a part of customer expenditure, retention costs are of great importance. In this paper, we use time series technique to predict the customer retention costs. We get these conclusions: firstly, time series technique is a good way to predict future costs; secondly, this method makes the dynamic econometrics Forecast of retention costs possible, which lays the foundation for further application.

Although, this paper makes some breakthroughs in measuring customer expenditure, it's still a long way to deepen the study of this field, if we want to develop the measurement of customer asset. For example, we can consider the prediction of retention costs from the constitution. It's the fact that there are many differences between every part, so it's necessary to analyze every part, and build prediction models. In the future, we will continue this research and make efforts to make other breakthroughs and make contribution to the measurement of customer asset.

Acknowledgments Foundation item: The National Natural Science Fund (70672116).
This research was supported by the National Natural Science Foundation of China under Grant 70672116.

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Chapter 65
The Research on the Location Selection of the Bank Outlets Based on Triangular Fuzzy Analytic Hierarchy Process

Yang Han and Fa-shan Dai

Abstract This paper analyzes the influencing factors of the location of bank outlets under the use of the triangular fuzzy analytic hierarchy process, then counts and gets the weights of each factor. Furthermore, it shows the feasibility of this model approach in the process of the site, in order to provide a reference for the decision-makers.

Keywords Bank outlets · Fuzzy analytic hierarchy process (FAHP) · Location · Triangular fuzzy numbers

65.1 Introduction

Physical outlets play a key part in bank marketing as the most important places where banks manage various business activities. They are the operational platform and the extension of information antennae of banks. However, commercial bank outlets in China which are often installed in the administrative level, lack scientific basis. Repeatability exists in the same business circle. Similarity in products and scales leads to low operation efficiency (Guo 2010). Nearly each bank carries out the research on the planning and transformation of the bank outlets as the result of the fierce horizontal competition. In this case, how to get scientific sites is full of practical significance.

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E. Qi et al. (eds.), *The 19th International Conference on Industrial Engineering and Engineering Management*, DOI: 10.1007/978-3-642-38391-5_65,

65.2 Analysis

65.2.1 Classifications in Influence Factors of Bank Outlets

The same as the location of other establishment, various factors should be taken into account. This paper will state it in the following five aspects.

(1) *Geographical site factor*: Location belongs to the geographical category. More convenient the geographical conditions are, bank outlets are more likely to gather together (Xu 2008). The indexes it involves are: road access, parking numbers, bus stop numbers, numbers of public places, communities, malls and enterprises in this area. There is feasibility to set up outlets as the business circle is more dense.
(2) *Competitors factor*: Try to have a understanding of your competitor numbers and your market share in this area. Distinction exists between service products in different banks. Compared to hardware facilities conditions of rivals, you're allowed to have an explicit self-positioning, learn your own advantages and disadvantages. If you want to gain more market and customers, you'd better improve the core competitive power and turn to personalized services.
(3) *Marketing factor*: Banks of different position have different location. For example, Bank of China position business priority in high-end customers, so their outlets mostly dot in urban district. The Agricultural Bank focus on agricultural support programs, so that they tend to place in suburbs. Supporting costs and rents must be different in each outlet. Higher cost will reduce the efficiency, and then influence the performance of banks. Marketing analysis mainly contains: bank positioning, own orientation, supporting costs and rents, floor space, outdoor visual effect.
(4) *Population economic factor*: Potential target customers depend on total population and economy, so do the bank size. Meanwhile, per capita income levels and persons flow rates in unit time also have an impact on the location.
(5) *Urban development planning*: As a typical factor, urban planning is an overall arrangement which municipal government is to deploy the urban land use, spatial distribution and various construction, according to the development goal in a period. It contains urban reconstruction of old areas and programming of new districts. In addition, urban traffic planning is also included.

65.2.2 Description of FHAP

Analytic hierarchy process (AHP) is a multi-objective decision analysis method combined with qualitative analysis and quantitative analysis, which is put forward by American operations research expert Satty in the 1970s (Xu 1988). Its feature is that dividing various factors of complexed problems into interconnected orderly hierarchy. Then experts can get judgment matrix by mutual estimating the significance of each factor, ensure its relative importance in the hierarchical structure. At last we can get the total order of each factor from the result of comparative judgment. In the multi-objective decision, increase of the index mean making up more judgment matrix with deeper levels and larger numbers (Cao 2009). In general we use AHP's pairwise comparison to explain its relative importance by number one to nine. But the more the index is, the judgment of the importance about each two indexes is more difficult (Li and Huang 2009). It even has an effect on consistency of the orders, failing to pass the consistency check. Because of the complexity of the objects or the one-sided understanding of the things, it may be not necessarily reasonable to find out eigenvectors. The main idea of AHP is to make up judgment matrix by using integer 1–9 and its reciprocal, but it neglects people's fuzzy judgments. It's difficult to obtain an accurate numerical to express comparison of the importance. When one expert regards index C_i is important to C_j, the numerical may approximate for 2, or between 1 and 2, this is fuzzy judgment rather than an accurate numerical. Based on it, taking fuzzy mathematics into AHP can make the structured judgment matrix more reasonable. Location of bank outlets is a decision-making process full of factors. Generally we make a choice in the given area after analyzing each factor. It can reduce the subjectivity of expert scoring by using triangular fuzzy numbers to a certain extent (Jiang and Liu 2010). We can ascertain the impact of each factor scientifically and systematize the location to get the best scheme according to the actual situation.

3 Specific application of FHAP in location of bank outlets

(1) *Triangular fuzzy number*

Definition 1 Fuzzy Set: In the domain U, for any $x \in U$, x often belongs to A to a certain extent $\mu(\mu \in [0,1])$, but not $x \in A$ or $x \notin A$, all the fuzzy sets are signified with F(U).

Definition 2 Subordinate Function: Set domain U, if present $\mu_A(x)$: U → [0,1], $\mu_A(x)$ is known as $x \in A$ membership, thus $\mu_A(x)$ is generally called A's subordinate function (Tao and Zhang 2012).

Definition 3 Triangular fuzzy number: Set fuzzy number M in the domain U, if M's subordinate function μ_M:U → [0,1] is expressed as (Yan and Zhu 2009)

$$\mu_M(x) = \begin{cases} \frac{1}{m-x}x - \frac{l}{m-l} & x \in [l,m] \\ \frac{1}{m-u}x - \frac{u}{m-u} & x \in [m,u] \\ 0 & x \in (-\infty, l] \cup [u, +\infty) \end{cases}$$

In the formula l ⩽ m ⩽ u, l and u are said as M's upper bound and lower bound m is the mid-value of M in the membership of 1. General triangular fuzzy number M is expressed as (l, m, u) (Chen 2004).

Operation method of two triangular fuzzy numbers M_1 and M_2 is:

$$M_1 = (l_1, m_1, u_1); M_2 = (l_2, m_2, u_2)$$
$$M_1 + M_2 = (l_1 + l_2, m_1 + m_2, u_1 + u_2)$$
$$M_1 \otimes M_2 = (l_1 l_2, m_1 m_2, u_1 u_2)$$
$$\frac{1}{M} \approx \left(\frac{1}{u}, \frac{1}{m}, \frac{1}{l}\right)$$

(2) *Steps of FHAP*

(1) Setting up the index system of the hierarchical structure model. Generally it's ascertained as target layer, rule layer, scheme layer. According to actual situation, sub-rule layer can be set up under the rule layer.

(2) On the basis of expert scoring, making up fuzzy judgment matrix (Xuan and Hua 2008). Expert gives a mark of pairwise comparison in the form of triangular fuzzy number, uses a_{ij} showing the importance degree of index i and j, including $a_{ij} = \left(l_{ij}, m_{ij}, u_{ij}\right)$.

(3) Determining the initial fuzzy weights of the index D_i^k is said as the element is comprehensive fuzziness in K layer, including,

$$\mathrm{D}_{\mathrm{i}}^k = \sum_{j=1}^{n} a_{ij}^k \div \left(\sum_{i=1}^{n}\sum_{j=1}^{n} a_{ij}^k\right), \quad i = 1, 2, \ldots, n \tag{65.1}$$

(4) Calculating the normalized weights of the index Setting $M_1(l_1, m_1, u_1)$ and $M_2(l_2, m_2, u_2)$ are triangular fuzzy numbers. The possibility that M_1 is more equal to M_2 can be defined in triangular fuzzy number as:

$$v(M_1 \geq M_2) = \sup_{x \geq y}[\min(u_{M1}(x), u_{M2}(y))]$$
$$v(M_1 \geq M_2) = \mu(d) = \begin{cases} 1 & m1 \geq m2 \\ \frac{l2 - u1}{(m1 - u1) - (m2 - l2)} & m1 \leq m2,\ u1 \geq l2 \\ 0 & otherwise \end{cases} \tag{65.2}$$

The possibility that one fuzzy number is more equal to other K fuzzy numbers can be defined as:

$$d'(C_i) = v(M \geq M_1, M_2, \ldots, M_k) = \min v(M \geq M_i), \quad i = 1, 2, \ldots, k \tag{65.3}$$

Then we can get weight vectors of all rules:

$$W' = [d'(C_1), d'(C_2), \ldots, d'(C_n)]^T \tag{65.4}$$

After the normalized processing, we can get normalized weights of each rule:

$$W = [d(C_1), d(C_2), \ldots, d(C_n)]^T \tag{65.5}$$

Table 65.1 Factors hierarchy chart of locatiom

Target	Rule	Sub-rule
Location of bank outlets A	Urban development planning B5	Urban traffic planning C18
		Urban reconstruction of old areas and programming of new districts C17
	Population economic factor B4	Persons flow rates in unit time C16
		Per capita income levels C15
		Economy C14
		Population C13
	Marketing factor B3	Outdoor visual effect C12
		Floor space of outlets C11
		Supporting costs and rents C10
		Bank positioning and own orientation C9
	Competitors factor B2	Hardware facilities condition C8
		Type of service products C7
		Competitor numbers C6
	Geographical site factor B1	Numbers of malls and enterprises C5
		Bus stop numbers C4
		Outlets towards the entrance C3
		Parking numbers C2
		Road access C1

(3) *Application of the model in the location*

(1) Taking the location of bank outlets as the target, we classify influential factors into different layers, then subdivide it to establish corresponding level structure model (as shown in Table 65.1).

(2) Designing the questionnaires combined with all factors and distributing them to experts who are from Construction Bank, Postal savings Bank and Rural commercial Bank for scoring. We can get three sets of data from several experts' scores by doing arithmetic average. Thus we could gain Fuzzy judgment matrix data about target layer and rule layer, also rule layer and sub-rule layer included. The following data is triangular fuzzy number, using nine scale method of AHP (Orlovsky 1986). The middle numerical is the most likely value. The former and later numbers are respectively ceiling and floor. This paper takes target layer A and rule layer B as an example to state and calculate (such as in Table 65.2). The B layer and C layer are not listed but only given the final score results.

(3) Finding out comprehensive fuzzy triangle matrix of each layer. According to Table 65.1, doing arithmetic average operations again on the basis of the former experts' scores. We can get comprehensive fuzzy value of each factor in rule layer, then comprehensive fuzzy triangle matrix is offered (Ji et al. 2007) (such as in Table 65.3).

Table 65.2 A–B fuzzy evaluation matrix

A–B	B1	B2	B3	B4	B5
B1	(1 1 1) (1 1 1) (1 1 1)	(1/3 1/2 3/4) (1/5 1/3 1/2) (2/3 1 3/2)	(3/2 2 5/2) (1 3/2 2) (2/3 1 3/2)	(3/4 1 3/2) (1 2 5/2) (1/4 2/7 1/3)	(4/3 2 9/4) (1 2 5/2) (4/5 1 3/2)
B2	(4/3 2 3) (2 3 5) (2/3 1 3/2)	(1 1 1) (1 1 1) (1 1 1)	(3 4 9/2) (2 3 4) (1/2 1 7/5)	(3/2 2 3) (1 3/2 2) (2/9 1/4 1/2)	(3 7/2 4) (2 3 4) (1 3/2 2)
B3	(2/5 1/2 2/3) (1/2 2/3 1) (2/3 1 3/2)	(2/9 1/4 1/3) (1/5 1/4 2/7) (5/7 1 2)	(1 1 1) (1 1 1) (1 1 1)	(1/4 1/2 2/3) (5/2 3 7/2) (2/9 1/4 1/2)	(4/5 1 4/3) (1 3/2 2) (1 7/4 2)
B4	(2/3 1 4/3) (2/5 1/2 1) (3 7/2 4)	(1/3 1/2 2/3) (1/4 1/3 1/2) (2 4 9/2)	(3/2 2 4) (2/7 1/3 2/5) (2 4 9/2)	(1 1 1) (1 1 1) (1 1 1)	(8/5 2 3) (1/2 1 6/5) (1 3/2 2)
B5	(4/9 1/2 3/4) (2/5 1/2 1) (2/3 1 5/4)	(1/4 2/7 1/3) (1/4 1/3 1/2) (1/2 2/3 1)	(3/4 1 5/4) (1/2 2/3 1) (1/2 4/7 1)	(1/3 1/2 5/8) (5/6 1 2) (1/2 2/3 1)	(1 1 1) (1 1 1) (1 1 1)

Table 65.3 A–B Comprehensive fuzzy triangle matrix

A–B	B1	B2	B3	B4	B5
B1	(1 1 1)	(0.4 0.611 0.917)	(1.056 1.5 2)	(0.667 1.095 1.167)	(3 4.333 5.667)
B2	(1.333 2 3.167)	(1 1 1)	(2.333 3 3.967)	(1.241 1.75 2.444)	(2.833 3.667 5)
B3	(0.522 0.722 1.056)	(0.368 1.5 0.873)	(1 1 1)	(0.991 1.25 1.556)	(1.533 2.333 3)
B4	(1.356 1.667 2.111)	(1.194 1.611 1.889)	(1.262 2.111 2.967)	(1 1 1)	(1.533 2.333 3)
B5	(0.187 0.244 0.361)	(0.2 0.278 0.373)	(0.444 0.579 1)	(0.361 0.484 0.708)	(1 1 1)

$$\sum_{i=1}^{5}\sum_{j=1}^{5} a_{ij} = (1\,1\,1) + (0.4\,0.611\,0.917) + \cdots + (0.556\,0.722\,1.208) + (1\,1\,1) = (23.553\,31.799\,41.276)$$

$$\sum_{j=1}^{5} a_{ij} = (1\,1\,1) + (0.4\ 0.611\ 0.917) + (1.056\ 1.5\,2) + (0.667\ 1.095\ 1.444) + (1.044\ 1.667\ 2.083) = (4.167\ 5.873\ 7.444)$$

From the above formula (65.1)

$$DB1 = \sum_{j=1}^{5} a_{ij} \otimes \left(\sum_{i=1}^{5} \sum_{j=1}^{5} a_{ij} \right)^{-1} = (0.1010\ 0.1847\ 0.3161)$$

Similarly we can get:

$$DB2 = \sum_{j=1}^{5} a_{ij} \otimes \left(\sum_{i=1}^{5} \sum_{j=1}^{5} a_{ij} \right)^{-1} = (0.1714\ 0.3014\ 0.5364)$$

$$DB3 = \sum_{j=1}^{5} a_{ij} \otimes \left(\sum_{i=1}^{5} \sum_{j=1}^{5} a_{ij} \right)^{-1} = (0.0927\ 0.1537\ 0.2659)$$

$$DB4 = \sum_{j=1}^{5} a_{ij} \otimes \left(\sum_{i=1}^{5} \sum_{j=1}^{5} a_{ij} \right)^{-1} = (0.1335\ 0.2481\ 0.4260)$$

$$DB5 = \sum_{j=1}^{5} a_{ij} \otimes \left(\sum_{i=1}^{5} \sum_{j=1}^{5} a_{ij} \right)^{-1} = (0.0721\ 0.1121\ 0.2081)$$

Then to blur, according to the above formula 65.2–65.4, we can get:

$$v(D_{B1} \geq D_{B2}) = \frac{0.1714 - 0.3161}{(0.1874 - 0.3161) - (0.3014 - 0.1714)} = 0.5536$$

$$v(D_{B1} \geq D_{B3}) = 1$$

$$v(D_{B1} \geq D_{B4}) = \frac{0.1335 - 0.3161}{(0.1874 - 0.3161) - (0.2481 - 0.1335)} = 0.7423$$

$$v(D_{B1} \geq D_{B5}) = 1$$

$$\begin{aligned} d'(B1) &= \min v(D_{B1} \geq D_{B2}, D_{B3}, D_{B4}, D_{B5}) \\ &= \min(0.5536\ 1\ 0.7423\ 1) = 0.5536 \end{aligned}$$

Similarly we can get:

$$d'(B_2) = 1 \quad d'(B_3) = 0.3902$$

$$d'(B_4) = 0.8269 \quad d'(B_5) = 0.1611$$

By calculation, we can get:

$$W' = (0.5536\ 1\ 0.3902\ 0.8269\ 0.1611)$$

After the normalized, we can get:

$$W = (0.1888\ 0.3411\ 0.1331\ 0.2820\ 0.0549)$$

Table 65.4 Index total weight

Index of layer B	Weight of the index of layer B	Index of layer C	Weight of the index of layer C	Weight of the total ranking of layer C
B1	0.19	C1	0.30	0.057
		C2	0.14	0.030
		C3	0.17	0.032
		C4	0.19	0.036
		C5	0.20	0.038
B2	0.34	C6	0.42	0.143
		C7	0.33	0.112
		C8	0.25	0.085
B3	0.13	C9	0.34	0.044
		C10	0.26	0.034
		C11	0.23	0.030
		C12	0.17	0.022
B4	0.28	C13	0.29	0.081
		C14	0.27	0.076
		C15	0.22	0.062
		C16	0.22	0.062
B5	0.06	C17	0.46	0.028
		C18	0.54	0.032

The same method can be obtained the weights that the first class index relative to the second class index, just like Table 65.4 shows, based on this we can gain the total order that the sub-rule layer C relative to the target layer A.

From Table 65.4, we know that competitors factor play an important part in the location, while the influence of urban development planning is relatively minimal. So numbers of competitor in this area should be given priority when a new site is set up (Li et al. 2005). Try to learn the diversity of services and products between rivals from market research. If you want more market share, innovation is indispensable. At the same time, population and economy should be taken into consideration. It's necessary to expand service radium and improve the service level.

65.3 Summary

In the hierarchical analysis of general problem, structured judgment matrix neglects people's fuzzy judgment, only including two possible extreme conditions: to choose an index in a membership of 1, meanwhile, to negate other scale value with the same membership (or other, to choose an index in a membership of 0) (Liu and Fan 2005). Sometimes experts may give some fuzzy quantity when to be consulted. It seems necessary to bring in fuzzy numbers to improve analysis. FHAP is the combination of AHP and the fuzzy comprehensive evaluation method. Evaluation based on it contributes to scientific and effective decisions.

Due to the limitation of scoring, the method is general applied in particular area (Fan et al. 2005). It cannot be denied that it has reference value by eliminating personal subjective judgment. Also, it has good evaluation in a given scheme to choose the best.

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Chapter 66
The Study of Sino-Russian Trade Forecasting Based on the Improved Grey Prediction Model

Zhen-zhong Zhang, Shuang Liu and Li-xia Tian

Abstract In this paper, we improved the traditional GM (1,1) model with the other-dimensional gray-scale by-ways, which has a higher accuracy, and predicted the Sino-Russian future trade. First of all, we introduced the theory of GM (1,1) grey and GM (1,1) grey equidimensional filling vacancies. Secondly, we established GM (1,1) grey forecasting model of equidimensional filling vacancies by using the trade volume between China and Russia from 2000 to 2011. Then, we forecasted the Sino-Russian trade in 2012. At the end of the paper, we analyzed the forecast results, and we found that Sino Russian trade still has very large development space.

Keywords GM (1, 1) · Grey forecasting model of equidimensional filling vacancies · Grey theory · Sino-Russian trade forecasting

66.1 Introduction

Along with the deepening of world economy integration, the economic connection between each country is increasingly close. China is the most populous country in the world. Russia, China's largest neighbors, is the world's largest country. They have a more than 4300 km common boundary line and a long trading history. At present, both of China and Russia are permanent members of the UN Security

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E. Qi et al. (eds.), *The 19th International Conference on Industrial Engineering and Engineering Management*, DOI: 10.1007/978-3-642-38391-5_66,

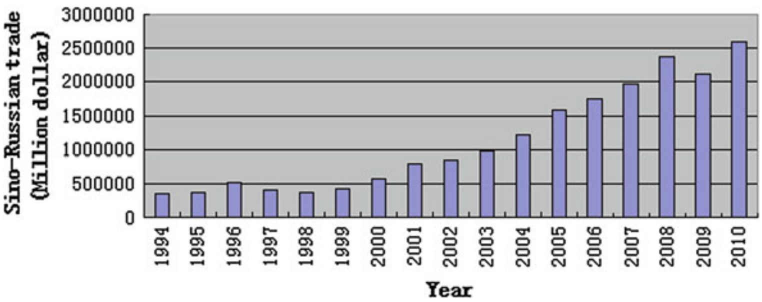

Fig. 66.1 Volume of trade between China and Russia from 1994 to 2010

Council, members of WTO, and play a significant role in international politics and economic affairs.

From Fig. 66.1, we can see, Sino-Russian trade history is a long and tortuous development process. For example, from 1999 to 2008, because of the reforms of Russia's foreign trade policy, the rapid growth of Chinese economy and other reasons, Volume of trade between China and Russia grew stably and rapidly, while the Sino-Russian trade sharp declined under the influence of the global financial crisis in 2008 (Du 2011; Ren and Wang 2011; Zhang and Liang 2011; Ma et al. 2006; Li et al. 2012; Chen 2009; Zhao 2010).

From the above situation, we can see, the foreign trade volume growth presents a certain degree of volatility and uncertainty, because of the impact of trade policy, international market demand, emergencies and many uncertainties, and so on, which has increased difficulty to the accurate prediction of trade volume. However, accurate prediction of volume of foreign trade has important significance in promoting the national economy stable and sustained growth, and in developing reasonable and effective foreign trade policy (Deng 2005; Li 2008; Chu 2011; Wang et al. 2008).

Because the volume of foreign trade will be influenced by many uncertain factors, some scholars use the traditional GM (1,1) model for foreign trade volume prediction. Because of its small sample size, the higher prediction accuracy, the gray prediction technology has been widely used. While, GM (1,1) models has its limitations as other forecasting methods. For example, when the data with a greater degree of dispersion, that is to say, the greater the gray scale data it is, the prediction accuracy worse; and it is not suitable for predicting long-term forecast for several years after the push (Zhou and Jiang 2004; Zhou and Zhou 2011; Wang et al. 2009; Zhang et al. 2009; Niu et al. 2006). In this paper, we improved the traditional GM (1,1) model with the other-dimensional gray-scale by-ways, and predicted the Sino-Russian future trade.

66.2 Introduction of Grey Forecasting Model of Equidimensional Filling Vacancies GM (1, 1)

66.2.1 GM (1, 1) Model

In 1982, Professor Deng Ju-long, a famous scholar in China, proposed and developed Grey system. When modeling the gray model of Sino-Russian trade forecasting, we usually use historical data to establish differential equations, which is used as the Sino-Russian trade forecasting models. Because there are many uncertain factors affect Sino-Russian trade, which is called gray system, the volume of trade between China and Russia is no rule. With the help of Grey theory, these seemingly irregular historical data, after generated by the cumulative, showed a clear exponential growth law compared with the original value. At the same time, differential equations have the same form of exponential form. That is to say, the prediction process can be divided into three steps. Firstly, fit exponential growth to generate regular data column by using differential equations. Secondly, conducting the Sino-Russian trade forecast. Thirdly, generate the actual Sino-Russian trade forecasts with the help of regressive reduction method. GM (1,1) model is one of the most simple models in gray system theory. The modeling process is as follows:

Recorded the Sino-Russian trade raw data in previous years is:

$$x^{(0)} = \{\mathrm{x}^{(0)}(1), \mathrm{x}^{(0)}(2), \ldots, \mathrm{x}^{(0)}(\mathrm{n})\} \tag{66.1}$$

The result of 1-AGO is:

$$x^{(1)} = \{\mathrm{x}^{(1)}(1), \mathrm{x}^{(1)}(2), \ldots, \mathrm{x}^{(1)}(\mathrm{n})\} \tag{66.2}$$

Among of them,

$$x^{(1)}(k) = \sum_{i=1}^{k} x^{(1)}(i) \quad (\mathrm{k} = 1, 2, \ldots, \mathrm{n}) \tag{66.3}$$

The sequence $x^{(1)}(\mathrm{k})$ has the law of exponential growth, so we generally believe the sequence $x^{(1)}(\mathrm{k})$ meets the exponential growth in the form of general solutions of first-order linear differential equation:

$$\frac{dx^{(1)}}{\mathrm{dt}} + dx^{(1)} = u \tag{66.4}$$

Under normal circumstances, the Sino-Russian trade data we get is discrete data, while the index should be a continuous type of equation. At this time, the general approach is: using $x^{(0)}(\mathrm{k}+1)$ to represent the differential term of the discrete form. Here, $x^{(1)}$ take the average load of k and k + 1, namely:

$$x^{(1)} = \frac{1}{2}\left[x^{(1)}(\mathrm{k}) + x^{(1)}(\mathrm{k}+1)\right] \tag{66.5}$$

Therefore, the equation is transformed into:

$$x^{(0)}(\mathrm{k}+1) + \frac{1}{2}\mathrm{a}\left[x^{(1)}(\mathrm{k}) + x^{(1)}(\mathrm{k}+1)\right] = \mathrm{u} \tag{66.6}$$

The results will be written in matrix form as follows:

$$\begin{bmatrix} x^{(0)}(2) \\ x^{(0)}(3) \\ \ldots \\ x^{(0)}(n) \end{bmatrix} = \begin{bmatrix} -\frac{1}{2}[x^{(1)}(1) + x^{(1)}(2)] & 1 \\ -\frac{1}{2}[x^{(1)}(2) + x^{(1)}(3)] & 1 \\ \ldots & \ldots \\ -\frac{1}{2}[x^{(1)}(n-1) + x^{(1)}(n)] & 1 \end{bmatrix} \begin{bmatrix} a \\ u \end{bmatrix} \tag{66.7}$$

Here, we order $Y_n = \begin{bmatrix} x^{(0)}(2) \\ x^{(0)}(3) \\ \ldots \\ x^{(0)}(n) \end{bmatrix}, A = \begin{bmatrix} a \\ u \end{bmatrix},$

$B = \begin{bmatrix} -\frac{1}{2}\left[x^{(1)}(1) + x^{(1)}(2)\right] & 1 \\ -\frac{1}{2}\left[x^{(1)}(2) + x^{(1)}(3)\right] & 1 \\ \ldots & \ldots \\ -\frac{1}{2}\left[x^{(1)}(n-1) + x^{(1)}(n)\right] & 1 \end{bmatrix}$, then: $Y_n = BA$.

By solving the equation, we know $A = (\mathrm{B}^{\mathrm{T}}\mathrm{B})^{-1}B^T Y_n = \begin{bmatrix} \hat{a} \\ \hat{u} \end{bmatrix}$, then put parameters back to the original equation, we know:

$$\hat{x}^{(1)}(\mathrm{k}+1) = \left[\mathrm{x}^{(1)}(1) - \frac{\hat{u}}{\hat{a}}\right] e^{-\hat{\mathrm{a}}(\mathrm{k}+1)} + \frac{\hat{u}}{\hat{a}} \quad (\mathrm{k} = 0, 1, 2, \ldots) \tag{66.8}$$

After 1-IAGO, we can get the discrete form:

$$\begin{aligned} \hat{x}^{(0)}(\mathrm{k}+1) &= \hat{x}^{(1)}(\mathrm{k}+1) - \hat{x}^{(1)}(\mathrm{k}) \\ &= (1 - e^{-\hat{a}})\left[\hat{x}^{(0)}(1) - \frac{\hat{u}}{\hat{a}}\right] e^{-\hat{a}\mathrm{k}} \quad (\mathrm{k} = 0, 1, 2, \ldots) \end{aligned} \tag{66.9}$$

Equations (66.8) and (66.9) are the time response function model of the GM (1,1) model. Among of them, when $k = 0, 1, \ldots, n-1$, $\hat{x}^{(0)}(\mathrm{k}+1)$ is the fitted values of the original data sequence $\hat{x}^{(0)}(\mathrm{k}) \quad (k = 1, 2, \ldots, n)$. While, $\hat{x}^{(0)}(\mathrm{k}+1)$ is the predictive value of the original data sequence $\hat{x}^{(0)}(\mathrm{k}) \quad (k = 1, 2, \ldots, n)$, when $k \geq n$.

66.2.2 Grey Forecasting Model of Equidimensional Filling Vacancies GM(1, 1)

Because of the first-order differential equation, which is used in Gray GM (1, 1) model, is exponential, GM (1,1) model is applied to a strong exponential Sino-Russian trade forecasting. But it requires the data is equidistant, adjacent, no jumping, and requires using the latest data as a reference point, the earliest data is dispensable, but the latest data have to be added. For these reasons, the application of Gray GM (1, 1) model is limited. So in this paper, the author would improve it.

The essence of Grey forecasting model of equidimensional filling vacancies GM(1,1)is to get each new forecast data into the original data, while removing one of the earliest data, thereby maintaining the same number of data. Then, use the sample sequence with the times to rebuild gray GM (1,1) model to predict the next value. Repeat the above process, forecast one by one, elected one by one. When using it to predict, it can replenish the use of new information and increase degree of gray plane albino. Finally, Sino-Russian trade forecasting accuracy will be improved significantly. The modeling process is as follows:

First of all, handling the data respectively by 1-AGO and 1-IAGO as the traditional GM (1,1) model, then you can get the corresponding time series $x^{(0)}(\mathrm{k}+1)+\frac{1}{2}\mathrm{a}[x^{(1)}(\mathrm{k})+x^{(1)}(\mathrm{k}+1)]=\mathrm{u}$ of GM (1,1) model:

$$\begin{aligned}\widehat{x}^{(0)}(\mathrm{k}+1) &= \widehat{x}^{(1)}(\mathrm{k}+1)-\widehat{x}^{(1)}(\mathrm{k}) \\ &= (1-\mathrm{e}^{-\hat{a}})\left[\widehat{x}^{(0)}(1)-\frac{\hat{u}}{\hat{\mathrm{a}}}\right]\mathrm{e}^{-\hat{\mathrm{a}}\mathrm{k}} \\ &(\mathrm{k}=0,1,2,\ldots n-1)\end{aligned}$$

The dynamic process of equidimensional filling vacancies on the original sequence: Remove$x^{(0)}(1)$, add $\widehat{x}^{(1)}(\mathrm{n}+1)$. Thus, the original data sequence turns into:

$$x^{(0)}=\left\{\mathrm{x}^{(0)}(2),\mathrm{x}^{(0)}(3),\ldots,\mathrm{x}^{(0)}(n),\widehat{\mathrm{x}}^{(1)}(n+1)\right\}$$

Based on this adjusted the original data sequence, re-use the traditional GM (1, 1) model to predict the next value.

Finally, repeat the above steps until get the final demand forecast results.

66.2.3 Sino-Russian Trade Forecasting

Sino-Russian trade has experienced a long and tortuous development history. In the modeling process, we selected Sino-Russian trade, from 2000 to 2010, as the raw data, and the 2011 Sino-Russian trade data as the year of testing the merits of

Table 66.1 The Sino-Russian trade from 2000 to 2011 (billion dollars)

Years	2000	2001	2002	2003	2004	2005
Volume of trade	80.03	106.71	119.27	157.58	212.26	291.01
Year	2006	2007	2008	2009	2010	2011
Volume of trade	333.87	481.55	569.09	387.52	555.33	835

the standard model. Then, we forecast the Sino-Russian trade in 2012. The Sino-Russian trade from 2000 to 2011 as follows (Table 66.1):

After using Matlab to get the original series and after series of accumulated generating trends, the exponential growth trend can be found. That is to say, we can use GM (1, 1) to predict (Fig. 66.2).

With the help of Matlab, the result could be got, as follows:

$$A = \begin{bmatrix} \hat{a} \\ \hat{u} \end{bmatrix} = \begin{bmatrix} -0.1539 \\ 1296409.5357 \end{bmatrix}$$

Therefore:

$$\widehat{x}^{(1)}(k+1) = 9224037.68e^{0.1539k} - 8423713.68$$

From 1-IAGO to get tired by the gray prediction model is:

$$\widehat{x}^{(0)}(k+1) = 9224037.68\left(1 - e^{0.1539}\right)e^{0.1539k}$$

$$(k = 0, 1, 2\ldots)$$

With the help of traditional GM (1,1) model and improved gray GM (1,1) model, we forecast the Sino-Russian trade in 2012, the results are as follows (Table 66.2):

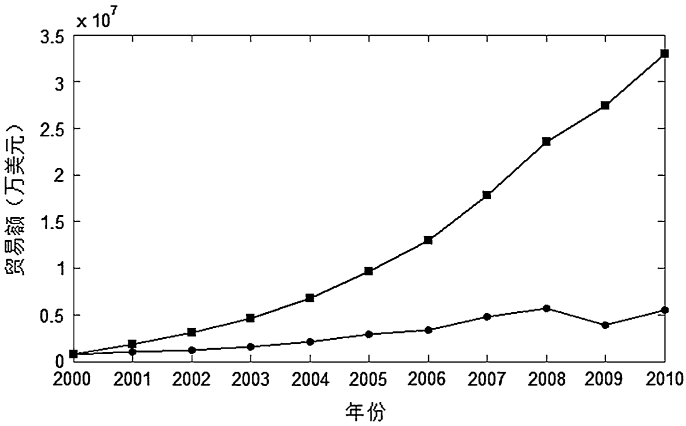

Fig. 66.2 The original series and additive series trends

Table 66.2 Compare the predictions between traditional GM (1, 1) model and improved model

		Traditional grey		Improved grey model	
Years	Actual value	Predictive value	Residuals	Predictive value	Residuals
2011	835	833.78	1.22	834.50	0.5

Table 66.3 Accuracy assessment model

Accuracy class	p	c
First grade:Good	>0.95	<0.35
Second grade:Qualified	>0.80	<0.5
Third grade:Reluctantly	>0.70	<0.65
Fourth grade:Failure	<= 0.70	> = 0.65

Table 66.4 The posterior margin of the two models

	p	c
Traditional GM (1,1) model	1.61	0.067
Improved GM (1,1) model	2.28	0.039

There are two indicators about difference test after test: poor ratio of posterior "c" and small error probability "p". "c" is smaller, the model is better; "p" is greater, the model is better (Tables 66.3, 66.4).

It can be seen from the result, the accuracy of the model no matter improved or not is good. However, the accuracy of the improved model was better than before the improvements. In other words, improved gray model has a higher extrapolation in Sino-Russian trade forecasting.

66.3 Conclusion

Because the foreign trade volume between the two countries is affected by the country's economic conditions, trade policy, international market demand, unexpected events and many uncertain factors, which belongs to the gray areas of the system. Because of foreign trade volume prediction in gray scale is too large, the traditional GM (1, 1) model to forecast precision is reduced which results in not applicable. In this paper, we improved the traditional GM (1, 1) model, and used the new model predicted Sino-Russian trade. At the end of the paper, we found that the improved model has much higher accuracy than the traditional one, through comparing the predict results which were got by using the traditional one and the improved one. However, the greater the need to predict the amount, the greater the computation it is. For this, the model still needs to improve again.

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Chapter 67
The Role of Preference and Emotion in Environmental Risk Perception

Charlene Xie, Yang Liu, Shengxiang She and Dixi Song

Abstract Environmental risks are becoming increasingly frequent and severe across the world, especially in China. An in-depth understanding of how public perceives risk is of crucial importance to effective environmental risk communication and management. Risk preference and emotion are two critical factors in environmental risk perception. This paper summarizes existing researches in risk preference and emotion, and reflects upon their roles in environmental risk perception. Based upon existing literatures, it argues that delay affects environmental risk perception more than time preference and proposes a research on disentangling time preference and risk preference, i.e. risk preference at different time periods. Under the guidance of Appraisal Theory, this paper explores the roles of emotion in environmental risk perception and attempts to combine it into the future examining of delay effect on risk preference.

Keywords Environmental risk perception · Risk preference · Time dealy effect · Emotion · Apprial theory

67.1 Introduction

The recent years has seen the sharp increase in environmental risk frequency and severity, causing casualty and financial loss. The petroleum leakage accident in the Bohai Sea and the cadmium pollution in Guangxi are typical examples of recent

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E. Qi et al. (eds.), *The 19th International Conference on Industrial Engineering and Engineering Management*, DOI: 10.1007/978-3-642-38391-5_67,

environmental risk events in China. Environmental risk management has become an important task for central and local governments in China.

When reviewing upon public reactions in these environmental risk events, we find that common people typically lack objective judgment and usually overreact in panic. However, people are apparently ignoring environmental risks like air pollution, climate change, and soil contamination in daily life. Such an obvious contrast cannot be fully explained by existent theories in decision research, psychology and risk management. According to the results of latest researches in this field, risk preference and emotion are two important underlying factors in such an obvious contrast (Scherer 2009; Keller et al. 2012).

Traditional rationality paradigm in decision theory attributes people's responses to risks to the probability and severity. For long-term risks like environmental risks which have noticeable time delays, scholars combine time preference into the decision process. As for the relationship between time preference and risk preference (manifested by subjective probability), most researches have treated them as independent from each other. Some scholars even simply equal subjective probability to statistical probability, absolutely ignoring the non-linearity of people's real risk preference.

People have long felt that their instant emotion holds a great power on their perception of uncertainty, environmental risks included. Researches into emotion and risk perception in the past few decades have shown that the role of emotion in risk perception is more important than previously thought. Advancement in appraisal theory has brought many new and more convincing insights into how emotion is elicited, combined with appraisal, and why people's emotional responses vary so much for the same environmental risk.

To research further into the relationship between time and risk preference and combine emotion into it is of great importance to better understanding of environmental risks. This paper will review researches in risk preference and emotion in environmental risk perception. It will proceed as follows. Section 67.2 will reflect on research development in the entangling relationship between risk preference and time preference, emphasizing its influence on environmental risk perception. Section 67.3 will summarize theories and findings concerning emotion, its effect upon environmental risk perception in particular. Section 67.4 will discuss our research plan to explore the time delay effect on risk preference, especially its influence on environmental risk perception, and its combination with emotion in specific environmental risks like nuclear leakage, and air pollution. Section 67.5 will discuss our expected results, and the problems we meet in design our research plan. Also directions for future researches are shown in this section.

67.2 Risk Preference in Environmental Risk Perception

Environmental risks are typically intertemporal risks, with delayed consequences and high uncertainty (Gattig and Hendrickx 2007). Perception of environmental risks involves both objective factors and subjective factors. Risk preference is one of the two main subjective factors in environmental risk perception, together with time preference. Although it is generally accepted that people can be risk-averse, risk-neutral, or risk-seeking, it is more practical to assume all human beings are averse towards environmental risks, since they cannot get any benefit from environmental risks. Also, it is reasonable to assume that all people require compensation for delayed benefit, i.e. people are averse to time delay.

Risk preference manifests people's attitudes towards risks. It is usually measured via the comparison between expected value and subjective certainty equivalent. When the subjective certainty equivalent of a risky option is equal to its expected value, the decision maker is risk-neural; when lower than expected value, he is risk-averse; and when greater than expected value, he is risk-seeking. Extensive explorations have been conducted in this field. The first and perhaps most influential result is the expected utility theory. This model received widespread support and became the basis for decision under uncertainty in several decades, due to clarity and simplicity in both logic and form. While in financial field Markowitz proposed his risk–return model to explain the St. Petersburg Paradox. However, the findings of more and more anomalies, like framing effect, challenged the two theories. It was under this situation that prospect theory was proposed.

Time preference shows people's discounting of future gain or loss. Extensive researches have been conducted in time preference, bringing forth multiple theories and findings. The Discounted Utility (DU) model is the first widely accepted model, in which future utility is manifested by utility discounting factor. Later researches found many anomalies, greatly undermining the validity of the DU model. To better explain people's real activities under time delay researchers proposed models like hyperbolic discounting (Pender 1996), and hyperboloid discounting (Green et al. 1997).

For intertemporal risks, discounted expected utility has long been the dominant model to explain people's attitudes towards both time delay and uncertainty at the same time. However, its underlying assumption that people are risk neutral towards gains and losses is under criticize.

Although both risk preference and time preference in intertemporal risks have been researched in detail, few have focused on the relationship between them, simply treating them as orthogonal dimensions. Recently, some studies have noticed that time delay can affect subjective probability judgment (Epper et al. 2009). Some researchers treat time delay as an implicit risk, arguing that time delay increases aversion towards risk (Baucells and Heukamp 2010). Some other researchers use impatience to argue that time delay makes people more risk-averse. While Construal Level theory (Liberman and Trope 2008) suggests that time delay reduces risk aversion. Latest behavioral experiments show that time delay makes people more risk tolerant. Anyhow, researches in neuroscience (Loewenstein 2001) and biology (Boyer 2008) strongly support that time has an impact on risk preference.

Risk preference greatly affects people's perception of environmental risks. Risk preference changes people's subjective probability of a risk event. For example, higher risk aversion increases people's subjective probability of environmental risk. Studies have found that people with different risk preference levels exhibit greatly different attitudes towards environmental risks and relevant policies and measures (Rundmo and Moen 2006). In a cross-cultural research as for environmental risk perception, Duan and Fortner found that Chinese people are more risk averse than Americans, and consequently more concerned with environmental risks (Hongxia and Rosanne 2010).

Combing the fact that time delay affects both time preference and risk preference, we can logically deduce that time delay affects people's perception of long-term risks like environmental ones more than time preference does. Our finding can improve our understanding of environmental risk perception in a more precise way. This new finding can better explain and predict people's environmental risk related behavior.

67.3 Emotion in Environmental Risk Perception

In the traditional rationality paradigm, emotion was treated as an external interference in risk perception, like many other subjective factors. With the psychological researches in environmental risk field, it has been found and widely accepted that environmental risk perception is closely related to individual traits, besides that objective condition of environmental risks (Vastfjall et al. 2008). In fact, many studies have shown that emotion is very important in environmental risk perception, more than only being external interference. The newly proposed Appraisal Theory has attempted to combine both cognition and affection into environmental risk perception, in favor of a dual-process model.

Appraisal theory has found that feelings involved in environmental risks are more than simply bad or good affect (Peters et al. 2004). Anger, fear and other specific emotions have been found very important in perception of environmental risks. The role of emotion in environmental risk perception can be analyzed from three kinds of different models—relational, process, and structural models. Relational models attempt to explain why individual's emotional responses to the same environmental risk are so different (Scherer 2009). It has been found that values, abilities, goals and needs are valid reasons for the difference in environmental risk related emotions (Lerner and Keltner 2000). Process models aim at finding how people's emotion is elicited when faced with risks. However, no specific research in environmental risk perception has been conducted under this type of model. Structural models explore the implicit relationship between emotion and environmental risk appraisal. These three kinds of models have the potential to be integrated as tried by Peters and his colleagues (Smith and Kirby 2009). Studies have confirmed that emotion is closely related to environmental risk appraisals (Watson and Spence 2007). Causes of emotion in environmental risks can be classified as the agency, coping potential, fairness, certainty, and outcome desirability (Watson and Spence 2007).

Emotion is one of the causes of behavioral tendency (Scherer 2009). Different emotion in risk perception can cause different environmental risk actions, implying the important role of emotion in environmental risk management. However, emotion is far from being the sufficient condition of behavior (Gattig and Hendrickx 2007; Pender 1996; Green et al. 1997). Environmental risk types and cultural factors coordinate the relationships between emotions and behaviors. In addition, different people have different ways to express their emotions. It requires further researches to find what emotions are relevant in specific environmental risks, and what are the effects of appraisals on emotional reactions in specific environmental risks. In brief, future research can focus on the particular factors in emotion in specific environmental risks, like nuclear leakage, water pollution, and soil contamination.

67.4 Future Research

The intertwinement of time preference and risk preference in environmental risk perception requires the effort to disentangle them. The research into the effect of time delay on risk preference is the key, since it has been found that time preference is stable under different uncertainties (Gattig and Hendrickx 2007).

The following simple question can show the existence of time delay effect upon risk preference. If a man treats \$1,000 which is to be paid one year later as equivalent to \$800 today, and treats \$800 as the certainty equivalent to a \$2,000 or \$0 risky option with probability of 50–50, will he be indifferent to the same risky option to be resolved and paid one year later and a certain amount of \$640 (\$800/(\$1,000/\$800))? Some recent studies have found people will prefer risky option to certain amount of \$640 (Noussair and Wu 2006).

We will extend the study in this topic, and expects to get reasonable and convincing result on time delay effect upon risk preference. The further research plan would consist of two types of research, laboratory behavioral experiments and questionnaire survey. For laboratory behavioral experiments, we will design a bunch of lotteries with different probabilities and results under both gain and loss situations. A possible design for loss situation is shown in Table 67.1.

As shown in the Table 67.1, we will use 10 different lotteries with different combination of results and probability. Each lottery will be exercise under four

Table 67.1 Behavioral experiment lottery design

	1	2	3	4	5	6	7	8	9	10
X	−1,200	−1,200	−600	−1,200	−600	−1,000	−1,200	−1,200	−1,200	−1,200
P	1/6	2/6	2/6	2/6	2/6	2/6	2/6	3/6	4/6	5/6
y	0	0	0	−600	−400	−900	0	0	0	0

different time delays, 0 day, 6 week, 12 week, and any uncertain time between 0 day and 12 weeks. Therefore, participants in the experiment will face 40 different choices.

Different from Noussair and Wu 2006, we will assume no specific models on expected values, especially the linear relationship between probability and probability weighting function, i.e. subjective probability. We will ask subjects to report certainty equivalent on exercise date for each lottery rather the present value. Data will be collected and analyzed, comparing the certainty equivalents for the same lottery under different time delays. By imposing specific form on probability, we will be able to analyze further into the structure of time delay effect on risk preference.

Given the influence of emotion on risk perception, we will also test how different emotions affect people's risk preference under delay. We will try to elicit different emotions among subjects with different contents and ask them to answer questions which are designed to test their emotions. By comparing the certainty equivalents of the same lottery with the same time delay under different emotions, it is able to catch insight into how specific emotions affect risk preference.

The questionnaire survey will feature specific environmental risks, like nuclear leakage, water pollution, soil contamination or air pollution. With properly designed questionnaire, we will gain data reflecting both people's risk preference in a specific environmental risk, and how their instant emotion affects time delay effect on risk preference.

The subjects will include students, teachers, and white collar workers. Those who join in laboratory behavioral experiments will be well guided before the experiments to well understand the effect of their choice and get some amount of money as reward according to their performance.

67.5 Conclusion

The roles of risk preference and time preference in environmental risks are crucial. The finding that risk preference can be affected by time delay is of value in understanding people's environmental risk perceptions. We expect to find that time delay makes people more risk tolerant. Based upon this, we will gain a new approach to explain people overreaction towards temporal environmental risks, and their neglect for long-term environmental risks like global warming. As for emotion, we anticipate to find that overwhelming emotions can greatly change people' risk preference and time delay effect on risk preference.

This research will be the first study to explore the effect of time delay on environmental risk perception. It is also supposed to be the first study that combines risk preference and emotion in environmental risk perception. Also, it will provide evidence for identifying the difference between people's risk preference under gain situations and that under loss situations. We hope to catch insight into the role of risk preference and emotion in environmental risk perception, especially the effect of time delay on risk preference with application in environmental issues. Our research will provide deeper insights to people's attitudes towards environmental risks, and thus offer better guidance for relevant environmental risk communication and management.

Acknowledgments This work was supported by the National Science and Technology Support Program (2009BAK53B06), the National Natural Science Foundation of China (71101035) and the Humanities and Social Sciences of Education Ministry (12YJA880130).

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Chapter 68
The Model Research on Risk Control

Qing-hai Zhang

Abstract With the development of the society and the growth of technical complexity, the risks of many problems are increasing, which promotes a pressing need to conduct a research on the technology and methods of risk control. Having identified and assessed all the possible risks, the paper divides them into four types, and designs the risk control model for each type aiming at minimizing the risk probability and harm degree. Furthermore, the paper also extends the model concerning the economic costs to the one concerning social benefits and other factors.

Keywords Risk · Risk control · Model

68.1 Introduction

Risk is the phenomenon that widely exists in people's work and life. Risk have the following characteristics. Firstly, risk is the cause of disaster and accident, or the economic loss and casualties of disaster and accident. Secondly, the occurrence of risk is uncertain. Thirdly, the loss degree of risk is uncertain, and there's difference between the probable result and anticipated outcome (Doherty 2000a).

The risk management was born for the existence of risk phenomenon, which is new management science about occurrence rule of risk and risk control technology deriving from the USA in 1950s. The three kernel stages in risk management are risk identification, risky appraisal and risk control. Risk identification is to identify the present and potential factors which may cause loss in the management course, analyze if there is uncertainty in the factors and determine if the uncertainty exists objectively. Risk identification is the first step and stage of risk management and the basement of the whole risk management. Risk appraise is also important work

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E. Qi et al. (eds.), *The 19th International Conference on Industrial Engineering and Engineering Management*, DOI: 10.1007/978-3-642-38391-5_68,

that tests, weighs and estimate the risk, size up the probability and predicate the serious degree.

The final aim of risk identify and assess is to avoid and control risk, achieving optimum political, economic, and social benefits with the minimum cost, reduce the probability of risk accidents and the scope and effect of loss by the greatest extent (Jarrow and Turnbull 1998; Dohety 2000; Arther Williams and Heins RM Jr 1997). Risk control, the most popular risk management technique is fit to plan and implementation stage, which is vividly described as "admit risk, try to reduce the occurrence and the effect".

Specially, the risk control includes prior control, press control and subsequent control. For the prior control, we need to compare risk of different schemes and choose the best plan one giving consideration to every aspect. For the press control, there are two conditions. In the first condition, the risk is unacceptable. In the second condition, however, the risk is acceptable. If the risk exceeds the maximum acceptable level of risk, we have to cancel the present scheme and choose the alternate one, or rescue the present scheme by reducing the assess indicator and adjust the tactical and technical data requirements. If the risk is acceptable, we should continue monitoring the risk. For the subsequent risk, we need to summarize and popularize advanced experience and take warning from the failure.

68.2 Risk Assortment

By risk recognize and assess, we can find out the main risk and fix its probability and harm degree. There are four types of risk.

Risk 1, low probability, low harm. This risk is secondary and acceptable.

Risk 2, high probability, low harm. This risk should be well controlled to reduce its probability. Though the dangerous level of individual risk is not high, it's necessary to guard against accumulator risk.

Risk 3, low probability, high harm. This risk is seldom, but it will be subversive dangerous once it happens. So precautionary measures should be taken and new type of risk should be kept a weather eye on.

Risk 4, high probability, high harm. This risk is essential, and precautionary, shifting, diminishing measures should be taken to reduce the influence of this risk and prevent the subversive risk (LiuJun 2008).

68.3 P–C MODEL

68.3.1 The Design Thinking of the Model

The purpose of risk control is to reduce the probability of risk accident by the greatest extent and reduce the scope of the loss. Apparently, this is a optimization problem. So we need to create risk control model with the method of mathematical programming.

This model is designed for high probability and low harm risk that is risk 2. This risk can be divided into two types. Firstly, the harm is acceptable when the risk happens. Secondly, the harm is small but unacceptable. In the first case, the risk can be defined as acceptable risk. In the second case, as the probability of risk 2 is high, control measures are needed to reduce the probability. Besides, the control measures demand for cost that is called control cost. So we need to fully consider probability P and cost C. The model is based on the integration, so it's called $P-C$ model (Vincent and Jeryl 1985). $P-C$ model aims at increasing economic efficiency, which is suitable to apply to normal risk control.

68.3.2 The Creation of the P–C Model

The First Model: Single factor model

Take $s_1, s_2, \cdots, s_n$ as the n measures, $x_1, x_2, \cdots, x_n$are the n control measures, $x_1, x_2, \cdots, x_n$ are the corresponding variables. For measure s_i,there are two choices which are taking measure s_i and not taking measure s_i. If measure s_i is taken, then $x_i = 1$; if not, then $x_i = 0$. Apparently, x_i should be 0-1 variable:

$$x_i = \begin{cases} 0 & , take\ s_i \\ 1 & , nottake\ s_i \end{cases}.$$

Design n one dimension functions $P_k = P_k(x_i)$, $(k = 1, 2, \cdots, n)$, for example, $P_1(0)$ is the risk probability when s_i isn't taken; $P_1(1)$is the risk probability when s_i isn't taken. Take $C_1, C_2, \cdots, C_n$ as the corresponding control cost of $s_1, s_2, \cdots, s_n$.

Take control measure s_i as an example. Whether to choose s_i, we should consider $P_i(0)$, $P_i(1)$ and C_i overall. Generally, there are three conditions:

1) If $P_i(1) << P_i(0)$, then choose s_i.
2) If $P_i(1) < P_i(0)$, we should first define

control revenueR_i: control revenue is revenue resulting from s_i which reduces the risk probability. Mathematic expectation method is a popular method of control profit measuring. Suppose the loss resulting from the risk is A, then control profit is $R_i = [P_i(0) - P_i(1)] \times A$.

There are two conditions. If $R_i \le C_i$, then don't take measure s_i; if $R_i > C_i$, then take measure s_i, but if $R_j - C_j > R_i - C_i$, then take measure s_j, that's to calculate $\max\{R_i - C_i\}$, $i = 1, 2, \cdots, n$ to determine which control measure to take. Common ground is told, "whether the control cost is worthy".

3) $P_i(1) \ge P_i(0)$ is unrealistic.

In the same way, we can analyze other control measures.

The Second Model: Several factor model

In single factor model, there are two hypothesizes about s_i which are taking measure s_i and not taking measure s_i. x_i is 0-1 variable:

$$x_i = \begin{cases} 0 & , \ take\ s_i \\ 1 & , \ nottake\ s_i \end{cases}.$$

But in practice, we can choose several measures to control the risk, and determine the extent of each measure. So create several factor model based on mathematic programming knowledge (Benink 1995).

Create n dimension function $P = P(x_1, x_2, \cdots, x_n)$, in which x_i is the extent of control measure s_i, according to different extent, give x_i different numerical value. P is the corresponding risk probability when taking different extent of control measures such as $s_1, s_2, \cdots, s_n$. Suppose $x_i (i = 1, 2, \cdots, n)$ is continuous variable, so function $P = P(x_1, x_2, \cdots, x_n)$ is a n dimension continuous function of $x_1, x_2, \cdots, x_n$. Our target is to reduce the probability of this risk, so take the function as the target function of the programming problem, and calculate the minimum :

$$\min \ P(x_1, x_2, \cdots, x_n).$$

Take $C_1, C_2, \cdots, C_n$ standing for the control cost of control measures $s_1, s_2, \cdots, s_n$. Apparently, different extent of control measure $s_i$brings different control cost, which means C_i is a function of x_i (Jiang 2002):

$$C_i = C_i(x_i) \ , \quad (i = 1, 2, \cdots, n).$$

Then we get the restrain condition:

$$C_1(x_1) + C_2(x_2) + \cdots + C_n(x_n) \leq C,$$

C is the total acceptable cost.

Then we get the programming problem:

$$\min \ P(x_1, x_2, \cdots, x_n)$$

$$s.t. \begin{cases} C_1(x_1) + C_2(x_2) + \cdots + C_n(x_n) \leq C \\ C_i(x_i) \geq 0 \quad , \quad i = 1, 2, \cdots, n \end{cases}.$$

By calculating the programming model, we get the numerical value of $x_1, x_2, \cdots, x_n$ corresponding to the minimum of $P(x_1, x_2, \cdots, x_n)$. Accordingly, we can decide the type and extent of control measures to control risk 2 and provide the risk control experts with accurate evidence.

68.3.3 The Extension of the P–C Model

The above model focuses on economic efficiency. But in actual life, except economic efficiency, social efficiency is more important in some cases. Then, S which stands for social efficiency is instead of C which stands for control cost. So the new model can be named as $P-S$ model whose create method and steps can refer to $P-C$ model. In the same way, the model can extend and changes into other forms according to various needs.

68.4 σ-C MODEL

This model aims at risk 3 with low probability and high harm. The risk can be divided into two parts. The probability of the first risk is acceptable. The probability of the second risk is low, but the risk is unacceptable. In the first case, the risk is considered to be acceptable risk (Jorion 1997; Arrow 1971; Smith 1998; Delianedis and Geske 1998). In the second case, as the harm is serious when risk 3 happens, so it's necessary to take control measures to reduce the loss.σsymbolizes the loss, which is the difference between the final result and the intended goal. The cost results from the control measures is called control cost. So we need to fully consider loss scope σ and cost C. The model is based on the integration, so it's called $\sigma-$ Cmodel.

The create method, steps and extension of the $\sigma-$ C model are similar to the $P-C$ model.

68.5 *P*-σ MODEL

This model aims at risk 4 with high probability and serious harm that is the key point. Both reducing the probability P and lightening the loss scope are necessary (Ward 1999). As a result, the model has two target functions, making use of double target programming model:

$$\min \ P(x_1, x_2, \cdots, x_n)$$

$$\min \ \sigma(x_1, x_2, \cdots, x_n)$$

$$s.t.\begin{cases} C_1(x_1) + C_2(x_2) + \cdots + C_n[x_n] \le C \\ C_i(x_i) \ge 0 \quad , \quad i = 1, 2, \cdots, n \end{cases}.$$

This model will consider the different focus levels and demands of P and σ according to the practice. Operation researches always change double target programming into single target programming(Editorial Board of Operational Research 2002). That's to make a weighted analysis of probability and loss scope to form a target: min $\lambda_1 P + \lambda_2 \sigma$.

In this formula, λ_1 is the weight of P, λ_2 is the weight of σ. λ_1 and λ_2 fit the relationship:

$$\lambda_1 + \lambda_2 = 1, \quad 0 \leq \lambda_1,\ \lambda_2 \leq 1.$$

68.6 Conclusion

Above all, the risk2, risk3 and risk4 have been talked out. So for risk1 with low probability and little serious, we generally consider it as secondary and acceptable risk. If the probability or the harm is unacceptable, we need to reduce the probability or the harm when the above models could be used.

In the particular problems, there are many methods of risk control. But theory and practice of risk management prove that either method has its applicability and limitation. So we need to choose different control method according to different problem and characteristic of risk. The three models in this paper reduce the probability of the risk and lighten the loss scope of four types of risk, using the programming knowledge together with economic cost. It provides risk control experts with theoretical basis from the view of methodology (Doherty 2000b; White 2004). But in actual risk control, the risk control experts ought to overall consider different factors to decide which method to take with their own experience.

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Chapter 69
TOPSIS Based Power-Saving Plans Choice for Manufacturing Enterprise

Dong-sheng Wang and Kuan-ming Zheng

Abstract To accommodate the demand of low-carbon economy and lowering enterprise's production costs, the issues of one electronic manufacturing enterprise on power-saving are analyzed, and the plans for its power-saving are devised. With TOPSIS, these plans are appraised and optimized, and the effects on cutting down costs and improving efficiency are summed up.

Keywords Low-carbon economy · Manufacturing enterprise · Power-saving · TOPSIS method

69.1 Introduction

Since the twenty-first century, low-carbon economy has been attached more and more importance to. For manufacturing enterprises, the low-carbon developing model means that diminishing their energy consuming, improving the utilizing efficiency, and curtailing waste discharging are the foremost issues to be resolved. Improving production efficiency and lowering equipment cost are the basic conditions for the optimization of any enterprise's power-saving plans. The optimization methods include Fuzzy Evaluation Model, Analytical Hierarchy Process, Gray Comprehensive Evaluation, TOPSIS, etc., (Yue 2003) among which TOPSIS, as a simple statistical method, is of high reliability and of low error (Guo and Jin 2010). This paper, taking one electronic manufacturing enterprise as the case, puts forward three power-saving plans, optimizes these plans with TOPSIS, and analyzes the effects of the optimal choice.

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E. Qi et al. (eds.), *The 19th International Conference on Industrial Engineering and Engineering Management*, DOI: 10.1007/978-3-642-38391-5_69,

69.2 Methodology

69.2.1 Basic Ideas of TOPSIS Method

Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) is an important multi-attributes decision model, which finds the positive ideal plan and negative ideal plan with normalized initial matrix, to calculate the relative closeness between one plan and two ideal plans (Xu 2010). Based on the relative closeness, the sequence of the evaluation results is achieved. The positive ideal plan is the optimal one, which is a virtual plan, and its attributes are the best. And the negative ideal plan is the worst one, which is also virtual plan, and its attributes are the worst (Feng and Liu 2005).

69.2.2 Steps of the TOPSIS Method

Step 1: Set up normalized decision matrix (Verma and Pullman 1998)

$$Y_{ij} = \frac{Xij}{\sqrt{\sum_{i=1}^{m} X^2 ij}} (\mathrm{j} = 1, 2, 3 \ldots \mathrm{n}) \tag{69.1}$$

Step 2: Set up weighted normalized decision matrix (Lin et al. 2008)

$$V_{ij} = W_i * Y_{ij} \, (\mathrm{i} = 1, 2 \ldots \mathrm{n} \, \mathrm{j} = 1, 2 \ldots \mathrm{n}) \tag{69.2}$$

Step 3: Calculate the positive solution V^+ and negative ideal V^- (Liao and Rittscher 2007)

$$\begin{aligned} V^+ &= \left\{ \left(\max v_{ij}, j \subseteq J_1 \right), \left(\min v_{ij}, j \subseteq J_2 \right), i = 1, 2, 3, \ldots, m \right\} \\ V^- &= \left\{ \left(\min v_{ij}, j \subseteq J_1 \right), \left(\max v_{ij}, j \subseteq J_2 \right), i = 1, 2, 3, \ldots, m \right\} \end{aligned} \tag{69.3}$$

Step 4: Calculate Euclidean distance (Barbarosoglu 2000)

$$\begin{aligned} D^+ &= \sqrt{\sum_{i=1}^{m} \left[W_i \left(V_{ij} - V_i^+ \right) \right]^2} \\ D^- &= \sqrt{\sum_{i=1}^{m} \left[W_i \left(V_{ij} - V_i^- \right) \right]^2} \end{aligned} \tag{69.4}$$

Step 5: Calculate the relative adjacent degree (Pawlak 1982)

$$C_i = \frac{D_i^-}{D_i^+ + D_i^-} \tag{69.5}$$

Step 6: Obtain the optimal plan from C_i (Bin and Li-jie 2006)

69.3 Application of TOPSIS Method to Enterprise's Power-Saving Plans

69.3.1 Troubles in the Power-Saving of the Case Enterprise

The case enterprise is an electronic manufacturing factory. There are too many testing processes with high energy consumption. Before packaging, there are for steps of test for the products. Its testing workshops use LCD equipment to display the testing information. The followings are the existed troubles for the enterprise:

Large space is occupied by LCD equipment. The information displayed by LCD equipments is very simple and much equipment is used for the tests, which lead to large space occupation. The whole produce lines are crowded and the layout of lines is in chaos, which caused the operating personnel to walk frequently, and to walk in large range. These factors speed up personnel's fatigue, and the efficiency is low.

The testing equipments are of high cost. Through statistics, there are 373 testing stations in the whole workshop. The cost of LCD equipment is 1200 Yuan per station, and the total cost is up to 447,600 Yuan.

The energy consumption is high. Through statistics, the power fee from one workshop is high up to 96,300 Yuan per year.

69.3.2 TOPSIS Based Power-Saving Plans Choice

Through brain-storm, three plans are addressed. The first is that replace the CMC for LCD equipment which is a kind of apparatus for displaying scanning and testing information. The advantage of this plan is of comprehensive information and of good effects; and the weakness is of low visual angles and of high cost. The second plan is that substitute LED equipment for LCD. The advantage is of good visualization, of efficient information and of low equipment cost; and the weakness is of too simple in displaying information. The third plan is that change LCD equipment for LED indicator lamps with different colors. The advantage is of direct observation, of efficient information and of low price; and the weakness is of little information and of chaos in visualization.

Through analysis and research, lowering equipment cost, diminishing space occupation, saving power, and improving the efficiency are the indexes for plan choice. The steps to use TOPSIS for the choice of the power-saving plans are the followings:

Step 1: Set up decision indexes set C

$$C = \begin{bmatrix} y_1 = lowering - cost \\ y_2 = improving - efficiency \\ y_3 = occupying\, space \\ y_4 = saving\, power \end{bmatrix}$$

Step 2: Set up plans set X

$$X = \begin{bmatrix} x_1 = plan1 \\ x_2 = plan2 \\ x_3 = plan3 \end{bmatrix}$$

Step 3: Decide the weight of indexes and set up the weight set W

$$W = \begin{bmatrix} W_1(lowering - cost) = 0.25 \\ W_2(improving - efficiency) = 0.15 \\ W_3(occupying - space) = 0.35 \\ W_4(saving - power) = 0.25 \end{bmatrix}$$

Step 4: Decide the actual value of indexes

Through market survey and field measurement, the price of CMC is 1500 Yuan per station, and the space occupation is 0.00179 m^3; the price of LED monitor is 200 Yuan per station, and the space occupation is 0.00145 m^3; the price of LED indicator is 150 Yuan each, and the space occupation is 0.00062 m^3. According to the above data, the score of the three plans' efficiency-improving and power-saving can be obtained as Table 69.1:

Step 5: Ascertain normalized decision matrix Y

The dimensions of the above values are different. Thus it is necessary to transform the value to normalized ones with Eq. 69.1.

$$\begin{aligned} &Y_{11} = 0.986394;\ Y_{12} = 0.131519;\ Y_{13} = 0.098639;\ Y_{21} = 1.053182; \\ &Y_{22} = 1.180127;\ Y_{23} = 0.52718;\ Y_{31} = 0.32014;\ Y_{32} = 0.260452; \\ &Y_{33} = 0.11146;\ Y_{41} = 0.840125;\ Y_{42} = 0.74425;\ Y_{43} = 1.04825 \end{aligned}$$

From the above values, the decision matrix Y can be obtained:

$$Y = \begin{bmatrix} 0.986 & 1.053 & 0.320 & 0.840 \\ 0.132 & 1.180 & 0.260 & 0.744 \\ 0.100 & 0.527 & 0.111 & 1.048 \end{bmatrix}$$

Step 6: Calculate weighted decision matrix V with Eq. 69.2.

$$Y = \begin{bmatrix} 0.247 & 0.158 & 0.112 & 0.210 \\ 0.032 & 1.180 & 0.091 & 0.186 \\ 0.025 & 0.527 & 0.039 & 0.262 \end{bmatrix}$$

Table 69.1 Initial value of decision indexes

Plan \ Index	Lowering cost (Yuan)	Improving efficiency	Occupying space (m^3)	Saving power
Plan 1	1500	8	0.00179	9
Plan 2	200	9	0.00145	8
Plan 3	150	4	0.00062	9

Table 69.2 Euclidean distance of the three plans

Item \ Plan	Plan 1	Plan 2	Plan3
D^+	0.240	0.092	0.099
D^-	0.082	0.236	0.246

Step 7: Calculate positive and negative ideal solution with Eq. 69.3.

$$V^+ = (0.025 \quad 0.177 \quad 0.039 \quad 0.262)$$
$$V^- = (0.247 \quad 0.079 \quad 0.039 \quad 0.262)$$

Step 8: Calculate Euclidean distance D with Eq. 69.4.

$$D_1^+ = 0.240; D_1^- = 0.082; D_2^+ = 0.092;$$
$$D_2^- = 0.236; D_3^+ = 0.099; D_3^- = 0.246$$

According to the above value, Table 69.2 can be ascertained.
Step 9: Calculate the relative adjacent degree C with Eq. 69.5.

$$C_1 = 0.255;\ C_2 = 0.720;\ C_3 = 0.713$$
$$C_2 > C_3 > C_1$$

Among which, the second plan is the most optimal as the final choice.

69.4 Performance Analysis on the Plan Choice

Until present, the case enterprise has introduced plan2 to display testing information, and the performance is fairly well. Before improvement, the total cost of equipment is up to 447,600 Yuan and the power fee from one workshop is high up to 96,300 Yuan per year. After the enforcement of plan 2, the total cost is 74,600 Yuan and the power fee is 12,000 Yuan per year. The cost saving is 373,000 Yuan, and the power fee is lowered by 84,300.

At the same time, the substitute of LED monitor for LCD equipment makes the production line in order, improves personnel's morale, and allows workers to see the information clearly without much motion. And through speech set on the equipment, the information of code type can not only be identified by visualization but also by sound, which facilitates workers' operation. And the replaced LCD equipment can be made use by other department and production line. The goal of lowering cost and saving power is attained.

69.5 Discussion

Since the early twenty-first century, we have focused on low carbon, which emphasizes protecting our environment. For the public, it means leading a simple and saving life. And for the enterprises, it means eliminating the redundant emission, lowering power using, comprehensively reusing the material called waste before, and recycling the materials that can be reused such as packages, bottles, and so on.

Unfortunately, in the early stage of the low-carbon economy, there are a number of requirements on the publics at present. Those on enterprises seem to be neglected. Someone will say that environment protection has been awakened by many governments in the world, and the relative institutions have been initiated since the 1960s. But an obvious fact must be laid on the desk that compared with the public the amount of power-using by enterprises is fairly huge. Thus, enterprises should be the priority to low-carbon economy.

For enterprises, to meet the requirement of reducing emission, reusing and recycling, they should enforce their consciousness and self-discipline besides abiding by the outer institutions, which means they should adjusting their operation strategies to cover reducing, reusing and recycling., and some scientific methods should be adopted.

This paper takes a specific case to explore the way to lower its power-using with TOPSIS. But faced with the pressure of profit earning and growing, quite a few enterprises will not consider too much low-carbon. Seemingly, it is reasonable. But through deep exploring, the fact that one enterprise which complies to the demand of low-carbon usually affords high costs, which will be a burden for its development. And those enterprises that consider these factors of low-carbon will not obtain anything in return. Although some stimulus measures have been enforced in low-carbon by some governments; these measures are usually treated as temporary ones. And form the long period perspective, these measures will cause damage to the enterprises' operation. The reasons are that some enterprises will rely highly on the allowances form government, and some will use these allowances to compete with others, which will cause unfairness, even international trade disputes such as anti-dumping and anti-subsidies.

So, for enterprises, the low-carbon economy needs more innovations including technology, operation and management. The technology innovation means some techniques that are efficient in low-carbon will be invented and adopted by enterprises. The operation innovation means the enterprises must change their visions. From the present research and practice, low-carbon supply chain seems as one effective strategy. Its application will equalize the costs of reusing, reducing and recycling on the supply chain. This strategy needs some supportive means such as low-carbon contracts for all members on the chain, interest-collaboration between different members, and so on. And on the basis of operation innovation, the management must innovate on some aspects such as information management, outsourcing, supplier management, channel management, etc.

In a word, this paper probes the way to low-carbon development of one enterprise's power-saving. To comprehensively realize low-carbon economy, the field must extend from the public to all industries. And enterprises should play relatively important role in the process. The cost of the realization of low-carbon economy requires a full range of innovations.

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Chapter 70
Research on Central Control DDSS System for Fund Portfolio Management

Cheng Hu and Er-shi Qi

Abstract In order to satisfy the demand of fund portfolio management and based on the feature of balancing in the central control and distribution decision, a central control DDSS is schemed based on the systemization of decision-making theory. The scheme provides a balance point of a dynamic management, and makes the fund investment more controllable and flexible.

Keywords Portfolio management · Systemization of decision-making · Distributed decision support system (DDSS)

70.1 Introduction

The basic principle of portfolio management is making investment scattered in many different kinds of assets by a certain percentage under the standard of investor risk appetite, to achieve the goal of utility maximization (Elton et al. 1996). In fact, investment funds reflect this concept of a portfolio management. Investment fund is a portfolio of investments, including various securities and assets; investor who purchases a fund is equivalent to purchase a group of company's stocks or a combination of different asset classes.

In practice, investment funds sometimes are decentralized managed by several different managers, rather than managed by a single manager. Large fund management companies will choose several managers to form a combination of investment managers, or consider the use of three to five funds to compose a Fund group. This is actually a portfolio management concept that spread the risks of investment objectives to different managers. Individuals have different risk

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E. Qi et al. (eds.), *The 19th International Conference on Industrial Engineering and Engineering Management*, DOI: 10.1007/978-3-642-38391-5_70,

preferences and profitability goals in different environments, a particular combination of the investment managers will wash away the non-rational deviation through their own independent operations to achieve both portfolio risk and profitability objectives.

Distributed Decision Support System (DDSS) is a tool that is compatible with this multi-team portfolio management style. DDSS is the combination of distributed decision-making method, distributed databases, distributed operating system and distributed supporting (Swanson 1990). The supporting environment for DDSS is a computer network which is constituted by various physically separated processing information node, each node of the network contains at least one decision-making supportive system or a number of decision supporting functions (Kirn and Schlageter 1992). Comparing with the centralized DSS, this distributed decision supporting system is closer to the actual situation of large-scale organizational decision-making activities, especially related to fund management system which is an organization that has a team of decision-makers with different responsibilities in a multi-level decision-making system.

But the idea of the classic distributed decision supporting system is to consider each individual decision-makers or decision-making organization as an independent, physically separated processing information node and the system provides individual, group and organizational support for processing and decision-making in these nodes (Gao 2005). Thus, the fully independent decision-making of each node and multi-team management of investment fund is different in reality. When multi-team of traders is operating the fund, the total amount of funds is always limited, the funds between the various teams are allocated, and the funds for each team in the selection of investment targets and resources are also limited. Therefore, central control has become necessary in DDSS system.

70.2 Theory

Systemization of decision-making theory is originally introduced by Herbert Simon (Yue 2003). He introduced the concept of systemization of decision-making after he studied a large number of highly organized linear programming applications, and tried to implement the method to solving company problems (Janis and Mann 1977). The decision comes from the detailed analysis and discussion in advance, gets the understanding of participants to input defined data, and generates decision in the form consistent with the expected results (Roy 1977). So we can determine in advance a type of decision that is wanted, run a series of fixed calculation, and get the expected result which is in line with organizational objectives (Zeleny 1977).

If the decision-making process is systemized, it can be prepared in routinization, so that you can delegate the task to first-line manager with independent decision-making (Chung 1993). Given controlled constraints and values within the expected range, they can make independent decisions. In this case, all decisions are

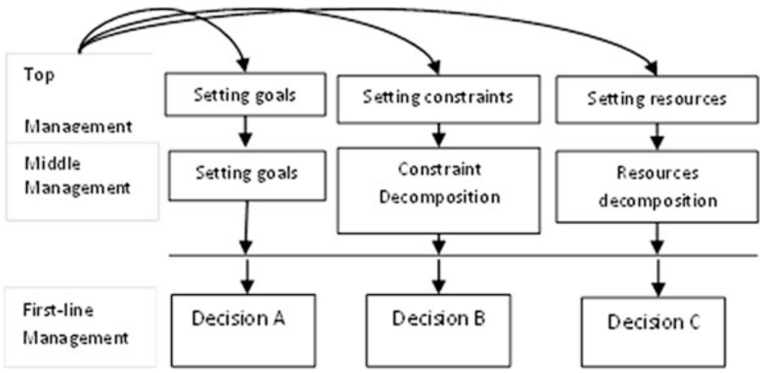

Fig. 70.1 A systemized decision-making model

constrained under the systemization of decision-making process. Decision-making process starts with restriction when developing decision. Another major restriction in decision-making process is that the available resources. These resources include the personnel and tools for decision-making that can be arranged. It is the restrictions that constitute a central control of distributed decision making.

The systemization of decision-making model can be expressed as shown in Fig. 70.1.

All decision-making runs in a systemized decision-making model under the constraints of a linear program. The top management will not make many decisions by following one routine; they are only responsible for setting the rules of first-line managers in decision-making. The systemization of decision-making system is developed analysis discussed previously with the understanding of the participants. By inputting defined data, the result produced by the system will meet our expectation. They can pre-determine the action of subordinates or the computer analysis. Subordinates or computer will follow the series of fixed calculation to achieve the expected results. This hierarchical decision-making process provides the basic concept of central control for the distributed decision support system in reality.

70.3 Model

In the DDSS classic model, each subsystem has its own database, model base and method base system. Data resources and decisions made are exchanged on each node through network information system; the result of processing all nodes would give us the final decision. This design emphasizes: the exchanges between the nodes, independent decision-making of the node, as well as the combined result of all decision made by all the independent nodes.

However, the structure of such systemized decision-making model lacks the control over decision-making in the system. As mentioned earlier, in order to systemize a DDSS, the DDSS model should also include a common database, a common model base, a common method base, and a common knowledge base. These four libraries are the constraints for all the subsystem when it comes to decision making. Comparing portfolio management in practice with DDSS, the common database stores data regarding fund managers team goals and the allocation of the resources; method base stores data that represents portfolio managers investment combinations and risk control policies; model base holds models to processing asset valuation and risk assessment formulas; knowledge base is the storage for the various subsystems decision-making results, and it also make adjustments to the other three database's constraint and algorithm.

A DDSS model with the four libraries as mentioned above is shown in Fig. 70.2:

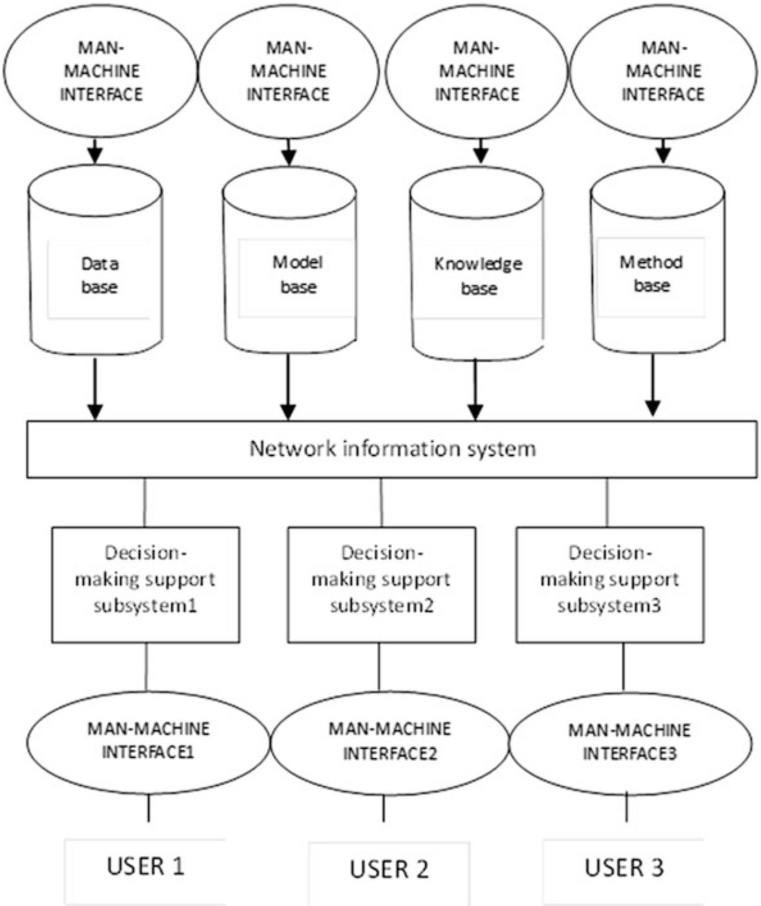

Fig. 70.2 Central control DDSS

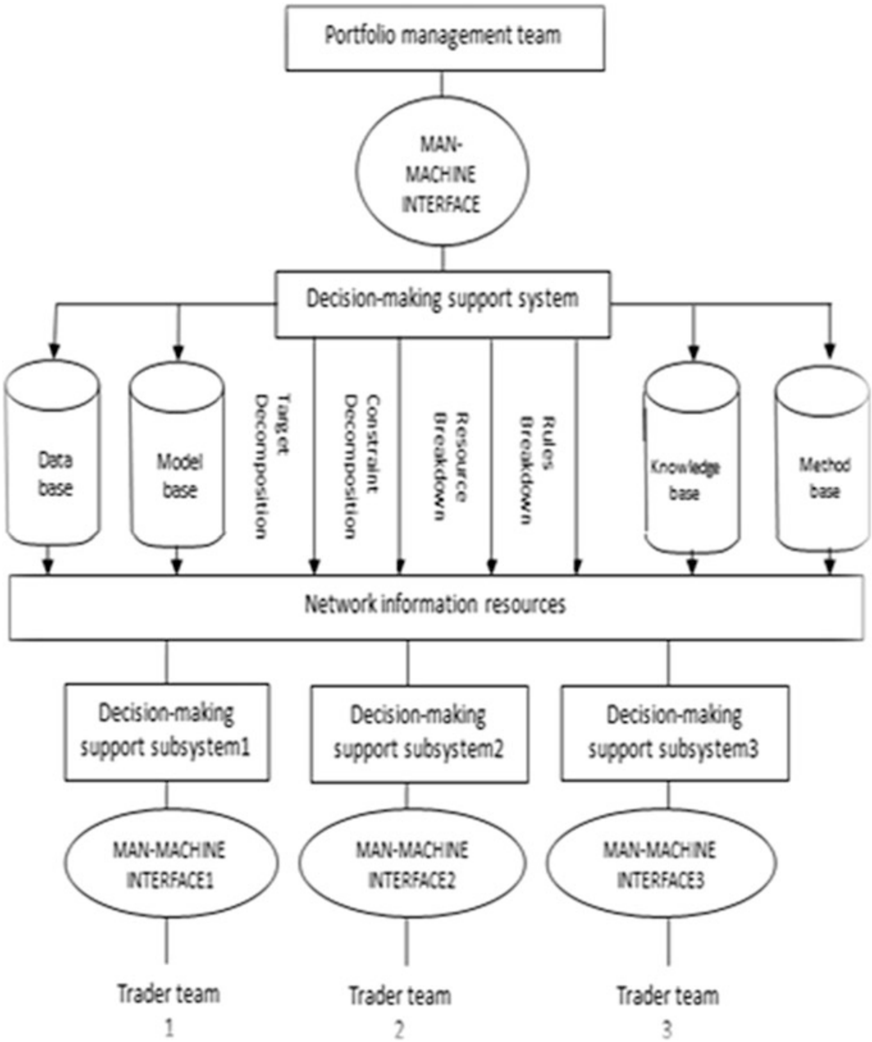

Fig. 70.3 DDSS model with multi-management and central control

In the above DDSS model, the four public database access the DDSS through the network information system, all independent decision-making subsystems use data from all four common database and provides result under the given constraints. In general, the four common databases require constraints inputted through the man–machine interface. In some special cases, these data can come from an intelligent decision support system with specialized control indicators.

70.4 Application

Based on the above structure of DDSS model, a DDSS model with multi-management and central control is developed, as shown in Fig. 70.3:

In this framework, the portfolio management committee inputs the investment funds, investment objectives, portfolio principles and other fund associated data to DDSS. Decision-making support system decomposes all managers' constraints into the four libraries, and they will become indicators and constraints in manager's decision-making process. At the same time, the knowledge base, model base and database provides the supporting environment for the subsystem on decision making by providing target parameters, constraints, and some general data, which determine the overall system control of the portfolio. Fund Manager of each team has its own independent decision support system, and they are the subsystem of a DDSS. This subsystem can be structure to be used by a single decision maker's DDS. Depending on the fund manager's knowledge of intelligent tools, the subsystem can be structured for a single decision-maker with a smart DDS. Fund managers make decisions under the above constraints and environment with their own judgments.

70.5 Conclusion

In this paper, in order to satisfy the demand of fund portfolio management and based on the feature of balancing between central control and distribution decision, a systemized central control DDSS scheme for portfolio management is proposed. By introducing the systemization of decision-making theory and model, and adding overall resource constraints and operational constraints of a central database onto the classic DDSS model, the DDSS model is more controllable and flexible for a dynamic portfolio management in terms of balancing between the central control and distribution decision of DDSS model.

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Chapter 71
The Evaluation and Application of Residential Structure System Based on Matter-Element Model

Sen Yu and Xiang-ju Liu

Abstract According to the progress of building industry, residential construction model suits to Chinese population, resource and environment development is required to be established as soon as possible. Residential industrialization is the inevitable course of development with premise of new technology, new material and appropriate structure system. The paper comprehensively evaluates the current residential structure by Matter-element theory to chose the most efficient residential structure system and supply theoretical basis for investment decisions.

Keywords The matter-element model · Structure system · Comprehensive evaluation · Application

71.1 Introduction

The current residential structure system contains Cast-in situ concrete structure, steel structure, the assemble type concrete structure with both advantages and disadvantages (Lei and Chen 2010). For example, Cast-in situ concrete structure is good at safety and durableness, but has a complex process and a high energy consumption; steel structure supplies a larger space (Bi 2008), needs a shorter construction period with higher cost, poor refractory and corrosive resistance and the assemble type concrete structure charactered a short construction period,

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E. Qi et al. (eds.), *The 19th International Conference on Industrial Engineering and Engineering Management*, DOI: 10.1007/978-3-642-38391-5_71,

energy efficiency, good quality but single structure form and poor seismic performance (Jia et al. 2010). Consider the above, it is extremely important to make an overall assessment on residential structure system in technological and economical aspects (Zhang 2010a).

Face the different structure of the residential system, how to carry out the effective evaluation become a key issues (Zhang 2010b). Until now, our evaluation system has been stayed at the primary stage, only used construction cost and energy consumption as main indexes without any analysis for influence on environment and society nor different degree of residential technical and economic performance between different social groups (Mi et al. 2010). To solve the question, a comprehensive evaluation system is called for.

Related Matter-element theory and some qualitative and quantitative research methods are used in this paper to evaluate the current residential structure system scientifically, synthetically and reasonably. Hoping to give a guidance to the government and real estate company, in order to promote popularize of the most effective residential structure and supply scientific basis for development of Residential industrialization (Huang and Zhu 2009).

71.2 Selection of the Case

Take a six layer residential building for example, its total length is 65 m, total width is 12 m, total height is 18 m, every floor area is 780 m^2, the construction of the residential area is 97.5 m^2, seismic intensity is 7°, the site category is 3rd. Three types of residential structures are chosen, the supporting dates are recorded in Table 71.1.

71.3 The Establishment of Performance Evaluating Indicator System

The establishment of performance evaluating indicator system should follow principles like Scientific principle, systematic principle, operability principle and others (Porter 1990). And residence life cycle is selected as research object, and

Table 71.1 The cost date

Structure	Construction cost (yuan/m^2)	Energy consumption (yuan/m^2)
Cast-in situ concrete structure	1430	65
Steel structure	1980	72
The assemble type concrete structure	1760	58

Table 71.2 Each index C_{ij} relative to the index system of T weights

First grade indexes	Weigh	Second grade indexes	Weigh
Applicability C_1	0.18	Reconstruction C_{11}	0.08
		Flat surface layout C_{12}	0.06
		Indoor and outdoor traffic condition C_{13}	0.04
Economy C_2	0.26	Construction cost C_{21}	0.16
		Use-cost C_{22}	0.10
Safety durability C_3	0.36	Durability of construction C_{31}	0.16
		Durability of decoration C_{32}	0.12
		Building Fire Protection C_{33}	0.06
		Control of indoor pollution C_{34}	0.02
Sustainable development C_4	0.2	Building energy saving C_{41}	0.11
		Green building materials C_{42}	0.04
		Rationality of the water resources utilization C_{43}	0.05

indexes of applicability c1, economy c2, safety durability c3 and Sustainable development c4 are taken into consideration (Porter 1985). Each level index weighs are calculated by AHP-LSDM, and the results are recorded in Table 71.2.

71.4 The Comprehensive Evaluation Based on the Matter-Element

71.4.1 The Establishment of the Matter-Element Evaluation Model

1. Determining the matter-element matrix of joint region, classics region and the matrix to be evaluated.

The system of matter-element is an unit to describe the object, which consists of the name of object N, characteristic c and the value v of the object's characteristic c. N, c, v is called the three key elements of the matter-element (Baldwin and Kim 1997).

The normalized form of matter-element is described as follows: R = [N, c, v].

Usually, an object has more than one characteristic. Given n characteristics of an object $\left(c_1, c_2, \ldots c_{n,}\right)$ and relevant values $v_1, v_2, \ldots, v_{n,}$, which we can use to describe the object called n-dimension matter-element, recorded as:

$$R = \begin{bmatrix} N & c_1 & v_1 \\ & c_2 & v_2 \\ & \vdots & \vdots \\ & c_n & v_n \end{bmatrix} = \begin{bmatrix} R_1 \\ R_2 \\ \vdots \\ R_n \end{bmatrix}$$

(a) Determining the matter-element matrix of partial unit

$$R_p = [P, c_i, x_{pi}] = \begin{bmatrix} P, & c_1 & \langle a_{p1}, b_{p1} \rangle \\ & c_2 & \langle a_{p2}, b_{p2} \rangle \\ & \vdots & \vdots \\ & c_n & \langle a_{pn}, b_{pn} \rangle \end{bmatrix}$$

In the murderer, P shows the whole effect level, $x_{pi} = \langle a_{pi}, b_{pi} \rangle$ shows the value range of domain object on the characteristic c_i (Baldwin and Kim 2000).

(b) Determining the matter-element matrix of classics region

$$R_j = [N_j, c_i, x_{ji}] = \begin{bmatrix} N_{j,} & c_1 & \langle a_{j1}, b_{j1} \rangle \\ & c_2 & \langle a_{j2}, b_{j2} \rangle \\ & \vdots & \vdots \\ & c_n & \langle a_{jn} . b_{jn} \rangle \end{bmatrix}$$

In the murderer, N_j shows j effect levels divided to evaluate ($j = 1, 2, \ldots, m$), c_i shows the characteristic of effect level $N_j (i = 1, 2, \ldots, n)$, $x_{ji} = \langle a_{ji}, b_{ji} \rangle$ shows the value range of N_j specified by c_i, that is the numerical scope of effect level on the characteristics (Liu 2010).

(c) Determining the matter-element matrix to be evaluated

$$R_0 = \begin{bmatrix} P_0, & c_1 & x_1 \\ & c_2 & x_2 \\ & \vdots & \vdots \\ & c_n & x_n \end{bmatrix}$$

In the murderer, R_0 shows matter-element to be evaluated, P_0 shows subject matter, x_i shows the value of P_0 specified by c_i.

2. Determining the correlation function and the order of evaluation

Correlation function is:

$$K_j(x_i) = \begin{cases} -\frac{\rho(x_i, x_{ji})}{|x_{ji}|} (x_i \in x_{ji}) \\ \frac{\rho(x_i, x_{ji})}{\rho(x_i, x_{pi}) - \rho(x_i, x_{ji})} (x_i \notin x_{ji}) \end{cases} \tag{71.1}$$

$$\rho(\mathrm{x_i}, \mathrm{x_{ji}}) = \left| \mathrm{x_i} - \frac{1}{2} (\mathrm{a_{ji}} + \mathrm{b_{ji}}) \right| - \frac{1}{2} (b_{ji} - a_{ji}) \tag{71.2}$$

$$\rho(\mathrm{x_i}, \mathrm{x_{pi}}) = \left| \mathrm{x_i} - \frac{1}{2} (a_{pi} + b_{pi}) \right| - \frac{1}{2} (b_{pi} - a_{pi}) \tag{71.3}$$

3. Determining the comprehensive correlation and the order of evaluation

$$K_j(P_0) = \sum_{i=1}^{n} w_{ij} K_j(x_i), \tag{71.4}$$

In the murderer w_{ij} For each characteristics of c_{ij} is weight coefficient. Evaluation of the level for the subject matter:

$$k_j = \max k_j(p_0) \qquad (j = 1, 2, \ldots, \text{m}).$$

71.4.2 Application in Residential Structure Evaluation System

1. Divising the standard of evaluation result

According the research interview of different projects and the specialistic, we make the evaluation result into four levels in broad outline: excellent, good, ordinary, bad (Li 2008) (see Table 71.3).

2. Determining the matter-element matrix of joint region, classics region and the matrix to be evaluated

(a) Determining the matter-element matrix of partial unit

$$R_p = \left(P, c_{i,} x_{pi}\right) = \left|\begin{matrix} \text{excellent–bad} & \text{reconstruction}\, C_{11} & \langle 0, 1\rangle \\ & \text{flat surface layout}\, C_{12} & \langle 0, 1\rangle \\ & \vdots & \vdots \\ & \text{ationality of the water resources utilization}\, C_{43} & \langle 0, 1\rangle \end{matrix}\right|$$

(b) Determining the matter-element matrix of classical domain

$$R_1 = \left(N_1, c_{i,} x_{1i}\right) = \left|\begin{matrix} \text{excellent,} & \text{reconstruction}\, C_{11} & \langle 0.75, 1\rangle \\ & \text{flat surface layout}\, C_{12} & \langle 0.75, 1\rangle \\ & \vdots & \vdots \\ & \text{ationality of the water resources utilization}\, C_{43} & \langle 0.75, 1\rangle \end{matrix}\right|$$

Table 71.3 Index level standard

Evaluation index	Excellent	Good	Ordinary	Bad
C_{11} reconstruction	$\langle 0.75, 1\rangle$	$\langle 0.5, 0.75\rangle$	$\langle 0.25, 0.5\rangle$	$\langle 0, 0.25\rangle$
C_{12} flat surface layout	$\langle 0.75, 1\rangle$	$\langle 0.5, 0.75\rangle$	$\langle 0.25, 0.5\rangle$	$\langle 0, 0.25\rangle$
⋮	⋮	⋮	⋮	⋮
C_{43} rationality of the water resources utilization	$\langle 0.75, 1\rangle$	$\langle 0.5, 0.75\rangle$	$\langle 0.25, 0.5\rangle$	$\langle 0, 0.25\rangle$

$$R_2 = \left(N_2, c_i, x_{2i}\right) = \begin{vmatrix} \text{good,} & \text{reconstruction } C_{11} & \langle 0.5, 0.75\rangle \\ & \text{flat surface layout } C_{12} & \langle 0.5, 0.75\rangle \\ & \vdots & \vdots \\ & \text{ationality of the water resources utilization } C_{43} & \langle 0.5, 0.75\rangle \end{vmatrix}$$

$$R_3 = \left(N_3, c_i, x_{3i}\right) = \begin{vmatrix} \text{ordinary,} & \text{reconstruction } C_{11} & \langle 0.25, 0.5\rangle \\ & \text{flat surface layout } C_{12} & \langle 0.25, 0.5\rangle \\ & \vdots & \vdots \\ & \text{ationality of the water resources utilization } C_{43} & \langle 0.25, 0.5\rangle \end{vmatrix}$$

$$R_4 = \left(N_4, c_i, x_{4i}\right) = \begin{vmatrix} \text{bad,} & \text{reconstruction } C_{11} & \langle 0, 0.25\rangle \\ & \text{flat surface layout } C_{12} & \langle 0, 0.25\rangle \\ & \vdots & \vdots \\ & \text{ationality of the water resources utilization } C_{43} & \langle 0, 0.25\rangle \end{vmatrix}$$

(c) Determining the matter-element matrix of evaluated

Cast-in situ concrete structure, steel structure and the assemble type concrete structure are selected as research object, through investigation and analysis, can get 12 of evaluation index of the normalized data, the matter-element matrix as follows:

3. Determining the correlation function and the order of evaluation (Table 71.4).

Take Cast-in situ concrete structure for example, by Eqs. (71.1), (71.2) and (71.3) can draw C_{11}—C_{44} about the level of correlation degree index and use Eq. (71.4) to review that the subject matter P_0 about each level of correlation degree, see Table 71.5.

After the same steps, we can get the result of three structures about each level of comprehensive correlation degree, see Table 71.6.

For the Cast-in situ concrete structure, $k_2(p) = \max k_j(p)$, $j \in (1, 2, 3, 4)$, that means that it belongs to level good.

Table 71.4 Normalized date

Structure	C_{11}	C_{12}	C_{13}	C_{21}	C_{22}	C_{31}	C_{32}	C_{33}	C_{34}	C_{41}	C_{42}	C_{43}
Cast-in situ concrete structure	0.91	0.71	0.65	0.47	0.56	0.74	0.65	0.46	0.32	0.43	0.32	0.65
Steel structure	0.82	0.68	0.64	0.28	0.24	0.65	0.52	0.42	0.55	0.56	0.46	0.42
He assemble type concrete structure	0.65	0.76	0.85	0.79	0.81	0.68	0.71	0.79	0.81	0.68	0.55	0.78

Table 71.5 Correlation of the index

Evaluation index	Weigh	Excellent	Good	Ordinary	Bad
C_{11}	0.08	−0.2222	0.4000	−0.3000	−0.5333
C_{12}	0.06	0.0435	−0.0400	−0.5200	−0.6800
⋮	⋮	⋮	⋮	⋮	⋮
C_{43}	0.05	0.1579	−0.1200	−0.5600	−0.7067
$K_j(p_0)$		0.1784	−0.0142	−0.4998	−0.6664

Table 71.6 Three structures about each level of correlation degree

Structure	Comprehensive correlation degree			
Cast-in situ concrete structure	−0.4362	0.0384	−0.0834	−0.571
Steel structure	0.4845	−0.0837	−0.0756	−0.8862
Assemble type concrete structure	0.1784	−0.0142	−0.4998	−0.6664

For the steel structure, $k_1(p) = \max k_j(p), j \in (1, 2, 3, 4)$, that means that it belongs to level excellent.

For the assemble type concrete structure, $k_1(p) = \max k_j(p), j \in (1, 2, 3, 4)$, that means that it belongs to level excellent.

In order to compare the two structures further, after we get each of the result normalized, we evaluate the results secondly. If $k_{j0}(p) = \max k_j(p), j \in (1, 2, \ldots, m)$, that means that p belongs to level j_0 (Li et al. 2007) if

$$K_j(p) = \frac{K_j(p) - \min K_j(p)}{\max K_j(p) - \min K_j(p)}$$

$$j^* = \sum_{j=1}^{s} j \cdot K_j(p) / \sum_{j=1}^{s} K_j(p) \tag{71.5}$$

That means that j^* is Eigenvalue of the variable level of p.

For example, if $j_0 = 1$, $j^* = 1.9$, that means it belongs to the first lever tend to the second lever, or rather, it is closer to the second lever (Guo 2006). So we can see the extent it biased in favor of the other. Now we make $j_1^* j_2^*$ as Eigenvalue of the variable level of steel structure and assemble type concrete structure.

By Eq. (71.5) can draw $j_1^* = 1.7128$, $j_2^* = 1.5923$. Because the Eigenvalue of the variable level of assemble type concrete structure is closer to 1, so it biased in favor of the lever excellent higher. Therefore, We can draw the conclusion that the assemble type concrete structure is superior to others.

71.5 Conclusions and Implications

The paper first calculates the weigh of indexes by AHP-LSDM, then make a comprehensive assessment on three types of structure systems by Matter-element model, and finally finds that the assemble type concrete structure is the better choice for its advantages and promotion of residential industrialization. The research is helpful to reduce the blindness of invest and promote the research and development of residential construction system.

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Chapter 72
Logistic Financial Crisis Early-Warning Model Subjoining Nonfinancial Indexes for Listed Companies

Shao-fang Ding, Ying-chao Hou and Pei-pei Hou

Abstract The occurrence of financial crisis is related with financial factors. Many nonfinancial ones also contain important information relevant to the occurrence of financial crisis. If merely financial factors are taken into consideration, much useful information will be lost. Thus, the early-warning capacity of the model will be reduced. What's more, we will fail to learn the cause for the occurrence of financial crisis at a more profound level. It is imperative to draw nonfinancial index into the study of financial crisis early-warning and build a more effective and more complete financial crisis early-warning model. The paper introduces not only financial index, but also nonfinancial index including enterprise ownership structure, corporate governance, and major item, etc, while it takes a preliminary identification and screening about the study sample, paired sample and early-warning indicators. Then we set up enterprise's financial crisis early-warning model to complete the warning index system.

Keywords Financial crisis early-warning · Nonfinancial indexes · Logistic regression · Factor analysis

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E. Qi et al. (eds.), *The 19th International Conference on Industrial Engineering and Engineering Management*, DOI: 10.1007/978-3-642-38391-5_72,

72.1 Introduction

In previous papers, in the application of nonfinancial index, scholars study more about relationship between nonfinancial index and company performance. Even in financial crisis early-warning model including nonfinancial index, they apply mainly the financial indexes without a comprehensive nonfinancial index system, while they introduce just a few nonfinancial indexes, as there is only a single ownership structure or corporate governance. However, this paper introduces ownership structure, corporate governance situation, and major item into the early-warning model, according to different samples, data characteristics, to achieve better warning effect.

72.2 The Selection of Financial Crisis Early-Warning Sample and Index

72.2.1 The Preliminary Determination of Samples and Data

This paper will take listed companies who have received ST for operation in China securities market A-shares as samples. 87 companies in total in Shanghai Stock Exchange and Shenzhen Stock Exchange are chosen: 25 ones who were the first to receive ST in 2007, 34 ones who received ST in 2008, and 28 ones who received ST in 2009. The financial and nonfinancial index information of those listed companies in the three years before ST is used to forecast whether they are financial crisis companies.

In order to find out the early-warning index which has an impact on ST companies by comparing ST companies with non-ST companies, this paper also chooses 87 non-ST companies by the ratio of 1:1 as paired samples. To guarantee the consistency and comparability with the original sample data, the paired samples are in the same or similar industry and in the similar asset size with the original ones while the same last three years' information is used as study object. Sample data come from Wind, CSMAR and RESSET Databases.

This paper classifies early-warning indexes into financial ones and nonfinancial ones. On the basis of previous research, 31 indexes are chosen, according to the principle of sensitivity, accuracy, representativeness and comprehensiveness. Among those indexes, there are 16 financial indexes, selected in accordance with debt-paying ability, operating capacity, earning power and development capacity. The other 15 indexes are nonfinancial ones, selected by shareholding structure, corporate governance, significant matters and other factors. See Table 72.1.

Table 72.1 Early-warning index

Index classification	Evaluation items	Index	Computational formula
Financial Index	Debt-paying ability	Current ratio X1	Current assets/current liabilities
		Quick ratio X2	(Current assets—inventory)/current liabilities
		Debt asset ratio X3	Total indebtedness/total assets
		Working capital total assets ratio X4	Working capital/average total assets
	Operating capacity	Receivables turnover ratio X5	Main business income/average receivables
		Inventory turnover ratio X6	Cost of goods sold/average inventory
		Current assets turnover ratio X7	Main business income/average current assets
		Total assets turnover ratio X8	Main business income/average total assets
	Earning power	Main business Profit rate X9	Main business profit/main business income
		Net profit rate to total assets X10	Net profit/average total assets
		Net profit margin on sales X11	Net profit/main business Income
		Profit margin on net assets X12	Net profit/average net assets
	Development capacity	main business's increasing rate of income X13	(Main business income of this year—main business income of last year)/main business income of last year
		Rate of capital accumulation X14	Growth of owner's equities this year/owner's equities at the beginning of the year
		Increasing rate of net assets X15	(Net assets of this period—net assets of last period)/net assets of last period)
		Increasing rate of total assets X16	(Total assets of this period—total assets of last period)/total assets of last period

(continued)

Table 72.1 (continued)

Index classification	Evaluation items	Index	Computational formula
Nonfinancial index	Shareholding structure (Tan and Zhang 2005)	Shareholding proportion of the controlling shareholder Y1	The ratio of the shares of the controlling shareholder to the total shares of the company
		Herdindhal_5 Index Y2	Sum of the squares of the first five substantial shareholders in the company's shareholding proportion
		Z IndexY3	Shareholding proportion of the first substantial shareholder/ shareholding proportion of the second substantial shareholder
		CR_5 Index Y4	Sum of the shareholding proportion of the first five substantial shareholders in the company
	Corporate governance (Deng and Wang 2006; Wang and Ji 2006)	Ratio of independent director Y5	Independent director/all director
		Ratio of state shares Y6	The amount of state shares/capitalization
		Ratio of upper management shares Y7	(Shareholding of board of directors +shareholding of management layer) /capitalization
		Position set of chairman of the board and general manager Y8	If the chairman of the board and the general manager is the same person, score 1; otherwise, score 0.
	Significant matters (Lv 2006)	Whether involving related party Transaction Y9	If yes, score 1; otherwise, score 0.
		Whether having violation record Y10	If yes, score 1; otherwise, score 0.
		Whether involved in Lawsuit or Arbitration Y11	If yes, score 1; otherwise, score 0.
		Whether involving external guarantees Y12	If yes, score 1; otherwise, score 0.
	Other Factors (Wan and Wang 2007; Yang 2008)	Whether having changed accounting firms Y13	If yes, score 1; otherwise, score 0.
		Whether having altered abbreviation Y14	If yes, score 1; otherwise, score 0.
		Type of audit opinion Y15	If the auditor presents standard clean opinions, score 1; otherwise, score 0.

72.2.2 *The Preliminary Selection of Early-Warning Indexes*

72.2.2.1 Normal Distribution Inspection

First, we take normal distribution test of these primary early-warning indexes. By means of the K–S test method in SPSS statistical software, we test the 31 primary indexes selected from the samples of two group.

$$\text{K statistic} = \max(|S(\mathbf{X_i}) - \mathbf{F}(\mathbf{X_i})|)$$

In the formula, $S(\mathbf{X_i})$ is the actual cumulative probability value of each different observing samples, of which $F(\mathbf{X_i})$ is the theoretical value. Under significant level of $\alpha = 0.05$, the bilateral progressive probability's P value of $\mathbf{X_3}$, $\mathbf{X_{13}}$, $\mathbf{X_{16}}$, $\mathbf{Y_1}$, $\mathbf{Y_2}$, $\mathbf{Y_5}$, $\mathbf{Y_{12}}$ is greater than 0.05, which means the 7 of them pass the inspection and overall accord with the normal distribution. By two independent samples test method of significant test, the rest 24 indexes do not accord with normal distribution, so we use a nonparametric test, Mann–Whitney test, to test their significance.

72.2.2.2 *T* test of Two Independent Samples

The equation of T (Zhang and Cheng 2004) statistic:

$$\mathbf{T} = \frac{\bar{\mathbf{X}}_1 - \bar{\mathbf{X}}_2 - (\boldsymbol{\mu}_1 - \boldsymbol{\mu}_2)}{\sqrt{\boldsymbol{\sigma}_{12}^2}}$$

The results are as follows:

Under significant level of $\alpha = 0.05$, $\mathbf{X_3}$, $\mathbf{X_{13}}$, $\mathbf{Y_1}$, $\mathbf{Y_2}$ pass the T test, which means that these 4 indexes have significant differences, while $\mathbf{X_{16}}$, $\mathbf{Y_5}$, $\mathbf{Y_{12}}$ does not, which means they have no significant differences.

72.2.2.3 U-Test of Two Independent Samples

This paper selected the most effective alternative method of parameter test, Mann–Whitney test.

U-test equation (Liao et al. 2008) is as followed:

$$\mathbf{U_{xy}} = \mathbf{mn} + \frac{\mathbf{m(m+1)}}{\mathbf{2}} - \sum_{\mathbf{i=1}}^{\mathbf{m}} \mathbf{R_i},$$

$$\mathbf{U_{yx}} = \mathbf{mn} + \frac{\mathbf{n(n+1)}}{\mathbf{2}} - \sum_{\mathbf{j=1}}^{\mathbf{n}} \mathbf{R_j},$$

The test results are as followed: the indexes' values of $\mathbf{X_1}$, $\mathbf{X_2}$, $\mathbf{X_4}$, $\mathbf{X_8}$, $\mathbf{X_9}$, $\mathbf{X_{10}}$, $\mathbf{X_{11}}$, $\mathbf{X_{12}}$, $\mathbf{X_{14}}$, $\mathbf{X_{15}}$, $\mathbf{Y_4}$, $\mathbf{Y_8}$, $\mathbf{Y_{10}}$, $\mathbf{Y_{11}}$, $\mathbf{Y_{13}}$, $\mathbf{Y_{14}}$, $\mathbf{Y_{15}}$, 17 in all, are smaller than the significant level, while the other 7 indexes do not pass the significant test.

In general, a total of 21 indexes pass the significant test.

72.2.3 A Further Integration of Early-Warning Index

The tests of significance above identify 21 early-warning indexes, including 12 financial indexes and 9 nonfinancial indexes. Both non- and financial indexes reflect a company's financial performance. Accounting for that these early-warning indexes may be relevant between each other, the paper convert the multiple observable variables into a few uncorrelated integrated indexes, by the method of factor analysis, to best simplified the high dimension data. Because some of the nonfinancial early-warning indexes are virtual variables, of which the data is not continuous, they can not be integrated.

72.2.3.1 KMO Test (Yang 2007)

We take a KMO test before factor analysis to determine whether the financial ratios involved are suitable for it (Table 72.2).

By KMO test, the results show 0.729 of KMO test coefficient, indicating a high relevant between the indexes, so they are suitable for factor analysis. The 744,202 of Bartlett Chi square value and $0.000 < 0.05$ of P value show the 12 financial indexes are not independent and there is a certain relationship between them.

72.2.3.2 Factor Analysis (Gui and Wu 2007)

We screen out 12 financial indexes by significance test above: $\mathbf{X_1}$, $\mathbf{X_2}$, $\mathbf{X_3}$, $\mathbf{X_4}$, $\mathbf{X_8}$, $\mathbf{X_9}$, $\mathbf{X_{10}}$, $\mathbf{X_{11}}$, $\mathbf{X_{12}}$, $\mathbf{X_{14}}$, $\mathbf{X_{15}}$. Then we take factor analysis on these 12 indexes, and find that, the characteristic values of first 4 common factor are greater than 1, and their accumulated contribution rates reach 84.819 %, recorded as $\mathbf{F_1}$, $\mathbf{F_2}$, $\mathbf{F_3}$, $\mathbf{F_4}$. To explain them reasonable, we need to get the correlation coefficients between the 4 common factor and the 12 initial financial indexes. So the paper uses orthogonal rotation maximum variance method to do the conversion, and gets the factor loading matrix as followed:

Table 72.2 KMO test

KMO and Bartlett test		
Enough sampling Kaiser–Meyer–Olkin test		0.729
Bartlett sphericity test	Chi square	744.202
	df	66
	Sig.	0.000

Table 72.3 Factor loading matrix

Rotated factor matrix				
	Factor			
	F_1	F_2	F_3	F_4
Liquidity ratioX1	0.043	0.943	0.057	−0.049
Quick ratioX2	0.064	0.910	0.065	−0.062
Asset liability ratioX3	−0.292	−0.672	0.396	0.072
Working capital to total asset ratioX4	−0.044	0.733	−0.096	0.026
Total assets turnover ratioX8	0.789	0.232	0.273	0.107
Main business profit rateX9	0.890	0.161	−0.196	0.029
Total net asset profit rateX10	0.859	0.091	0.298	−0.061
Sales net profit rateX11	0.942	0.107	0.033	−0.033
Net assets income rateX12	0.231	0.187	0.594	0.090
The growth rate of main businessX13	0.256	−0.098	0.112	0.645
Capital accumulation rateX14	0.075	−0.017	0.006	0.962
Net asset growth rateX15	0.383	0.212	0.733	0.166
Extraction method: principal component analysis method rotation method: Kaiser standardized orthogonal rotation method				

From the factor loading matrix after rotation above, we can see that the 4 factor variances respectively yield high load capacity in different index variables. According to the factors' load distribution, we can make a further analysis as followed (Table 72.3):

(1) Index factor load capacity of $\mathbf{F_1}$ on $\mathbf{X_8}$, $\mathbf{X_9}$, $\mathbf{X_{10}}$, $\mathbf{X_{11}}$, is far greater than that of other indexes. It shows the company's operating profit level and the ability.
(2) Index factor load capacity of $\mathbf{F_2}$ on $\mathbf{X_1}$, $\mathbf{X_2}$, $\mathbf{X_3}$, $\mathbf{X_4}$, is far greater than that of other indexes. It shows the company's solvency.
(3) Index factor load capacity of $\mathbf{F_3}$ on $\mathbf{X_{12}}$, $\mathbf{X_{15}}$ is far greater than that of other indexes. It shows the company's profitability and growth ability.
(4) Index factor load capacity of $\mathbf{F_4}$ on $\mathbf{X_{13}}$, $\mathbf{X_{14}}$, is far greater than that of other indexes. It shows the company's ability to grow.

By calculating the coefficients in the linear combination of common factors, as dependent factors, and initial index variables, as the independent factors, we get the initial linear expression as followed:

$$F_1 = -0.048x_1 - 0.037x_2 - 0.038x_3 - 0.074x_4 - 0.228x_8 + 0.271x_9 + 0.293x_{10} + 0.307x_{11} + 0.078x_{12} + 0.176x_{13} - 0.057x_{14} + 0.068x_{15}$$
$$F_2 = 0.314x_1 + 0.301x_2 - 0.194x_3 + 0.250x_4 + 0.183x_8 - 0.013x_9 - 0.028x_{10} - 0.033x_{11} + 0.063x_{12} - 0.079x_{13} + 0.029x_{14} + 0.035x_{15}$$
$$F_3 = 0.065x_1 + 0.070x_2 + 0.291x_3 - 0.061x_4 + 0.236x_8 - 0.116x_9 + 0.269x_{10} + 0.064x_{11} + 0.487x_{12} + 0.051x_{13} + 0.048x_{14} + 0.554x_{15}$$
$$F_4 = -0.090x_1 - 0.025x_2 + 0.084x_3 + 0.056x_4 + 0.130x_8 - 0.050x_9 - 0.118x_{10} - 0.108x_{11} + 0.101x_{12} + 0.626x_{13} + 0.930x_{14} + 0.106x_{15}$$

72.3 The Construction of Logistic Financial Crisis Early-Warning Model

72.3.1 The Construction of Logistic Model Based on Financial Indexes Alone

In the construction of Logistic financial crisis early-warning model based on financial indexes alone, the previous three years' data of the 44 ST companies and 44 non-ST companies are taken as original data and F1, F2, F3, F4 as dependent variables. Multiple Logistic regression is employed to do the analysis. The regression results are presented in Table 72.4.

The above chart illustrates that the coefficient of every explanatory variable is significant when it is $\alpha = 0.1$, which implies that the model fits well. Hence, the company's Logistic financial crisis early-warning model based on financial indexes alone in the year T is:

$$\mathbf{P} = \frac{\mathbf{1}}{\mathbf{1} + \mathbf{exp}\left[-\left(\begin{array}{c}\mathbf{-0.730 - 4.261F_1 - 0.748F_2 - 0.400F_3} \\ \mathbf{-0.687F_4}\end{array}\right)\right]}$$

72.3.2 The Construction of Logistic Model Injecting Nonfinancial Indexes (Chen 1999; Wu 2001)

Conduct regression analysis with the four common factors F1, F2, F3, F4 obtained by factor analysis and the nine nonfinancial index variables Y1, Y2, Y4, Y8, Y10, Y11, Y13, Y14, Y15, which have been through parameter T test and non-parameter U test. Through forward gradual selection variables method, the synthetical early-warning model based on both financial and nonfinancial indexes is constructed. The regression results are presented in Table 72.5.

The above chart illustrates that the coefficient of every explanatory variable is significant when it is $\alpha = 0.05$, which implies that the model fits well. Through the

Table 72.4 The logistic regression results based on financial indexes alone

Variables in equation

		B	S.E.	Wald	df	Sig.	Exp (B)
Step 1[a]	F1	−4.261	1.069	15.884	1	0.000	0.014
	F2	−0.748	0.343	4.749	1	0.029	0.473
	F3	−0.400	0.369	1.172	1	0.079	0.670
	F4	−0.687	0.624	1.212	1	0.071	0.503
	Constant	−0.730	0.363	4.042	1	0.044	0.482

[a] inputting Variables F1, F2, F3, F4 in step 1

Table 72.5 The regression results of the Logistic synthetical model injecting nonfinancial indexes

Variables in equation

		B	S.E.	Wald	df	Sig.	Exp (B)
Step 3a	F1	−3.219	1.094	7.390	1	0.003	0.039
	F2	−2.114	1.168	3.908	1	0.023	0.121
	F3	−2.103	1.612	6.367	1	0.014	0.122
	F4	−1.601	1.701	9.948	1	0.005	0.202
	Shareholding Proportion of the Controlling Shareholder Y1	3.437	1.806	6.312	1	0.006	31.094
	CR_5 Index Y4	−2.108	1.236	7.836	1	0.018	0.121
	Whether having Violation Record Y10	3.262	1.155	7.975	1	0.005	26.102
	Whether involved in Lawsuit or Arbitration Y11	3.285	1.019	10.404	1	0.001	26.709
	Whether having altered abbreviation Y14	3.923	1.201	10.678	1	0.001	50.552
	Type of Audit Opinion Y15	−2.888	1.098	6.915	1	0.009	0.056
	Constant	1.130	1.024	1.217	1	0.007	3.095

coefficients of the variables in the chart above, the Logistic financial crisis synthetical early-warning model injecting nonfinancial indexes is obtained:

$$\mathbf{P} = \frac{\mathbf{1}}{\mathbf{1} + \mathbf{exp}\left[-\begin{pmatrix} \mathbf{1.130 - 3.219F_1 - 2.114F_2 - 2.103F_3} \\ \mathbf{-1.601F_4 + 3.437Y_1 - 2.108Y_8} \\ \mathbf{+3.262Y_{10} + 3.285Y_{11}} \\ \mathbf{+3.923Y_{14} - 2.888Y_{15}} \end{pmatrix}\right]}$$

From the above synthetical early-warning model, one can see that it is positive correlation between the nonfinancial index variable Shareholding Proportion of the Controlling Shareholder Y1 and the occurrence of financial crisis probability P, which implies that the higher the shareholding proportion of the controlling shareholder, the greater the probability of financial crisis. It is negative correlation between the nonfinancial index variable CR_5 index Y4 and P, which indicates that the higher the shareholding proportion of the first five substantial shareholders and the ownership concentration, the less the probability of financial crisis. Meanwhile, if the company is involved in violation record, lawsuit or attribution and abbreviation alteration, the probability of financial crisis will be further greater.

72.4 The Test of the Early-Warning Model

72.4.1 The Test of Logistic Early-Warning Model Based on Financial Indexes Alone

Since the ratio between the original samples and the paired samples is 1:1, hence 1 is to represent companies with financial crisis while 0 is to represent companies without financial crisis. $P = 0.5$ is taken as discriminating section ratio. If $P > 0.5$, it is marked as company with financial crisis; if $P < 0.5$, it is marked as company with normal financial condition.

Input the index variable data of the 86 companies in the testing samples, consisting of 43 ST listed companies and 43 non-ST listed companies, into the early-warning model based on financial indexes alone to test the model's veracity. Testing results are illustrated in Table 72.6.

The above chart shows that the constructed early-warning model based only on financial indexes is able to discriminate accurately 32 ST companies and 35 non-ST companies, taking $P = 0.5$ as predicted discriminating point and the actual 43 ST listed companies and 43 non-ST ones as testing samples. In other words, the accuracy rates of the early-warning model based only on financial indexes to the prediction for the ST companies and non-ST ones respectively are 74.42 and 81.39 %. the average percentage is 77.91 %.

Table 72.6 Testing results of the Logistic model based on financial indexes alone

Classification table[a]

Observed value		Predicted value			
		Group		Accuracy rate (%)	Misjudgment rate (%)
		ST company	Non-ST company		
Group	ST company	32	11	74.42	25.58
	Non-ST company	8	35	81.39	18.61
Total percentage				77.91	22.09

[a] Discriminant Piont.500

72.4.2 The Test of the Logistic Synthetical Early-Warning Model Injecting Nonfinancial Indexes

Input the index variable data of the 86 companies in the testing samples, consisting of 43 ST listed companies and 43 non-ST listed companies, into the Logistic synthetical early-warning model based both on financial and nonfinancial indexes to test the model's veracity and compare the testing results of the two models. Testing results are illustrated in Table 72.7.

From the above chart one can see that the constructed Logistic synthetical early-warning model injecting nonfinancial indexes is able to discriminate accurately 35 ST companies and 37 non-ST companies, taking $P = 0.5$ as predicted discriminating point and the actual 43 ST listed companies and 43 non-ST ones as testing samples. Thus, the accuracy rates of the Logistic synthetical early-warning model injecting nonfinancial indexes to the prediction for the ST companies and non-ST ones respectively are 81.39 and 86.05 %. The average predicting percentage is 83.72 %.

Table 72.7 Testing results of the Logistic synthetical early-warning model injecting nonfinancial indexes

Classification table[a]

Observed value		Predicted value			
		Group		Accuracy rate (%)	Misjudgment rate (%)
		ST company	Non-ST company		
Group	ST company	35	8	81.39	18.61
	Non-ST company	6	37	86.05	13.95
Total percentage				83.72	16.28

[a] Discriminant Piont.500

By comparing the testing results of the two models, one can see that after drawing nonfinancial index variables in, model's accuracy rate increases by 5.81 %, which manifests that it enhances effectively the predicting accuracy rate of the model to draw nonfinancial index into the study of financial crisis early-warning.

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Chapter 73
Evaluation Research on Logistics Development of the Yangtze River Port Based on the Principal Component Analysis

Gao Fei

Abstract This article analyzes the significance of port logistics as well as factors influencing the development of Yangtze River port logistics. On this basis, a scientific evaluation system of the Yangtze River port logistics development and a principal component analysis model of the port logistics development level evaluation are established. Taking the ports group along the Yangtz river in Anhui province as an example, this article justifies the validity of the river port logistics development level evaluation system.

Keywords Ports along the Yangtze River · Port logistics · Evaluation system · Principal component analysis

At present, related research on port logistics evaluation has become one of the focuses of the theory. Many scholars have done a lot of work in this field, such as Cao Weidong, Cao Wave, Wang Ling, Wei Ran etc. Some use a specific object for the evaluation and analysis of the port logistics system. However, most researches focus on the application of modeling methods while paying little attention to the evaluation index system. In addition, inaccurate understanding of the port logistics'concept leads to a one-sided evaluation index system, which to some extent affects the evaluation result. Combined with previous research, this paper attempts to discuss the connotation of the port logistics, build a relatively reasonable river port logistics evaluation index system on the basis of analyzing influencing factors of port logistics' developmental level, and conduct a case study of ports along the Yangtze river through evaluation model by applying the principal component method (Xu 2004).

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E. Qi et al. (eds.), *The 19th International Conference on Industrial Engineering and Engineering Management*, DOI: 10.1007/978-3-642-38391-5_73,

73.1 The Meaning of Port Logistics

Port logistics refers to that the center port cities make use of its own port's advantages, relying on advanced hardware and software environment, to strengthen its radiation ability in logistics activities around the port, highlight the port set of goods, inventory, distribution features, with harbor industry as the basis, with information technology as the support, aim at integration of port resources and develop a comprehensive port service system covering the features of all links in the industry chain of logistics. Port logistics is a special form of the integrated logistics system and also is an irreplaceable and important node, which completes the basic logistics service and the value added service to supply the whole chain logistics system (Play 1995).

73.2 The Construction of Evaluation Index System

73.2.1 Factors Influencing the Port Logistics' Developmental Level

Port logistics' developmental ability along the Yangtze River: logistics' developmental ability reflects the existing development of port logistics' capability, based on their own advantages and competitive resource, its outcome and the status of the past and present logistics market's development. The port logistics development ability can be reflected from the logistics' infrastructure equipment, haven dimensions, informatization level, the standardization of logistics and port's developmental level.

The river port logistics developmental environment: port logistics developmental environment is an extrinsic factor for measuring the port's logistical development, and is the guarantee of the present developmental ability and the cultivation basis of potential development. Port's overall environment has very important influence on the development of logistics. For instance, logistics services and hinterland economic development level will have direct impact on logistics service demand and growth potential. Port logistics developmental environment usually depends on the economic environment, policy environment, human resource environment and so on (Han and Wang 2001).

The port logistics' capability of sustainable development: the sustainable development capacity of port logistics is a measure of port logistics' subsequent development ability. Logistics sustainable development must be in accordance with the carrying capacity of nature. Only by guaranteeing the sustainability of resource and ecology can we make the sustainable development of logistics possible. This requires that in the pursuit of logistics development, we must pay attention to protection of environment and resources to ensure sustainable use of resources. The sustainable utilization of resources and good ecological environment are important symbols of the logistics' sustainable development (Han and Wang 2001).

73.2.2 The Index System of Port Logistics Evaluation

Based on the analysis of the port logistics' connotation and its influencing factors above, this paper divides port logistics' evaluation index system into three levels: the first level is the target level (Mao 1996), namely the evaluation of river port logistics development level; the second level is an first-class indicator. Based on the analysis of factors influencing the port logistics, it establishes two first-class indicators, which are logistics developmental ability and environment and influence of logistics development respectively; the third level is the second-class indicator. This is the core part of the index system as well as the operable indicator's component. This article identifies 14 two-level index according to the three factors influencing the port logistics system while considering the theoretical and practical possibility (Han and Micheline 2001) (Table 73.1):

Table 73.1 14 two-level index according to the three factors influencing the port logistics system

Target layer	Level indicator	Two level index	
The port logistics development level of	Logistics development	X_1	Waterfront line length (KM)
		X_2	Berth number
		X_3	Cargo throughput
		X_4	The port number of employees
		X_5	The level of public information platform
		X_6	Logistics standardization level
		X_7	Profit ability
		X_8	The level of logistics services
		X_9	Investment in fixed assets (Million yuan)
	Logistics development environment and influence	X_{10}	Hinterland economy GDP (Billion yuan)
		X_{11}	Total retail sales of consumer goods in the hinterland of (Billion yuan)
		X_{12}	Hinterland trade (Billion yuan)
		X_{13}	Policy environment
		X_{14}	College school student number

73.3 The Case Study of the Port Logistics Development Level Evaluation

The principal component analysis is used to calculate the comprehensive strength index of the port logistics. Its basic principle and steps are: assumption on the N port logistics development in M indexes of comprehensive evaluation, the index set of matrix is X_{ij} (I = 1, 2,…, N; J = 1, 2,…, m) (Tian 2000). In order to eliminate the effects of different classes of magnitude, it is necessary to standardize the original matrix, form a new index set matrix Y_{ij}, calculate Y_{ij} correlation coefficient matrix R, obtain eigenvalue λ_i through inner product vector of R, get the corresponding feature vector I_{ij} by solving inverse compact transform, the characteristic value of the cumulative percentage determination of P components Z_i, and for each principal component contribution rate P_j; calculation of the I port logistics of each principal component scores of Z_{ij}; finally, calculated for each port logistics development comprehensive strength index Q_i (Nevem Working Group 1989).

$$Q_i = \sum_{j=1}^{p} p_j Z_{ij} \,(i = 1, 2, \ldots, n) \tag{73.1}$$

The value of Q_i is in proportion to the port logistics' development level of i years, and vice versa. By that analogy, we can calculate the comprehensive strength index of various port logistics development (Lu Avenue 1988).

Anhui port group includes 5 major ports like Ma'anshan, Wuhu, Tongling, Chizhou and Anqing. The port system has unique geographical advantages and important strategic position. With the promotion of Anhui along-river area's openness and development as well as the demand of accepting industrial transfer, various regions implement the strategy of "port prospers city" one after another and increase haven infrastructure construction. Some areas rely on their regional advantages of port to develop port logistics in order to realize port city's sustained and rapid economic development, along with the specific characteristics of the port (Xu 1998).

73.3.1 Computational Results Analysis

Choosing four years, 2000, 2003, 2007, 2010 from 2000 to 2010, according to the "China City Statistical Yearbook" (2001, 2004, 2008 and 2011), "statistical yearbook of Anhui province" (2001, 2004, 2008 and 2011) and the Anhui Yangtze River 5 ports' statistics report (Chun 2001), through the establishment of 5 Port Logistics comprehensive strength evaluation index database, using SPSS13.0 software, to analyze and process the data. According to standard extracting main factor with factor eigenvalue greater than 1 and the cumulative contribution rate

Table 73.2 Anhui River Port Logistics comprehensive strength index along the Yangtze (Q_i)

	2001	2004	2007	2010
Ma'anshan	6.82711	19.57205	5.32404	12.74210
Wuhu,	69.977337	87.99985	67.10115	91.96178
Tongling	−18.49716	−25.48272	−45.71171	−55.06373
Chizhou	−61.99780	−55.49272	−30.70364	−5.56749
Anqing	40.69597	50.40360	18.99016	61.92710

more than 85 %, and according to the formula (73.1), comprehensive strength index of the port logistics (Table 73.2) for different years are calculated (Xiao and Han 2001). Q_i represents Port Logistics comprehensive strength index.

73.3.2 Analysis of Port Logistics Development Level

From Table 73.2 we can see that Port Logistics comprehensive strength index of Wuhu harbor, Ma'anshan port and Anqing harbor is always positive, indicating that logistics development level in the area of the port logistics development is above the average (Foster 1992); Chizhou Port Logistics comprehensive strength index has always been negative, which indicates that the port logistics development level has always been below the average; the development of Tongling port logistics has obvious ups and downs, with comprehensive strength index turning from −18.49716 in 2001 into 55.06373 in 2010, and it continues to be negative, suggesting that the port logistics development has been below the average (Helen 1992).

73.3.3 Analysis of Port Logistics Development and Performance

According to the comprehensive strength index of the port logistics development trend, Anhui port logistics development is divided into the following types: (1) rising type, mainly represented by Chizhou port logistics. Chizhou Port Logistics comprehensive strength index increases from −61.99780 in 2001 into −5.56749 in 2010, a markable rise; (2) declining type, mainly represented by Tongling port logistics (Thompson 2002). Tongling Port Logistics comprehensive strength index drops from 18.49716 in 2001 into −55.06373 in 2010, big dropping range; (3) fluctuations, including Ma'anshan, Wuhu and Anqing port logistics. Ma'anshan Port Logistics comprehensive strength index rise from 6.82711 in 2001 into 19.57205 in 2004, reaching a peak, and then falling to 12.74210 in 2010; 2001 Wuhu Port Logistics comprehensive strength index is 69.977337, reaching the peak of 91.96178 in 2001, while the development of port logistics level will always be in the first place; Anqing Port Logistics comprehensive strength index rank second in 2001, and its value is 40.69597, with its index 18.990162010 falling to its low ebb. In 2010, its port logistics comprehensive strength index rise to 61.92710, ranking second.

On the port logistics development level evaluation system, we should first pay attention to the research of evaluation index system (Chames et al. 1978). Only with an in-depth analysis of the influencing factors of port logistics system established on the basis of scientific and reasonable index system can we conduct further evaluation. At the same time, we should also take the development level of hinterland economy as the important evaluation index (Saul and Adam 1999).

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Chapter 74
A Game Analysis of New Technical Equipment Procurement

Ai-hua Zhang, Zhi-wei Yang, Qiong Zhang and Hong-wei Fu

Abstract With the rapid development of modern science and technology, equipment construction plays an increasingly active role in Chinese military modernization construction. Given the limited funds input in the military equipment and the pressing need to strengthen the funds management, the paper analyzes the game process of the new technical equipment procurement and put forwards some scientific suggestions, which helps to win a priority, improve the benefits in the procurement game, and finally realize the optimization of the source distribution.

Keywords New technology · Equipment · Procurement · Game

74.1 Introduction

Equipment construction plays an increasingly active role in Chinese military modernization construction With the rapid development of modern science and technology. Equipment procurement, the critical link in the entire life cycle of weapon equipment, is restrained by equipment funds input and benefits (Zhao et al. 2011). Serious contradiction between military expenditure and demand leads to limited funds pouring into equipment construction. Given this condition, strengthening the management of the funds and analyzing the Procurement Process of the new technical equipment help to win a priority and improve the benefits in the procurement game (Xie et al. 2011; Xiang and Xin 1997).

Equipment purchase expenditure is the money the purchaser pays the supplier for the equipment (International Society of Parametric Analysts 2007). For the

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E. Qi et al. (eds.), *The 19th International Conference on Industrial Engineering and Engineering Management*, DOI: 10.1007/978-3-642-38391-5_74,

convenience of expression, Party A and Party B may be applied somewhere in the following text to represent the purchaser and the supplier respectively. Party A expects to purchase the equipment they need as cheaply as possible, while Party B hopes to sell it at the best possible price. Then the contradiction between the two Parties appears, namely, each Party becomes one of the main roles in the game of business or bargaining (Aghion and Bolton 1992; Weitzman 1980).

The following three circumstances usually occur during the process of equipment procurement: ① mature technology of producing equipment and a single supplier; ② mature technology of producing equipment and more than one suppliers; ③ immature technology of producing equipment and no available supplier. Under the first two circumstances, the essence of the concern both parties focus on is price (Hou and Wang 2001). This article highlights the third circumstance, under which, not only price but also risk control should be seriously considered. Lacking mature technology, the supplier need to pour an amount of money into research. There is some uncertainty about how much money should be poured into research, whether the new equipment can be developed, and if so, whether the function of the newly-developed equipment meet the requirement of the purchaser. So given this condition, The procuring behavior of the purchaser can also considered as the venture investment.

74.2 The Model of New Technical Equipment Procurement

The major problem of new technical equipment procurement lies in the uncertainty of its development and manufacture (Hartley 2007). And for military purchasers and the new equipment suppliers, this uncertainty is characterized by the difficulty of conquering new technology. Different difficulty leads to different developing costs, which can not be confirmed before the procurement contract is signed, but its probabilistic distributions can be estimated (Aliprantis and Chakrabarti 2000). The concrete costs the new technical equipment developer (Party B) pay out is their privacy. So for the good of the company, they always claim their high technical difficulty leads to high costs even with low technical difficulty and low costs. Then it is so difficult for the purchaser(Party A) to judge whether the cost information form Party B is true. But Party A can choose different quantity of the purchase, also their own privacy, to avoid the moral risk of Party B.

Suppose both parties have to reach an agreement in the purchase and sale contract that the price under high technical difficulty is P_h, and under low technical difficulty the price is P_l. Then under high technical difficulty, the marginal cost of Party B is C_h, and purchase quantity of Party A is Q_h; under low technical difficulty the marginal cost of Party B is C_l, and purchase quantity of Party A is Q_l. And,

$$P_h > C_h\,,\ P_l > C_l\,,\ Q_l > Q_h$$

Here, $C_h$and C_l represent the privacy of Party B, which are the fixed values, while Q_h and Q_l are variables in the free charge of A, which has to become fixed

Table 74.1 Gain matrix of new equipment game based on high technical difficulty I

		Party B	
		P_h	P_l
Party A	Q_h	$-P_h$, $Q_h\ (P_h-C_h)$	$-P_l$, $Q_h\ (P_l-C_h)$
	Q_l	$-P_h$, $Q_l\ (P_h-C_h)$	$-P_l$, $Q_l\ (P_l-C_h)$

after the contract is signed to facilitate the development process of Part B. So before signing the contract, Party A is expected to fix the values of Q_h and Q_l under the condition of both the high and low technical difficulties.

There exists the moral risk that Party B may present the low technical difficulty as high one and vice versa. And at the same time, Party A may present the high quantity as low one and vice versa (Wang 2011).

Party A, who has the last word on quantity of the purchase, is aiming at purchasing the equipment they need as cheaply as possible, while Part B, who has the last word on the price, is hoping to sell the newly developed technical equipment at the best possible price. That is to say, Party A pursues minimizing the average cost of the equipment purchase, while Party B pursues maximizing the selling profits. And the gain matrix game is shown in the following table (Table 74.1)

In this table, there is no difference to Party A whichever quotation Party B chooses. However, Party A prefers low quantity given the high quotation, and prefers high quantity given low quotation. In order to identify the difference in this preference, the matrix in the table should be modified as follows.

According to the Table 74.2, expecting to get the low price, all Party A could do is to force Party B to take the initiative in choice of low quotation. The quotation Party B chooses depends on the their possible profits, which is clearly shown as follows:

$$Q_h(P_h - C_h) > Q_h(P_l - C_h)$$
$$Q_l(P_h - C_h) > Q_l(P_l - C_h)$$

So, whatever choice Party A makes, Party B will inevitably choose to quote high price, and there is nothing party A can do to force Party B into preferring low quotation. That is to say, game equilibrium will be reached under the condition that Party A requires low quantity and Party B presents high quotation.

Under the circumstances of low technical difficulty, gain matrix game is shown in the following table.

Table 74.2 Gain matrix of new equipment game based on high technical difficulty II

		Party B	
		P_h	P_l
Party A	Q_h	$-P_h + \Delta$, $Q_h\ (P_h-C_h)$	$-P_l$, $Q_h\ (P_l-C_h)$
	Q_l	$-P_h$, $Q_l\ (P_h-C_h)$	$-P_l + \Delta$, $Q_l\ (P_l-C_h)$

Table 74.3 Gain matrix of new equipment game based on low technical difficulty

		Party B	
		P_h	P_l
Party A	Q_h	$-P_h + \Delta$, Q_h $(P_h - C_h)$	$-P_l$, Q_h $(P_l - C_l)$
	Q_l	$-P_h$, Q_l $(P_h - C_l)$	$-P_l + \Delta$, Q_l $(P_l - C_l)$

Like the game of new equipment based on high technical difficulty, this game is also equilibrated under the condition that Party A requires low quantity and Party B presents high quotation (Table 74.3).

The main reason why both games are equilibrated based on the same condition is that whatever choice Party A makes, Party B inevitably chooses high quotation which is beneficial. Namely, high quotation is the dominant strategy of Party B and low quotation is his strict dominated strategy.

Under the condition of high technical difficulty, if $P_l > C_h$, $Q_l(P_l - C_h) > Q_h(P_h - C_h)$, the disequilibrium game point that Party A requires high quantity and Party B presents low quotation: $(-P_l + \Delta, Q_l(P_l - C_h))$, is strictly superior to the equilibrium game point that Party A requires low quantity and Party B presents high quotation: $(-P_h + \Delta, Q_h(P_h - C_h))$. Then, the game between both parties get stuck in the "prisoner's dilemma", which stems from the fact that Part B always pursue the optimal profit which is however considered the worst to Party A, who has to choose the suboptimal point to improve the unfavorable condition, so does Party B, and subsequently both sides are bound to reach a suboptimal equilibrium rather than optimal equilibrium which is unstable.

The same analysis is also applicable to the purchase of new technical equipment under the condition of low technical difficulty.

To avoid "prisoner's dilemma" and arrive in the optimal condition, both parties may reach an agreement beforehand and may sign the following two contracts: ① The quotation of Party B is P_h while the purchase quantity of Party A is Q_h; ② The quotation of Party B is P_l while the purchase quantity of Party A is Q_l. And Party B is allowed to choose either of two, at the same time, Party A may make a promise during the game that Party A does choose low quantity if Party B prefers high quotation and vice versa. This promise is made by Party A without risk, just conveying the message to Party B that those who reap profits at the expense of others will end up ruining themselves.

74.3 Conclusions

Whether the procurement price is accurate and rational is closely related to the improvement of military equipment and the benefits of military expenditure on equipment purchase (Li et al. 2011). Therefore, new technical equipment procurement seems especially important that it is urgent to win a priority and improve the benefits in the procurement game, though the optimal equilibrium is not stable, which promotes a pressing need to take specific measures as follows.

74.3.1 Measures from a Macroscopic Point of View

Firstly, Equipment procurement rules should be gradually improved based on the administrative rules of military equipment procurement expenditure and some related administrative regulations on military product price, to form a comprehensive system of laws and regulations on equipment procurement management, ensuring that there are laws to go by and rules to obey (Zhang and Zhang 2007; Hang and Tan 2011).

Secondly, the building of procurement team, the scientific group, should be strengthened to make every talent of it be good at price review work, understanding both techniques and finance (Hao and Jiang 2010).

74.3.2 Measures from a Microscopic Point of View

On the one hand, given many related links and departments involved in the equipment procurement, purchasers should build up the sense of responsibility to deal well with and strengthen all kinds of relationships (Zhang et al. 2009).

On the other hand, purchasers should make a good job of price review work, which requires them to actively focus on or participate in scientific research, gaining an adequate understanding of the details (quality, performance, design, material, manufacture, etc.) of the equipment to accumulate some related information, and also pushes them to get acquainted with the critical information (business concepts, pricing strategy, foaming quotes, rational price, etc.) of the suppliers to make a good preparation for the subsequent work (Yuan and Hu 2008; Wang et al. 2007). All the measures mentioned above, if taken completely, can not only effectively prevent the suppliers exaggerating the equipment cost but also give firm guarantee for a rational quotation and an effective procurement contract.

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Chapter 75
Constructing Performance Measurement Indicators in the Government' Information Unit in Taiwan: Using Balanced Scorecard and Fuzzy Analytic Hierarchy Process

Yi-Hui Liang

Abstract The purpose of the study is to establish balanced scorecard (BSC) in performance measurement of Government' MIS Department. We take a broader definition of Government' MIS Department as "an assembly which brings forth some specific functional activities to fulfill the task of MIS." BSC used as a measurement tool to assess study subjects, according to its strategy and goal formed by its assignment property, can be divided into four dimensions: internal process, customer, business value, and future readiness, which can provide us with a timely, efficient, flexible, simple, accurate, and highly overall reliable measurement tool. In order to extract the knowledge and experience from related experts to pick out important evaluation criteria and opinion, this study combines fuzzy theory and the analytical hierarchy process (AHP) to calculate the weights. After completing weighted calculation of every dimension and indicator, the BSC model is thus established. The findings of this study show that the indicator weightings between and among all the levels are not the same, rather there exists certain amount of differences. The degrees of attention drawing in order of importance among all dimensions are internal process, customer, business value, and future readiness. After comprehensively analyzing indicators of performance measurement included in every level, the highly valued top three indictors are, when conducting dimension performance measurement in Government' MIS Department, "Control cost," "Satisfy end user demand," "Operate and maintain information technologies efficiently". From these studies we will be able to develop the indicators and the calculated weights of the four dimensions and the indicators mentioned above. This model can be utilized by the information units of

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E. Qi et al. (eds.), *The 19th International Conference on Industrial Engineering and Engineering Management*, *DOI: 10.1007/978-3-642-38391-5_75*,

the governments for constructing the strategies and blueprints for self evaluation. Further, these can also provide important information for effective resource investment in Government' MIS Department.

Keywords Government · MIS · Performance measurement · Balanced scorecard

75.1 Introduction

Performance appraisal system is the most effective tool used for government reengineering. Performance appraisal aims to help people achieve their strategies, missions, visions and goals.

Wu (2000) supposed that Good performance appraisal systems can enable government departments to allocate reasonable resources, prioritize resource investment, further improve departmental effectiveness and efficiency, and organizational members adopt identical methods to pursue their goals, encourage their morale, and cause them to focus on organizational vision.

Traditional government departments usually developed their information systems according to their individual requirements, and hence did not communicate with each other, leading people to develop bad impressions and stereotypes regarding government performance owing to inefficient government operations.

Balanced Scorecard (BSC), which was developed by Kaplan and Norton (1992), is a useful and popular method of identifying business performance using lagging and leading indicators based on the foundation of visions and strategies. Balanced Scorecard implies that organizational performance is evaluated not only utilizing financial indicators, but also simultaneously non-financial indicators. Balanced Scorecard built a framework to transform organizational vision and strategies into a series of consistent performance indicators, and thus execute and control organizational administration, allow organizational members to more concretely learn the vision and strategies of organization, and also l and also help managers track the outcomes of implemented strategies.

Since Executive Yuan, Republic of China implemented performance reward and performance management plan in 2003, this plan followed the BSC spirit. However, Executive Yuan then consider the business properties, organizational culture, and management and check, so as to authorize each government department to set up its own performance evaluation process and evaluation indicators (Directorate-General of Personal Administration 2005). Until now, Executive Yuan does not force government departments to set up their own performance evaluation process and evaluation indicator (Chu and Cheng 2007).

The analytical hierarchy process (AHP) (Kaplan and Norton 1992), which is the multi-criteria technique, is considered appropriate for solving complex decision problems (Directorate-General of Personal Administration 2005). The AHP is based on theory, and offers information on the relative weight of the BSC performance indicator (Chu and Cheng 2007; Searcy 2004). Otherwise, (Zadeh 1965) (Liedtka 2005) developed fuzzy theory to handle uncertain problems involving fuzziness and vagueness. Lee et al. (Martinsons et al. 1999) posited that traditional BSC failed to consolidate diverse performance indicators. Lee et al. (Martinsons et al. 1999) also suggested the fuzzy AHP method as as an answer for this problem.

BSC can help managers of government organizations holistically evaluate information technology (IT) investments, as well as the performance of information system (IS) departments. This study builds a Framework for evaluating government MIS departments based on BSC. The study summarizes how to combine the BSC and fuzzy AHP to serve as a decision tool for government organization. The tool can be used not only to assess the contribution of a specific government MIS department, but also analyze the performance and direct the activities of government MIS departments.

75.2 Methodology

75.2.1 Research Structure

This study builds a Framework for evaluating government MIS departments based on BSC and fuzzy AHP.

75.2.2 Select Research Variables

This study adopted the dimensions and indicators which developed by Martinsons et al. (1999), Liang et al. (2008), and related government MIS experts to develop my proposed the dimensions and indicators. The research variables are showed as Table 75.1.

75.2.3 Fuzzy AHP

Step 1: Construct hierarchical framework of the BSC performance evaluation criteria

From the four BSC perspectives, the hierarchical framework of the BSC performance evaluation criteria is constructed.

Step 2: Using AHP method to calculate the weight

If get the weightmatrix W in pairwise comparison matrix A, standardize geometrical mean of row vectors, multiply element in every row, get geometrical mean and normalize it.

Table 75.1 Research variables

Dimension	Indicator	
Customer	1. Build and maintain the good image and reputation with end users.	A1
	2. Have the opportunity to develop IT.	A2
	3. Maintain a good relation with user communities.	A3
	4. Satisfy end user requirement	A4
	5. Perceived the preferred IS products and services provider by end users.	A5
Business value	1. Manage the good image and reputation.	B1
	2. Make sure IS projects to offer business value.	B2
	3. Control cost.	B3
	4. Be onerous to offer the suitable IS products and services to the third party.	B4
Inner process	1. Expect and affect the demands from end users and managers.	C1
	2. Plan and develop IT efficiently.	C2
	3. Operate and maintain IT applications efficiently.	C3
	4. Obtain and test new hardware and software.	C4
	5. Offer to satisfy the end user trainings with effective cost.	C5
	6. Manage the IS problems effectively.	C6
Future readiness	1. Expect and prepare the IS problems.	D1
	2. Train and develop regularly to improve IS skills.	D2
	3. Promote regularly IS applications mix.	D3
	4. Increase regularly IS hardware and software.	D4
	5. Implement cost-effective and new technological researches which are suitable for organizations.	D5

Step 3: Construct Positive Reciprocal Matrix

Every evaluation member use fuzzy AHP evaluation scale to express relative weight between each dimensions and criteria, and construct fuzzy Positive Reciprocal Matrix.

Step 4: Consistency Check

The check methods are as follows:

4.1 Consistency Index (C.I.)

According to Consistency Index (C.I.), C.I $= 0$ indicate that evaluation has perfect consistency; C.I > 0 indicate that evaluation has consistency; C.I. < 0.1 indicate that evaluation has evaluation has tolerant bias.

4.2 Consistency Rate (C.R.)

Saaty (1980) (Kaplan and Norton 1992) supposed that Consistency Rate (C.R.) to evaluate the consistency of pairwise comparisons in a matrix among criterions. Under the condition of different rank of matrix, it produce different random index (R.I.). Under the condition of the same rank of matrix, the ratio of C.I. to R.I. is called C.R.. When C.R ≤ 0.1, the consistency level is acceptable.

Step5: Calculate fuzzy weight value

Utilize the Lambda-Max method which Csutora and Buckley (2001) proposed, calculate the fuzzy weight of evaluation criterions. The steps of calculation are as follows:

5.1 When $\alpha = 1$, use α-cut to get median Positive Reciprocal Matrix. Then, calculate the weight use AHP method to get the weight matrix.

5.2 When $\alpha = 0$, use α-cut to get minimum positive reciprocal matrix and maximum positive reciprocal matrix. Then, calculate the weight use AHP method to obtain the weight matrix.

5.3 In order to make sure that calculated weight value is fuzzy number, therefore, adjusted the coefficient.

5.4 After obtained adjusted coefficient, calculate minimum positive reciprocal weight matrix and maximum positive reciprocal weight matrix of every measurement dimension.

5.5 Combing adjusted minimum, maximum and median values to get the fuzzy weight in kth evaluation member and kth measurement dimension.

5.6 Utilize average method to integrate the fuzzy weight of evaluation members and measurement dimensions.

75.3 Results

75.3.1 Survey Candidates

Based on previous studies on applying the BSC approach to information systems, this study used the 21 indicators as performance evaluation indicators to construct the research model and develop the questionnaire items based the model. The 20 indicators are showed in Table 75.2.

Next, take the central engineering government department as the example, and calculate the weights of all dimensions and indicators of the model using Fuzzy AHP method. The questionnaire was distributed among Director and Vice Director of the direct department, 7 Director of first-class independent unit, 3 Section Manager of the direct department, and Director of Information Technology, and a total of 13 valid questionnaires were returned and censored 2 invalid questionnaires (refusing answer, incomplete answer, or don't passing the consistency check). The result of this study is showed in Table 75.2.

The results demonstrated that the importance weights of all dimensions were ordered as follows: internal process, customer, business value, and future readiness. Additionally, the top three importance weights of performance evaluation indicators were top three indicators are “Control cost,” “Satisfy end user demand,” “Operate and maintain information technologies efficiently”.

75.3.2 Results of Fuzzy AHP Method

Table 75.2 Results

Dimension	Weight	Indicator	Weight	Rank
Customer	0.277	1. Build and maintain the good image and reputation with end users.	0.046	11
		2. Have the opportunity to develop IT.	0.037	15
		3. Maintain a good relation with user communities.	0.053	8
		4. Satisfy end user requirement	0.098	2
		5. Perceived the preferred IS products and services provider by end users.	0.043	12
Business value	0.239	1. Manage the good image and reputation.	0.050	10
		2. Make sure IS projects to offer business value.	0.050	9
		3. Control cost.	0.100	1
		4. Be onerous to offer the suitable IS products and services to the third party.	0.040	13
Inner process	0.328	1. Expect and affect the demands from end users and managers.	0.055	7
		2. Plan and develop IT efficiently.	0.060	5
		3. Operate and maintain IT applications efficiently.	0.064	3
		4. Obtain and test new hardware and software.	0.032	16
		5. Offer to satisfy the end user trainings with effective cost.	0.062	4
		6. Manage the IS problems effectively.	0.055	6
Future readiness	0.156	1. Expect and prepare the IS problems.	0.029	18
		2. Train and develop regularly to improve IS skills.	0.030	17
		3. Promote regularly IS applications mix.	0.029	19
		4. Increase regularly IS hardware and software.	0.028	20
		5. Implement cost-effective and new technological researches which are suitable for organizations.	0.040	14

75.4 Conclusion

Performance appraisal systems for profit organizations have traditionally measured performance financially. For non-profit organizations a different approach is used, since for profit is not a main objective for such organizations, and possibly is even a constraint. Financial performance represents a subjective measure of how well a firm can use assets from its primary mode of business to generate revenues. Notwithstanding, for government organizations and other non-profit organizations, financial performance primarily represents a measure of how efficiently a government organization can use its budget. Using financial performance to measure is not sufficient to measure the government organization performance.

This study develops BSC framework and calculate the weights of the four perspectives and the indicators mentioned above. These performance evaluation indicators will then be utilized by the information units of governments for constructing the strategies and blueprints for self evaluation. Further, these can also provide other related departments for effective resource investment in information units of governments.

Compared to Miller and Doyle (1987) 和 (Saunders and Jones 1992), the proposed IS evaluation dimensions and indicators more focus non-profit organizations characteristics.

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Chapter 76
A Decision Model and Its Algorithm for Vehicle Routing Problem to Meet Emergencies

Xing Liu, Min Zhong and Ya-hong Ma

Abstract A kind of vehicle routing problem is discussed to meet emergencies, in which some routes may be destroyed or blocked uncertainly. The value of a route in an uncertain situation is analyzed and a two-stage integer program model is constructed. To simplify the computation of the model a method is put forward. And in this method, only the maximum value and the minimum value are calculated for the object value. In the end, a two-stage taboo search algorithm is designed and an example is given.

Keywords Logistics · Taboo search algorithm · Uncertain decision · Vehicle routing problem

76.1 Introduction

People had and have to face so many natural disasters, for example, the Kobe earthquake (1995) in Japan, the hurricane “Rita” (2005) in the United States, the Wenchuan earthquake (2008) in China, etc. These natural disasters had destroyed a lot of traffic facilities and made emergency rescue very difficult. For example, some key bridges, tunnels and line hubs of the traffic lines may be damaged or destroyed. If vehicles can pass through the key bridges (tunnels), transportation mileage will be shortened. But if these bridges (tunnels) were destroyed, the vehicles may have to make a detour to transport, or even backtrack (Li and Guo 2001; Gan et al. 1990;

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E. Qi et al. (eds.), *The 19th International Conference on Industrial Engineering and Engineering Management*, DOI: 10.1007/978-3-642-38391-5_76,

Liu and Jiao 2000; Wu and Du 2001; Zhang et al. 2002; Renaud and Boctor 2002). It may delay the mission. So decision-making of multi-vehicle path decision problem in the emergency environment became more and more important.

This article discusses the multi-vehicle path decision problem when some critical sections (bridges, tunnels, etc.) of the road network may be destroyed. The mathematical model is constructed and the taboo heuristic algorithm is given to solve the problem.

76.2 Description of the Problem and Complexity Analysis

76.2.1 Description of the Problem

The problem can be described as follows:

Let $G = (V,\ A)$ be the transportation network graph. Let $V = \{v_0, v_1, v_2, \cdots, v_n\}$ be the set of vertices. And let v_0 be the freight yard, which is the point that the vehicles will start from and will get back when delivery finished. The other vertices $v_i(i = 1, 2, \ldots, n)$ are the locations which are in need of services. Let $A = \{[v_i, v_j] | i \neq j, v_i, v_j \in V\}$ be the set of edges. Each edge represents a road between two vertices. Vector set $C = \{c_{ij}\}$ is defined on the edge set A to present the distance, travel costs or travel time between the two vertices.

Suppose $[b_1, b_2] \in A$ is an edge to represent a road which may be destroyed at any time. And the destruction time and the probability of uncertainty could not be known. Graph $\hat{G}$ would be the new network graph after $[b_1, b_2] \in A$ was destroyed. The graph $\hat{G}$ will be almost the same as graph G except the edge $[b_1, b_2]$. Customer demand at vertices v_i will be noted as $q_i(i = 1, 2, \ldots, n)$. All the demand will be met by M vehicles whose maximum cargo capacity is Q. Now problem is how to find the smallest expenses (the shortest time, the smallest mileage, or other smallest comprehensive index) transportation routes.

76.2.2 Complexity Analysis

The vehicle routing problem is recognized NP-hard. If there are n demand vertices, there will be $n!$ kinds of optional routes. The number of optional routes which include (b_1, b_2) or (b_2, b_1) is $2(n-1)!$. Those optional routes which include (b_1, b_2) will be at least $(n-k)!$ when $k(k \leq n)$ demand vertices have been fulfilled and the route ahead of the vehicles has been destroyed. Only consider $k = 1$, the number of optional routes may be

$$n! - 2(n-1)! + 2(n-1)!(n-1)! \approx n! + 2(n-1)!(n-1)!$$

If $n = 10$, the number of optional routes is about 2.6×10^{11}. When the evaluation of each scheme should be calculated, it will take too long to finish. If consider $k > 1$ and the whole network be taken into account, the calculation time will be longer more.

76.3 Mathematical Model

For any pre-planning transport route scheme $R_i\left(r_{i1}, r_{i2}\ldots r_{ij}\ldots, r_{iM}\right)$ (r_{ij} represents the route of the vehicle j). d_j is used to represent the set of demand vertices that the vehicle j should service. Then the set of all demand vertices can be noted as $D = \cup d_j$. If r_{ij} doesn't contain the road (b_1, b_2) or (b_2, b_1) which may be damaged or destroyed, the scheme does not need to adjust in transit. If r_{ij} contains the road (b_1, b_2) or (b_2, b_1), h_j is used to represent the current location of the vehicle j when the vehicle j gets the information that the road (b_1, b_2) or (b_2, b_1) was destroyed. The set of all vehicles' current location is $H = \left\{h_j | j \le M\right\}$. d'_j is used to represent the rest set of demand vertices that the vehicle j hasn't serviced. Then the set of all the rest demand vertices can be noted as $D' = \bigcup d'_j$.

The results of re-optimizing the line of the vehicle j should be related to the current location of all vehicles, the remaining demand vertices, and the transportation network graph $\hat{G}$. Since the time when the road will be destroyed is uncertain, the factors above are uncertain too.

So the problem can be represented by a two-stage uncertain planning problem. If all the vehicles are collaborative the path global collaboration optimization model can be expressed as follows:

$$\min z = \sum_{i=0}^{n}\sum_{j=0}^{n}\sum_{m=1}^{M} c_{ij}x_{ijm} \quad + \quad switch(\sum_{m=1}^{M}(x_{b_1b_2m} + x_{b_2b_1m}))\sum_{h_b=1}^{e} p_{h_b}[\min z' - \sum_{r=0}^{n}\sum_{s=1}^{n}\sum_{m=1}^{M} c_{rs}x_{rsb}]$$

$$r, s \in (d - d') \cup \{0\} \tag{76.1}$$

$$\min z' = \sum_{m=1}^{M}\sum_{i=0}^{n}\sum_{j=0}^{n} c_{ij}\, x'_{ijm} \tag{76.2}$$

$$\sum_{i=1}^{n}\sum_{j=1}^{n} q_j x_{ijm} \le Q_m \quad m = 1, \ldots M \tag{76.3}$$

$$\sum_{m=1}^{M}\sum_{i=1}^{n} x_{ijm} = 1 \quad j \in d \tag{76.4}$$

$$\sum_{m=1}^{M}\sum_{j=1}^{n}x_{ijm}=1 \quad i\in d \tag{76.5}$$

$$\sum_{m=1}^{M}\sum_{j=1}^{n}x_{0jm}=\sum_{m=1}^{M}\sum_{i=1}^{n}x_{i0m}=m \tag{76.6}$$

$$\sum_{m=1}^{M}\sum_{j=1}^{n}x'_{h_ijm}=1 \quad h_i\in H \tag{76.7}$$

$$\sum_{m=1}^{M}\sum_{i=1}^{n}x'_{i0m}=M \tag{76.8}$$

$$\sum_{m=1}^{M}\sum_{j=1}^{n}x'_{ijm}=1 \quad i\in d' \tag{76.9}$$

$$\sum_{m=1}^{M}\sum_{i=1}^{n}x'_{ijm}=1 \quad j\in d' \tag{76.10}$$

$$x'_{b_1b_2m}=x'_{b_2b_1m}=0 \tag{76.11}$$

$$x_{ijm}=0,1 \quad x'_{ijm}=0,1 \tag{76.12}$$

Expression (76.1) is the first-stage objective function of the two-stage planning. x_{ijm} is a 0–1 variable that it will be 1 when the vehicle m passes through the road (i,j), otherwise it will be 0. The first term on the left of expression (76.1) means the value of the first planning. And the second term means re-optimizing value when the line was destroyed and a new scheme was planed. $switch(\cdot)$ is a switch function. It will be 1 when the line contains sections may be destroyed and will be 0 otherwise. The serial number of the first vertex in destroyed line r_{ib} is noted as e. p_{h_b} is the probability that the line might be re-optimized at the location h_b. $\min z'$ is the re-optimized value of the line and $\sum_{r=1}^{n}\sum_{s=0}^{n}\sum_{m=1}^{M}c_{rs}x_{rsm}$ is the milage planed in first stage but won't be achieved because of re-optimizing. Expression (76.2) is the second-stage objective function of the two-stage planning. Similarly, x'_{ijm} is a 0–1 variable in the second-stage that it will be 1 when the vehicle m passes through the road (i,j), otherwise it will be 0.

Expressions (76.3)–(76.6) are constraints of the first-stage planning. (76.3) means that the transport needs of each vehicle must be less than the gross vehicle weight. (76.4) and (76.5) mean that each demand vertex can only access one time. (76.6) means the vehicle issued from the warehouse must be the same of the returned and equal to the number of all transport vehicles. (76.7)–(76.12) are constraints of the second-stage planning. (76.7) means that the vehicle involved in the collaboration will start from the current location. (76.8) means that the vehicles involved in the collaboration will return to the warehouse. (76.9) and (76.10) mean that each remaining demand vertex can only access one time. (76.11) means the vehicle can not pass by the destroyed road.

76.4 Evaluation of the Schemes

If each value of p_{h_b} in the expressions (76.1) is taken into account, the algorithm will need too long time to calculate. And the law of the destruction is hard to find in emergency environment. In fact, the decision makers always concerned about worst-case situation or best-case situation. So the evaluation of the schemes can be simplified to the maximum evaluation value in worst-case situation, or the minimum evaluation value in best-case situation.

The minimum milage of the scheme R_i is noted as $best(R_i)$ and the maximum milage of the scheme R_i is noted as $worst(R_i)$. The utility of the scheme R_i can be noted as

$$u(R_i) = u(best(R_i), worst(R_i)).$$

If $(b_1, b_2) \notin R_i$, namely if there is no road being destroyed then

$$u(R_i) = f(R_i) = best(R_i) = worst(R_i).$$

If $(b_1, b_2) \in R_i$, when decision-maker gets the information that the road was destroyed, the scheme should be renewed.

Therefore, the worst-case situation is that the information of damaged road is known when the vehicle has been arrived at the vertex of the damaged road and the vehicle may have to make a long detour to transport. If $(b_1, b_2) \in R_i$, $s_k(R_i)$ is the serial number of demand vertex k in r_{ib}. And $ff(R_i(i,j))$ is the milage of all the vehicles when the vehicle b runs from demand vertex i to demand vertex j. $ff(R_i'(s_k))$ is the milage of all the vehicles after the scheme has been renewed at s_k.

Theorem *If $(b_1, b_2) \in R_i$, the maximum milage for the transport process is $f_1(s_e, R_i)$, and $f_1(s_e, R_i) \geq f_1(s_e, R_i)$, in which $s_e = \min(s_{b1}, s_{b2})$ and $s_k \leq s_e$.*

Proof According to the path of the scheme R_i

$$f_1(s_k, R_i) = ff(R_i(0, s_k)) + ff(R_i'(s_k)) \tag{76.13}$$

$$f_1(s_e, R_i) = ff(R_i(0, s_e)) + ff(R_i'(s_e)) \tag{76.14}$$

Let (76.13)–(76.14), get

$$f_1(s_e, R_i) - f_1(s_k, R_i) = ff(R_i(s_k, s_e)) + ff(R_i'(s_e)) - ff(R_i'(s_k)) \tag{76.15}$$

Because $ff(R_i(s_k, s_e))$ is the milage of all the vehicles when the vehicle b runs from demand vertex s_k to demand vertex s_e, then

$$ff(R_i(s_k, s_e)) \geq 0.$$

Because $ff(R_i'(s_k))$ is the milage of all the vehicles after the scheme has been renewed at s_k and $ff(R_i'(s_e))$ is the milage of all the vehicles after the scheme has been renewed at s_e and $s_k \leq s_e$,

$$ff(R_i'(s_e)) \geq ff(R_i'(s_k)).$$

So

$$f_1(s_e, R_i) - f_1(s_k, R_i) = ff(R_i(s_k, s_e)) + ff(R_i'(s_e)) - ff(R_i'(s_k)) \geq 0$$

Hence

$$f_1(s_e, R_i) \geq f_1(s_k, R_i).$$

76.5 Taboo Search Algorithm

The main process of the taboo search algorithm is as follows:

(1) Generate a path sequence randomly for the initial solution. Code n demand vertices and note warehouse as 0. Path solution is a random arrangement of the number 0 to n. The head and tail of the path solution are 0. There are $M - 1$ 0 s in the middle of the path solution. And they are situated among 1 to n randomly. The numbers between two 0 s represent the service path of one vehicle.
For example, to 6 demand vertices and two cars, a path solution is 0-1-2-3-0-4-5-6-0.
(2) Generate neighborhood of the solution. Exchange the situation of two demand vertices or insert a new vertex into the service path to gain new solutions.
(3) Process the constraints of the vehicle capacity. If the total demands of demand vertices exceed cargo capacity of the vehicle, the scheme should be eliminated.
(4) Taboo objects are two adjacent demand vertices. The length of the taboo list increases with the increase of evolution generation. If current value is better than the optimal value in history, the taboo is lifted.
(5) Evaluate the value of the scheme. Calculate the minimum mileage and maximum mileage of each scheme. When calculate the maximum mileage of the scheme which contains the destroyed sections of the path, use an inner taboo search algorithm that is similar to the external algorithm. The final evaluation value depends on the decision-making criteria, such as optimistic criteria, pessimistic criteria, compromise guidelines and expectations criteria, etc. (Qu et al. 2004; Golden et al. 1998; Lia et al. 2005; Renaud et al. 1996; Stenger et al. 2012; Li and Li et al. 2011; Qian 2011; Liu et al. 2005).

(6) Consider the direction of the path. On optimistic criterion, the changed value of the destruction has not been calculated to evaluate the value. In order to compensate for this deficiency, a number of sub-optimal evaluation values will be picked up, and the worst case results will be calculated for decision-making reference. The schemes that have the same sequence but different direction are considered to be different. Such as 0-1-2-3-4-0 and 0-4-3-2-1-0 are different schemes.

76.6 Example

There are 1 warehouse vertex and 10 demand vertices in the Table 76.1. And data in the table is the distance between two vertices.

For each demand vertex, the demand is 5. There are two vehicles being used to transport. For each vehicle, the maximum cargo capacity is 35 (Table 76.2).

Table 76.1 The distance between the vertices (I)

Vertices	0	1	2	3	4	5
0	0	1000	38	37	45	25
1	1000	0	1000	14	1000	1000
2	28	1000	0	1000	25	28
3	27	14	1000	0	40	1000
4	45	1000	25	40	0	1000
5	25	1000	28	1000	1000	0
6	1000	39	36	1000	1000	10
7	36	36	1000	1000	1000	25
8	41	1000	1000	1000	1000	13
9	1000	17	1000	15	1000	1000
10	30	1000	1000	34	1000	1000

Table 76.2 The distance between the vertices (II)

Vertices	6	7	8	9	10
0	1000	26	41	52	40
1	39	36	1000	37	1000
2	36	1000	1000	1000	1000
3	1000	1000	1000	15	44
4	1000	1000	1000	1000	1000
5	10	25	13	1000	1000
6	0	25	19	1000	1000
7	25	0	12	1000	14
8	29	12	0	1000	31
9	1000	1000	1000	0	30
10	1000	14	41	40	0

Table 76.3 The optimal solutions when 2–4 may be destroyed

Decision making criteria	Optimism criteria		Compromise criteria		Pessimistic criteria
	a	b	a	b	
	301	301	312	324	323
The best situation	7 10 9 1 3 0 4 2 6 8 5	7 10 9 1 3 0 4 2 6 8 5	7 10 9 1 3 0 4 2 6 8 5	4 3 9 1 6 2 0 5 8 7 10	7 8 5 6 2 0 4 3 1 3 9 10
	323	382	323	324	323
The worst situation	7 8 5 6 2 0 4 3 1 3 9 10	7 10 9 1 3 0 4 3 1 7 8 5 6 2	7 8 5 6 2 0 4 3 1 3 9 10	4 3 9 1 6 2 0 5 8 7 10	7 8 5 6 2 0 4 3 1 3 9 10
Evaluation value	301	301	312	324	323

Between vertices 2 and 4, there is so important a bridge that if it was damaged it could not be repaired. The optimal solutions are calculated out using the tabu search algorithm under the different criteria (Table 76.3).

76.7 Conclusion

Decision-making of multi-vehicle path decision problem in the emergency environment became more and more important. This article discusses the multi-vehicle path decision problem when some critical sections (bridges, tunnels, etc.) of the traffic network may be destroyed. The mathematical model is constructed and the taboo heuristic algorithm is given to solve the problem. Research results can be used for uncertain environment logistics distribution decision.

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Chapter 77
A Solution to Optimize Enterprise Business and Operation Process

Xue-wu Chang, Xiao-yuan Ji and Jian-xin Zhou

Abstract Process continuous optimization plays an important role in enterprise informatization; however, there are few solutions with good operation and practicability for enterprises to implement. In this paper, a solution was proposed, which included a decomposition method of business process named "Timeline-Place-Roles (TPR)" and an "8 steps" value-added method of process analysis and continuous optimization based on the value chain. Then this paper took the "product-prepared" business process of a Chinese continuous manufacture enterprise as a case, and made the case analysis and optimization by using the solution. The results proved that the solution could optimize enterprise business process and improve the effect continuously and deepen informatization application to a certain extent.

Keywords Business process · Depth application · Enterprise informatization · Operation process · Process optimization · Solution

77.1 Introduction

On July 8, 2011, as an informatization web portal, e-works sponsored "2011 Chinese Manufacture Management Informatization Conference" in Zhengzhou, China. The depth application of Enterprise Resource Planning (ERP) was an

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E. Qi et al. (eds.), *The 19th International Conference on Industrial Engineering and Engineering Management*, DOI: 10.1007/978-3-642-38391-5_77,

important topic for discussion at the conference, and the enterprise business process optimization was considered as a key method. The Chinese manufacture enterprises have begun to enter the stage of process optimization, so it is meaningful to research and propose a solution of process optimization.

In a corporation, enterprise management consists of many business processes, and a business process is composed of many operation processes executed by different roles at different places. The aim of enterprise informatization is to improve enterprise management, and the improvement of enterprise management could be realized by optimizing the business process, and the optimization of business process could be supported by optimizing the operation process, the relationship among them is shown in Fig. 77.1. So the level of enterprise informatization could be advanced by optimizing the operation process continuously.

The aims of optimizing enterprise business process should include 2 points:

(1) To decrease the total time consumed of the business process;
(2) To strengthen the value-added capability of the business process and reduce the non-value-added link.

There were many researches about business process optimization. Some people use the petri net technology to construct a model for a business process, and then use software to analyze and optimize it (Wang et al. 2008; Wang 2007; Aalst 1998; Ling and Schmidt 2000; Pan et al. 2005; Li and Fan 2004; Pang et al. 2008). The method could find the key route and figure out the shortest route, but it does not tell us how to describe, decompose and sort out the business process. Someone presented a process log method of business process digging by using the users' operation log in some information system, such as business process management (BPM) system, ERP system and so on (Zhang 2010; Feng 2006; Gaaloul et al. 2005, 2009). This process log method could represent the invisible business process, but there are few such information systems which could support it. To optimize business process, somebody used cost analysis method (Hu et al. 2003; Cooper 1990; Spoede et al. 1994), or a Business Process Reengineer (BPR) method based on the value chain (Baxendale et al. 2005), but the methods lacks maneuverable steps; Prof. Lan proposed a new method, which established a general equilibrium relationship of the enterprise value chain based on the dual theory of linear program (Lan et al. 2011), but the operation of calculating the value by using the cost was also a little complex.

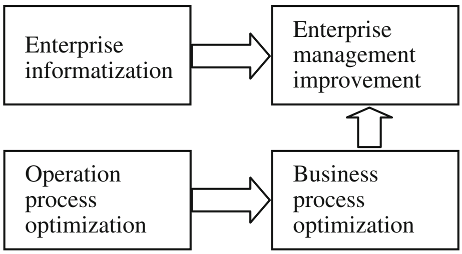

Fig. 77.1 The relationship between process optimization with enterprise informatization

In fact, nowadays, the design and optimization of business process is completed by hand in many Chinese companies generally. So the solution to improve business process should be easy, and maneuverable. Business process optimization requires modeling conveniently on one hand, and needs to add value on the other hand. Thus, this paper proposed a whole set of solution with a decomposition method of business process named "Timeline-Place-Roles (TPR)" and an "8 steps" value-added method of process analysis and continuous optimization based on the value chain, which the chain value was estimated by time-consumed.

77.2 Methodology

The solution consists of two parts. The first part is a method to decompose a business process into a series of continuous operation processes, which is named Timeline-Place-Roles (TPR) method, as shown in Fig. 77.2. Based on the timeline, decompose a business process into many activities according to activity places, and make sure the places of each two adjacent activities are different. Then decompose every activity into several operation processes according to activity roles to assure that the roles of each two adjacent operation processes are not the same. All the operation processes construct the business process. Record the place, roles, and time consumed of every operation process in a table after the operation process has been decomposed.

The second part is an "8 steps" value-added method to optimize every operation process of the business process, which contains 8 steps from simplification to appreciation in order to make it more valuable, as shown in Fig. 77.3.

The optimization steps are as follows:

(1) Judge whether it could be deleted. If it is meaningless or repeating, then delete it.
(2) Judge whether it could be executed at the same time with other operation.
(3) Judge whether it could be carried out by the computer.
(4) Judge whether it could be simplified.
(5) Judge whether it could be standardized.
(6) Judge whether it could be extended to contain more information.
(7) Judge whether it could add another new operation process to make it more valuable.
(8) Judge whether it could strengthen the value-added part.

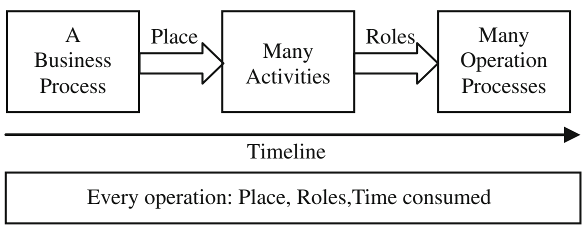

Fig. 77.2 The timeline-place-roles (TPR) method to decompose a business process

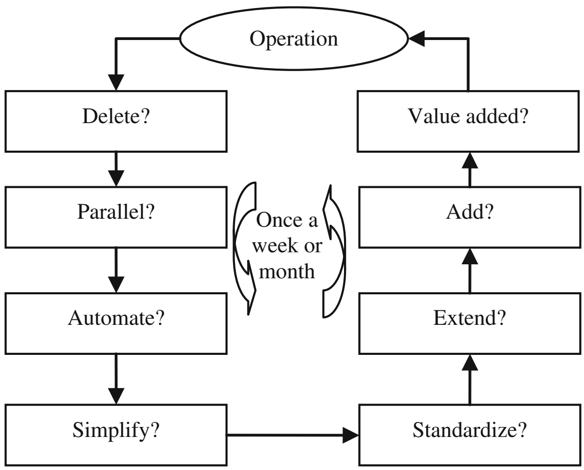

Fig. 77.3 The method to optimize an operation process

Meanwhile, the business process could be optimized once a week or once a month by using these 8steps.

77.3 Case

The casting factory A is a continuous manufacture enterprise. Its enterprise management was disorder and inefficient before its business process was optimized to find an informatization platform by using the HZERP system (Zhou et al. 2008). For example, it was a long time from when the plan was made to when workers began to product in the workshop, which seriously impacted on the production schedule. The business process included in the period could be called "product-prepared" business process, as shown in Fig. 77.4.

In this paper, the "product-prepared" business process was taken as a case, and then the solution was used to decompose and optimize the business process.

77.4 Results and Discussions

According to the first step of the Timeline-Place-Roles method, the previous "product-prepared" business process in the foundry enterprise A was decomposed into 7 activity places, and each place had some activity roles, as show in Fig. 77.5.

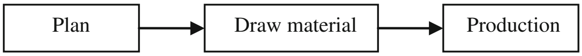

Fig. 77.4 The previous "product-prepared" business process in the company A

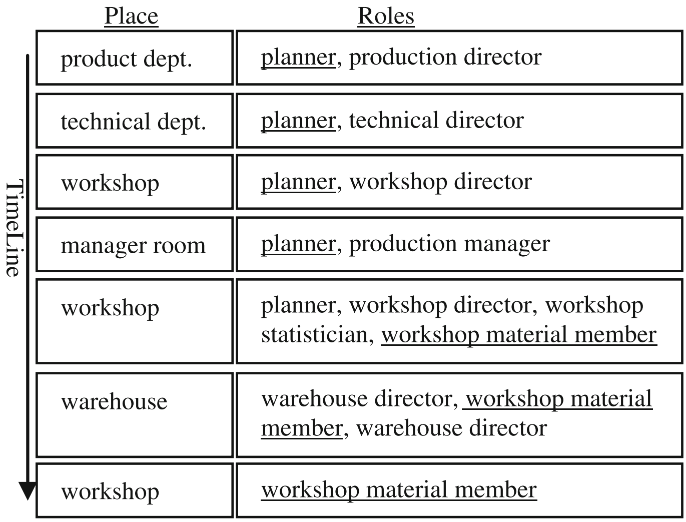

Fig. 77.5 The method to optimize an operation process

This Figure shows that the "planner" and "workshop material member" are the main roles.

According to the second step of the Timeline-Place-Roles method, the activities were decomposed into 14 operation processes, as shown in Table 77.1. The Table records process Serial Number (SN), place, and roles of every operation process. Then work out the average Time Consumed (TC, minutes) of every role in every operation process. For instance, it would cost the planner 5 min (and 5 min back) to send the plan to the workshop and give it to the work director who would spend 1 min to scan and check the plan. Then workshop statistician would summarize into a material requisition according to the plan and the Bill of Material (BOM) of the related product, and it cost would him 30 min.

According to the 14 operation processes in the Table 77.1 and the "8 steps" optimization method of the solution, the previous "product-prepared" business process was optimized into 8 operation processes combining the information base which was formed by the HZERP system in the company A. The optimized "product-prepared" business process was shown in Table 77.2. The three operations (Audit by production director, Audit by technical director and Audit by workshop director) could be paralleled and simplified by the HZERP system; the three roles could audit the plan and sign their names in no order or even at the same time.

From Table 77.2, the company A could optimize its business process according to the information system. Three operations were deleted or replaced by the system automatically. Especially, the operation of summarizing into a material requisition by the workshop statistician was carried out by the MRP subsystem of the HZERP system, which saved time and made the result accurate.

Table 77.1 The operation processes of the previous "product-prepared" business

SN	Operation	Place	Roles	TC(m)
1	Draw up production schedule	Product dept.	Planner	/
2	Audit by production director	Product dept.	Planer, production director	2, 1
3	Audit by technical director	Technical dept.	Planer, technical director	2, 1
4	Audit by workshop director	Workshop	Planer, workshop director	10, 1
5	Audit by production manager	Manager room	Planer, production manager	5, 1
6	Send to workshop	Product dept.	Planer, workshop director	10, 1
7	Summarize into a material requisition	Workshop	Workshop director, workshop statistician	0, 30
8	Audit by workshop director	Workshop	Workshop statistician, workshop director	0, 1
9	Audit by warehouse director	Warehouse	Warehouse director, workshop material member, warehouse director	0, 3, 1
10	Prepare material by warehouse keeper	Warehouse	Warehouse director, warehouse keeper	0, 20
11	Sign warehouse keeper's name	Warehouse	Warehouse keeper	1
12	Carry material to vehicle and sign	Warehouse	Workshop material member	3
13	Retain the inventory on account	Warehouse	Warehouse keeper	10
14	Send material to workshop by vehicle	Workshop	Workshop material member	5

Table 77.2 The optimization of operation processes of the previous "product-prepared" business

SN	Operation	Optimization method	Optimization detail
1	Draw up production schedule	/	/
2	Audit by production director	Parallel, Simplify	Check the plan and sign the name in the HZERP system
2	Audit by technical director	Parallel, Simplify	
2	Audit by workshop director	Parallel, Simplify	
0	Audit by production manager	Delete	An extra step
0	Send to workshop	Automate	Send the plan to the workshop automatically by the HZERP system
3	Summarize into a material requisition	Automate, Standardize	Summarize into a material requisition automatically by the MRP subsystem
4	Audit by workshop director	Parallel, Simplify	Check the plan and sign the name in the HZERP system
4	Audit by warehouse director	Parallel, Simplify	
5	Prepare material by warehouse keeper	/	/
6	Sign warehouse keeper	/	Sign the name in the HZERP system
7	Carry materials to vehicle and sign	/	Sign the name in the HZERP system
0	Retain the inventory on account	Automate	Account inventory automatically after signing warehouse keeper's name
8	Send materials to workshop by vehicle	/	/

Table 77.3 The time consumed (including work and wait) before and after process optimization

Role	TC/Before (m)	TC/After (m)	Proportion of value added (%)
Planner	2 + 2 + 10 + 5 + 10 = 29	0	100
Production director	1	1	0
Technical director	1	1	0
Workshop director	1 + 1 + 0 + 1 + 0 = 3	2	0
Production manager	1	0	100
Workshop statistician	30 + 0 = 30	0	100
Workshop material member	3 + 20 + 1 + 3 + 10 + 5 = 42	3 + 3 + 5 = 11	73.8
Warehouse director	1	1	0
Warehouse keeper	20 + 1 + 3 + 10 = 34	20 + 1 = 21	38.2
Total	112	37	70
Total business duration	2 + 2 + 10 + 5 + 10 + 30 + 1 + 3 + 20 + 1 + 3 + 10 + 5 = 102	1 + 1 + 1 + 20 + 3 + 3 + 5 = 34	66.7

Finally, analysis and contrast with the time consumed (including work time and wait time) before and after the process optimization, the result was shown in Table 77.3. TCB means the time consumed before, and TCA means the time consumed after. The proportion of value added was characterized by the proportion of the time saving, and was equal to (TCB − TCA)/TCB.

Table 77.3 shows that the total TCA was 112 min, while the total TCB was only 37 min with 70 % value added. The total business duration before optimizing process cost 102 min, while the one after optimizing process cost 34 min with 66.7 % value added. The time consumed by the three key roles (planner, workshop statistician and workshop material member) was decreased largely, and the work of the workshop statistician was omitted.

The results proved that the solution could optimize enterprise business process and improve the effect continuously and deepen informatization application to a certain extent, and the effect would be much better combining the usage of the information system. Enterprises could improve the effect continuously and deepen informatization application by using the solution proposed in this paper.

77.5 Conclusion

(1) The relationship among the process optimizing and enterprise informatization was discussed.
(2) A Timeline-Place-Role (TPR) method of decomposing business process into operation processes was proposed.

(3) The “8 steps” value-added method of operation process analysis and continuous optimization based on the value chain was proposed.
(4) The TPR method and “8 steps” method made up a complete set of solution.
(5) Take a business process of a continuous manufacture company as a case, this paper made the case analysis and optimization by using the proposed solution and compared with the time consumed before and after process optimization.
(6) The results proved that the solution could optimize enterprise business process. And the effect would be much better by combining the usage of the information system, which is also a new trend to promote management technological upgrading.

Acknowledgments This study was financially supported by HUST self-determined and innovative research funds for national defense (2011), Fundamental Research Funds for the Central Universities (2011TS039), and Program for New Century Excellent Talents in University (No. NCET-09-0396).

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Chapter 78
An Approach with Nested Partition for Resource-Constrained Project Scheduling Problem

Zhen-yuan Liu and Wen-min Yu

Abstract A time-based nested partition (NP) approach is proposed to solve resource-constrained project scheduling problem (RCPSP) in this paper. In iteration, one activity is selected as the base point of which the finish time interval calculated by CPM is divided into two parts to form two subregions on the basis of the promising region of the last iteration. Then sampling is taken in both subregions and the surrounding region to determine the promising region and aggregate the other as the surrounding region of this iteration so that whether the backtracking or the moving operation being performed is determined. Double justification is also performed in iteration to improve the results. The results of numerical tests on PSPLIB show the effectiveness and time-efficient of the proposed NP method.

Keywords Double justification · Nested partition · RCPSP · Sampling

78.1 Introduction

Since the nineties of the last century, resource-constrained project scheduling problem (RCPSP) has become a standard problem generated by standard project generator ProGen, which forms a resource-constrained project scheduling problem

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E. Qi et al. (eds.), *The 19th International Conference on Industrial Engineering and Engineering Management*, DOI: 10.1007/978-3-642-38391-5_78,

library (Kolisch and Sprecher 1997). Many algorithms have been developed to solve the problem and compare and analyze the results with experiment using the standard problem in the library.

The essence of the resource-constrained project scheduling is to arrange the execute time of each activity in the network under the constraints of resources and precedence relations. There are three kinds of solution method which are optimization (Bianco and Caramia 2012), heuristics (Kolisch 1996) and intelligent algorithm (Kolisch and Hartmann 2006).

Nested Partition is to partition the feasible solution space so that more search efforts can be expanded in the subregions that most likely contain the best solution. One of its important features is its flexibility that it can incorporate many efficient heuristics into its search procedure in order to get better solution. Another one is that parallel computing capacities can be taken advantage of and searching in subregions can be done independently and in parallel with only a little coordination overhead. Therefore, it's usually used to solve large-scale problems (Shi and ölafsson 2000).

In this paper, a time-based Nested Partition Framework is proposed to solve RCPSP, where the operations in NP will be discussed respectively. And the whole framework will be tested on PSPLIB.

78.2 Definition of Problem

The classic RCPSPs can be stated as the following. It's assumed that a single project consists of $j = 1,\ldots, J$ activities with a non-preemptive duration of d_j periods, respectively. Due to technological requirements, precedence relations between some of the activities enforce that an activity $j = 2,\ldots, J$ may not be started before all its immediate predecessors $i \in P_j$ (P_j is the set of immediate predecessors of activity j) have been finished. Without loss of generalization, we can assume that activity 1 is the only start activity and activity J is the only finish activity. K types of renewable resources supplied by the partners will be consumed during the project. It is assumed that the project needs r_{jk} units of resource k to process activity j during every period of its duration. Let A_t be the set of activities being executed in period t.

The capacity of resource k supplied is noted by R_k. The due date of the project is D. With a given D, we can get the earliest finish time e_j and the latest finish time l_j of activity j by using Critical PathMethod (CPM). The time parameters in the problem are all integer valued.

We use a set of continuous decision variables $x_j \in (e_j, l_j) j = 1, \cdots, j$ to be the finish time of activity j. The decision variable can be stated as $X = \{(x_1, x_2, \ldots, x_j) | x_j \in (e_j, l_j), j = 1, \ldots, j\}$.

The model of RCPSP can be presented as follows:

$$\min x_j \tag{78.1}$$

$$s.t.\ \ x_i \le x_j - d_j, \forall i \in P_j, j = 1, \ldots, j \tag{78.2}$$

$$\sum_{j \in A_t} r_{jk} \le R_k, k = 1, \ldots, D \tag{78.3}$$

$$x_j \in Z_+^1, j = 1, \ldots, J \tag{78.4}$$

(78.1) is the objective that minimize the makespan of the problem, (78.2) demonstrates the precedence relation constraints among activities, (78.3) demonstrates the resource constraints, (78.4) demonstrates the natural constraints of each activity's finish time.

78.3 The Generic Nested Partition Framework

The Nested Partition method is partitioning and sampling based strategy. In iteration of the algorithm, the entire solution space is viewed as a union that comprises a promising region and a surrounding region. The four operations of Nested Partition method are as follows.

(1) *Partitioning*: This step is to partition the current most promising region into several subregions and aggregate the remaining regions into the surrounding region. With an appropriate partitioning scheme, most of the good solutions would be clustered together in a few subregions after the partitioning.

(2) *Random Sampling*: Samples are taken from the sub regions and the surrounding region according to some sampling procedure. The procedure should guarantee a positive probability for each solution in a given region to be selected. As we would like to obtain high quality samples, it is often beneficial to utilize problem structure in the sampling procedure.

(3) *Calculation of the Promise Index*: For each region, we calculate the promise index to determine the most promising region. The promise index should be represented as the performance of the objective.

(4) *Moving*: The new most promising region is either a child of the current most promising region or the surrounding region. If more than one region is equally promising, ties are broken arbitrarily. When the new most promising region is the surrounding region, backtracking is performed. The algorithm can be devised to backtrack to either the root node or any other node along the path leading to the current promising region.

78.4 Partition Operation

78.4.1 Definition of Feasible Space and Partition

We know the solution space is

$$X = \{ (x_1, x_2, \ldots, x_j) | x_j \in (e_j, l_j), j = 1, \ldots, j, \\ x_i \le x_j - d_j, \forall i \in P_j, j1, \ldots, J \\ \sum_{j \in A_t} r_{jk} \le R_k, t = 1, \ldots, D, k = 1, \ldots, K.$$

By critical path method (CPM), the earliest finish time e_j and latest finish time l_j of each activity j can be calculated as variable $x_j \in (e_j, l_j)$ with the relaxation of resource constraints.

The whole searching space of the problem without resource-constraints and precedence relations in the space can be described as:

$$\sum : [e_1, l_1] \times [e_2, l_2] \times \ldots \times [e_J, l_J].$$

78.4.2 Partition in the Searching Space

In order to partition the J-dimensional space, an activity is selected as the base point of which feasible time interval is divided.

Different mapping mechanism of selecting the activities and different way to decide the size of subregions as well as the number of the activities being selected once would diverse the partition operation.

Since the time interval change of the activity would influence the time interval of the activities that have precedence relationship with it, activity with more precedence constraints in the network is preferred to make the partition more effective. The end time by initial schedule of the selected activity is chosen as the boundary point to get more precisely definition of the searching space as well as efficiency and concentration of the searching. And only one activity is chosen once. Here such mechanism of partition operation is named as Biased Partition.

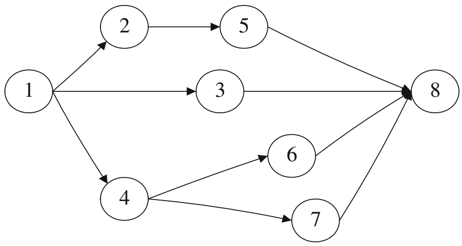

Fig. 78.1 The example activity network

Table 78.1 The parameters of activities in the project shown in Fig. 78.1

j	1	2	3	4	5	6	7	8
d_j	0	4	5	1	8	1	10	0
r_j	0	1	1	3	1	1	1	0
e_j	0	4	5	1	12	2	11	12
l_j	12	16	24	14	24	24	24	24

78.4.3 Subregion Redefinition

By CPM, change of the activity's earliest finish time (EF) would influence the EF of the activities that has direct or indirect successor relationship with it; change of the activity's latest finish time (LF) would influence the LF of the activities that has direct or indirect precedence relationship with it.

Such influence is considered in order to narrow the searching space as possible. Here complete partition operation is demonstrated below. Figure 78.1 shows the network of a project.

In Table 78.1, j represents activity sequence, d_j represents the time of activity j being executed r_j represents the resource consumed units of activity j per period during the activity j being executed e_j and l_j represents the EF and LF of activity j by CPM setting deadline D = 24 respectively. Initial searching space of the project is denoted as follow:

$[0, 12] \times [4, 16] \times [5, 24] \times [1, 14] \times [12, 24] \times [2, 24] \times [11, 24] \times [12, 24]$

Suggest that activity 2 is selected as the base point and the finish time interval of activity 2 is divided into two parts as [4, 10] and [11, 16]. For the part [4, 10], the LF is changed, which results in the modification of the activities that are predecessors or transitive predecessors of activity 2. So the finish time interval of activity 1 and activity 6 are changed into [0, 6] and [11, 16] respectively.

For the part [11, 16], the EF is changed, which results in the modification of the activities that are successors or transitive successors of activity 2. So the finish time interval of activity 5 and activity 8 are changed into [11, 16] and [19, 24].

78.5 Sampling Method

Sampling is to generate schedules. Here two basic schedules generate schemas (SGS) is demonstrated as below.

78.5.1 Series Scheduling Schema

In every stage, an activity is selected to expand a partial schedule, setting its start time and finish time without violating resource constraints and precedence constraints among activities. The procedure is as below.

Definition:

$$\pi R_{kt} := R_k - \sum\nolimits_{j \in A_t} r_{jk}, \forall k, t;$$

$$E_n := \{ j | j \notin C_n, P_j C_n \};$$

Initialization:

$$n = 1, C_n = \varnothing;$$

$$while\ |C_n| < JDostagen$$

$$define\ E_n, \pi R_{kt}, t = 1, \ldots, T, k = 1, \ldots, K;$$

$$j^* = \min_{j \in E_n} \left\{ j | \upsilon(j) = \inf_{i \in E_n} \upsilon(i) \right\};$$

$$e_{j^*} = \max\{ FT_j | j \in P_{j^*} \} + d_{j^*};$$

$$FT_{j^*} = \min \left\{ \begin{array}{l} t | e_{j^*} \le t \le l_{j^*}; \\ r_{j^*k} \le \pi R_{kt'}, t' = t - d_{j^*} + 1, \ldots, t, \forall k \end{array} \right\};$$

$$C_n = C_n \cup \{ j^* \};$$
$$n = n + 1;$$

78.5.2 Parallel Scheduling Schema

In every stage, there is a schedule time to be determined in order to release some resource capacity, and then some activities are selected to do scheduling, setting their start time and finish time without violating constraints. The procedure is as below.

Definition:

$$\pi R_k := R_k - \sum\nolimits_{j \in A_n} r_{jk}, \forall k;$$

$$E_n := \left\{ \begin{array}{c} j | j \notin \{ C_n \cup A_n \}, P_j C_n, \\ r_{jk} \le \pi R_k, \forall k; t_n + d \in [e_j, l_j] \end{array} \right\};$$

$$E_n' := \left\{ \begin{array}{c} j | j \notin \{ C_n \cup A_n \}, P_j C_n, \\ r_{jk} \le \pi R_k, \forall k; t_n + d > l_j \end{array} \right\};$$

$$E_n'' := \left\{ \begin{array}{c} j | j \notin \{ C_n \cup A_n \}, P_j C_n, \\ r_{jk} \le \pi R_k, \forall k; t_n + d < e_j \end{array} \right\};$$

Initialization:

$$n = 1, t_n = 0;$$
$$E_n = \{1\}, A_n = C_n = \varnothing;$$
$$\pi R_k := R_k, \forall k;$$

$$while |C_n \cup A_n| < JDostagen$$

$$(1) t_n = \min\{FT_j | j \in A_{n-1}\};$$

$$A_n = A_{n-1} \backslash \{j | j \in A_{n-1}, FT_j = t_n\};$$

$$C_n = C_{n-1} \cup \{j | j \in A_{n-1}, FT_j = t_n\};$$

$$define \pi R_k, E_n, E'_N, E''_n;$$

$if\ E'_n \neq \varnothing,$
Exit without feasible solution;

$$if\ \ E_n \neq \varnothing, goto(2);$$

$$if\ \ E_n = \varnothing\ and\ \ if\ \ A_n \neq \varnothing,\ goto(1);$$

$$else\ if\ E''_n \neq \varnothing,$$

$$t_n = \min\{e_j - d_j | j \in E''_n\},$$
$$\mathrm{Re}\, define\, E_n,\ goto(2)$$

$$(2)\, j^* = \min_{j \in E_n} \left\{ j | \upsilon(j) = \inf_{i \in E_n} \upsilon(j) \right\};$$

$$ST_{j^*} = t_n, FT_{j^*} = t_n + d_{j*};$$

$$A_n = A_n \cup \{j^*\};$$

$$\mathrm{Re}\, define\, \pi R_k, E_n;$$

$$if\, E_n \neq \varnothing, goto(2);$$

$$else n = n + 1;$$

78.5.3 Sampling Schema

Activities need to be selected in both serial schedule and parallel schedule generate schema. To select appropriate activities and selecting different activities in different schedules can guide to better results and avoid repeated optimal solution. The follow are several sampling schemas.

(1) *Random sampling*: Activities are selected randomly.

(2) *Biased sampling*: Activities are selected according to some mapping mechanism that with a priority rule to get corresponding priority rule $\varphi(j)$ of activity j, the feasible activity is selected by a probability$\Phi(j) = \frac{\varphi(j)}{\sum_{j \in E_n} \varphi(j)}$

(3) *Regret-based biased sampling*: It's similar to biased sampling; the difference is to set a set of regret value $\varphi(j)$ which compares the priority value of activity j with the worst sequence in feasible activity set as $\rho(j) := \max_{i \in E_n} \varphi(j) - \varphi(j)$ where a "minimal" priority rule is employed. Then, the probability for j to be selected is $\Phi(j)$. In these sampling schemas, the priority rules can be the same as those in

$$\Phi(j) = \frac{(\rho(j)+1)^{\alpha}}{\sum_{i \in E_n} (\rho(i)+1)^{\alpha}}$$

78.6 Optimization of the Solution

78.6.1 Promising Region Predefinition

We can get initial schedule from the last iteration that can be taken advantage in this iteration for iteration depth deeper than 1. Therefore, the promising region can be estimated with the finish time in initial schedule of the selected activity where double searching effort would be expanded.

78.6.2 Double Justification

Double Justification is testified to be an efficient method to improve a feasible solution which may be found by taking most kinds of heuristics (Vallsa and Ballest 2005). It consists of a backward pass and a forward pass.

(1) *Backward pass*: in a decreasing order, it is to completing a partial activity sequence by scheduling each activity as late as possible based on a schedule generated by a basic SGS.

(2) *Forward pass* is similar to backward pass in an ascending order.

The double justification process is presented in pseudo code as below.

Definition:

$$S_i = \{j | FT_i + 1 > \ = ST_j\}$$

$$P_i = \{j | ST_i > \ = FT_j + 1\}$$

$$\pi R_{kt} = R_k - \sum_{j \in OL_n} r_{jk}, \forall k, t$$

$$OL_n = \phi$$

BackwardPass:

$$ComputeFT_j, j \in [1, J]$$

descending order activity sequence by FT_j

$$to\ createUL_0 = (p_0, p_1..p_{J-1})$$

$$n = 0, i = 1$$

$$WhileUL_n \neq \phi$$

Begin

$$NewLatestFT = \min ST_{S_i} - 1$$

$$NewFT_i = \max\{t | FT_i \leq t \leq NewLatestFT;$$

$$r_{ik} \leq \pi r_{kt'}, t' = t - d_i + 1, \ldots, t, \forall k\}$$

$$UL_{n+1} = UL_n \backslash p_i$$

$$OL_{n+1} = OL_n \cup p_i$$

$$i = i + 1$$

End
ForwardPass:

$$ComputeST_j, j \in [1, n]$$

ascending order activity sequence by ST_j

$$to\ createUL_0 = (q_1, q_2..q_n)$$

$$n = 0, i = 1$$

$$WhileUL_n \neq \phi$$

Begin

$$NewEaliestST = \max FT_{P_i} + 1$$

$$NewFT_i = \max\{t | FT_i \leq t \leq NewLatestFT;$$
$$r_{ik} \leq \pi r_{kt'}, t' = t - d_i + 1, \ldots, t, \forall k\}$$

$UL_{n+1} = UL_n \backslash q_i$

$OL_{n+1} = OL_n \cup q_i$

$i = i + 1$

End

P_i is the set of immediate predecessors of activity *i*, S_i is the set of immediate successors of activity *i*. OL_n represents union of the activity sequence that has been rearranged at the step *n*. UL_n represents union of the activity sequence that has not been rearranged at the step *n*.

78.7 Moving

For each region δ_j, the promising index as the best performance value within the region is calculated.

$$I(\delta_j) = \min x_j, j = 1, 2 \ldots M + 1$$

Promising region is selected by

$$\delta_j = \arg(\min x_j)$$

If promising region is one of the sub regions then we set $n = n + 1$ as well as $\delta_n = \delta_j$, and δ_n is to be partitioned in the next iteration.

Otherwise, backtrack operation is performed then we set $n = n - 1$ as well as $\delta_n = \delta_{n-1}$, and the promising region in the previous iteration is to be partitioned.

Here the iteration is ended when the schedule number reaches some specific amount.

78.8 Computational Experiment

Based on some basic experiments, we paid more attention to the following configuration of parameters in this NP framework: Biased Sizing, Regret-based Biased Sampling with priority rule LFT. In addition, we employ Double Justification to improve feasible solution. In the iteration we schedules 30 times in both promising region and surrounding region in experiment of 1000 schedules and 120 times in experiment of 5000 schedules.

We employ test sets J120 instance in PSPLIB and make a comparative study as below (Table 78.2)

We can read from the table that NP method performs excellent among algorithms that are not intelligent and good among all the algorithms.

Table 78.2 Average deviation from critical path lower bound-J120

Method	Author	1000	5000
Frog-leaping	Chen and Ling (2012)	34.83	33.2
ACCOS	Chen et al. (2010)	35.19	32.48
Random GA	Mendes (2003)	35.87	33.03
NP	This study	36.14	35.47
ANGEL	Tseng et al. (2006)	36.39	34.49
Improved GA	Alcaraz et al. (2004)	36.53	33.91
Self-adapting GA	Hartmann (2002)	37.19	35.39
BA-FBI	Ziarati et al. (2011)	37.72	36.76
Activity list GA	Hartmann (1998)	39.37	36.74
LFT sampling	Kolisch (1996)	39.60	38.75
Adaptive sampling	Schirmer and Riesenberg (1998)	39.85	38.70

Table 78.3 Computational time of different schedule method of J120

	NP-SGS2	SGS2	NP-SGS1	SGS1	NP-SGS3	SGS3
1080	3.159	3.26	3.929	20.12	3.296	12.09
5400	14.39	14.79	18.63	–	11.65	–

The specification of Lenovo computer used in the experiment is as follow: Intel(R) Core(TM) 2 Duo CPU E7500@2.93 GHz, 2.93 GHz, 1.96 GB. SGS1 represents serial schedule. SGS2 represents parallel schedule. SGS3 represents hybrid schedule. NP-SGS1 represents serial sampling in NP framework.

As Table 78.3 shows, NP method is time efficient especially in serial schedule since it sharply decreases the searching space. For sampling with parallel schedule in NP, though searching space is also decreased, the computing time spent on the other three operations in NP especially the partition operation offsets it.

78.9 Conclusion

The paper shows how the NP framework is applied in the RCPSP.

As a global, open, fast convergence algorithm, NP method can be well applied to the solution of the RCPSP problem. It performs well in getting the minimized makespan of the project especially in greatly reducing the searching time.

Acknowledgments This work has been supported by the Chinese National Science Fund under the Grant 71071062, the Hubei Science Fund under the Grant 2009 CDB242 and the Scientific Research Foundation for the Returned Overseas Chinese Scholars, State Education Ministry of China and Open Foundation of Key Laboratory of Education Ministry for Image Processing and Intelligent Control.

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Chapter 79
An Approximate Dynamic Programming Approach for Computing Base Stock Levels

Hong-zhi He

Abstract This paper studies the classical model for stochastic inventory control, i.e. a finite horizon periodic review model without setup costs. A base-stock policy is well known to be optimal for such systems. The author gives a new heuristic computation procedure for calculating the base-stock levels. The idea is based on approximate dynamic programming. A numerical example is provided to serve as an illustration.

Keywords Approximate dynamic programming · Base-stock policy · Stochastic inventory control

79.1 Introduction

This paper is an attempt to get an approximate solution in stochastic inventory control problems by utilizing approximate dynamic programming. Although what we study in the current paper is the simplest stochastic inventory system where single location and single item are assumed, and with negligible setup costs, the approach we use is of particular significance for solving large-scale problems where multi-item and multi-location are assumed.

The idea is based on approximate dynamic programming. First the next-period optimal value function is approximated by a quadratic polynomial. Then the base stock level from this approximation is computed. After that, three points are taken for the approximate optimal value to be computed, and then the Lagrange method is utilized to get the quadratic polynomial.

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E. Qi et al. (eds.), *The 19th International Conference on Industrial Engineering and Engineering Management*, DOI: 10.1007/978-3-642-38391-5_79,

Using a quadratic polynomial function is reasonable. This is because the optimal value function for the simplest inventory system possesses convexity and hence exhibits a ‘U’ shape.

Base-stock policy is widely used in inventory systems where setup cost is negligible. Such a policy is well known to be optimal for simplest single-item stochastic inventory models (see, for example, Gaver 1959; Zipkin 2000). Although the base-stock levels can be computed recursively by exact dynamic programming, the classical computing procedure is nevertheless arduous. This paper provides a new algorithm for computing such base stock levels. By this algorithm, the computational effort can be greatly cut down, and extension to multi-item, multi-location models is of much possibility.

Literatures in the realm of computation of base-stock levels mainly consider infinite horizon models. Karlin (1960) studied the infinite horizon problem of the most basic type. Zipkin (1989) used an alternative approach to compute the base-stock levels. Roundy and Muckstadt (2000) studied an infinite horizon problem with capacity-limited facility and gave a heuristic computation procedure. Zipkin (2000) gave the solution for a continuous review, infinite horizon problem. Chen and Song (2001) studied an infinite horizon, multiechelon inventory system. Iglehard and Karlin (1962), Srinagesh and Sridhar (2001) and Levi et al. (2007) studied the exact and approximation algorithms for stochastic inventory model with correlated and non-stationary demand. Song and Zipkin (1993) provided both a value iteration and an exact algorithm for computing base stock levels in a fluctuating demand environment. Huh et al. (2009) provided an adaptive algorithm to minimize the long run average cost. There are a few papers addressing finite horizon models, and they mainly use myopic policies as heuristics. See, for example, Lovejoy (1992) and Morton and Pentico (1995). The only exception is Iida and Zipkin (2006), who used a piecewise linear function to approximate the cost function. Their idea is similar to ours.

Surprisingly, literatures for computing finite horizon base-stock levels with quadratic function approximations are nonexistent, although the idea is straightforward. This paper fills into this gap.

79.2 Formulation

This paper considers the simplest inventory system where setup cost is negligible. The inventory policy is implemented on a periodic-review basis. The finite time horizon is assumed to be T periods.

Let $J_t(y)$ represents the optimal value function at time t, x represents the order-up-to level, D_t represents the random customers’ demand during time t and t + 1, $f_t(D_t)$ represents the density function of the demand distribution during period t, $F_t(D_t)$ represents the cumulative distribution function of customers’ demand during period t, p represents penalty cost for one unit of backlogged product during one period, h represents the unit holding cost, c represents the unit purchasing cost, the stochastic inventory control model can be represented as:

$$\begin{aligned} J_t(y) &= \min_{x \geq y} E\{h(x - D_t)^+ + p(D_t - x)^+ \\ &\quad + c(x - y) + J_{t+1}(x - D_t)\} \\ &= \min_{x \geq y} \mathrm{h} \int_0^x (\mathrm{x} - \mathrm{D_t})\mathrm{f_t}(\mathrm{D_t})\mathrm{dD_t} + \mathrm{p} \int_x^\infty (\mathrm{D_t} - \mathrm{x})\mathrm{f_t}(\mathrm{D_t})\mathrm{dD_t} \\ &\quad + \mathrm{c}(\mathrm{x} - \mathrm{y}) + \int_0^\infty \mathrm{J_{t+1}}(\mathrm{x} - \mathrm{D_t})\mathrm{f_t}(\mathrm{D_t})\mathrm{dD_t}. \end{aligned} \tag{79.1}$$

It's well-known that this value function is convex, and the optimal policy is a base stock policy. Computing the base stock level s becomes the key question in this paper. In the end of the last period T, the salvage value function is assumed to be $J_{T+1}(x)$, which is a convex, decreasing and differentiable function in x.

79.3 The Computation Procedure

The computing procedure is described in this section. In the beginning of period T, solve the base stock level. In (79.1), taking derivative over x, one has

$$\mathrm{h} \int_0^x \mathrm{f}_T(\mathrm{D}_T)\mathrm{d}_T - \mathrm{p} \int_x^\infty \mathrm{f}_T(\mathrm{D}_T)\mathrm{dD}_T + \mathrm{c}(\mathrm{x} - \mathrm{y}) + \int_0^\infty \mathrm{J_{T+1}}(\mathrm{x} - {}_T)\mathrm{f_T}(\mathrm{D}_T)\mathrm{dD}_T = 0, \tag{79.2}$$

i.e.

$$hF_T(x) - p(1 - F_T(x)) + c + \int_0^\infty \mathrm{J'_{T+1}}(\mathrm{x} - \mathrm{D}_T)\mathrm{f_T}(\mathrm{D}_T)\mathrm{dD}_T = 0. \tag{79.3}$$

It deduces

$$(\mathrm{h} + \mathrm{p})\mathrm{FT}(\mathrm{x}) = \mathrm{p} - \int_0^\infty \mathrm{J'_{T+1}}(\mathrm{x} - \mathrm{D}_T)\mathrm{f_T}(\mathrm{D}_T)_T - c. \tag{79.4}$$

This equation determines the last-period base stock level s_T, i.e. s_T should satisfy

$$F_T(s_T) = \frac{p - \int_0^\infty \mathrm{J}'_{\mathrm{T}+1}(\mathrm{x} - \mathrm{D}_T)\mathrm{f}_{\mathrm{T}}(\mathrm{D}_T)\mathrm{dD}_T - c}{h + p} \tag{79.5}$$

Now let's interpolate the value function for period T by a quadratic function. Take three points: $y = \left[\frac{s_T}{2}\right]$, $y = \left[\frac{3s_T}{2}\right]$, $y = 2s_T$. For $y = \left[\frac{s_T}{2}\right]$, from base stock policy we have $x = s_T$ at minimum. Value function

$$\begin{aligned} J_T\left(\left[\frac{s_T}{2}\right]\right) &= h\int_0^{s_T}(s_T - D_T)f_T(D_T)dD_T + p\int_{s_T}^{\infty}(D_T - s_T)f_T(D_T)dD_T \\ &\quad + c\left(s_T - \left[\frac{s_T}{2}\right]\right) + \int_0^\infty \mathrm{J}_{\mathrm{T}+1}(s_T - \mathrm{D}_T)\mathrm{f}_{\mathrm{T}}(\mathrm{D}_T)\mathrm{dD}_T. \end{aligned} \tag{79.6}$$

For $y = \left[\frac{3s_T}{2}\right]$, from base stock policy we have $x = \left[\frac{3s_T}{2}\right]$ at minimum. Value function

$$\begin{aligned} J_T\left(\left[\frac{3s_T}{2}\right]\right) &= h\int_0^{\left[\frac{3s_T}{2}\right]}\left(\left[\frac{3s_T}{2}\right] - D_T\right)f_T(D_T)dD_T + p\int_{\left[\frac{3s_T}{2}\right]}^{\infty}\left(D_T - \left[\frac{3s_T}{2}\right]\right)f_T(D_T)dD_T \\ &\quad + \int_0^\infty \mathrm{J}_{\mathrm{T}+1}\left(\left[\frac{3s_T}{2}\right] - \mathrm{D}_T\right)\mathrm{f}_{\mathrm{T}}(\mathrm{D}_T)\mathrm{dD}_T. \end{aligned} \tag{79.7}$$

For $y = 2s_T$, from base stock policy we have $x = 2s_T$ at minimum. Value function

$$\begin{aligned} J_T(2s_T) &= h\int_0^{2s_T}(2s_T - D_T)f_T(D_T)dD_T \\ &\quad + p\int_{2s_T}^{\infty}(D_T - 2s_T)f_T(D_T)dD_T + \int_0^\infty \mathrm{J}_{\mathrm{T}+1}(2s_T - \mathrm{D}_T)\mathrm{f}_{\mathrm{T}}(\mathrm{D}_T)\mathrm{dD}_T. \end{aligned} \tag{79.8}$$

Let a quadratic function $\tilde{J}_{t+1}(y) = a_{t+1}y^2 + b_{t+1}y + c_{t+1}$ be an approximate value function. Put the above three pair of points into the approximate value function, one gets $a_{t+1}, b_{t+1}, c_{t+1}$.

Put $\tilde{J}_{t+1}$ into the dynamic programming equation,

$$\begin{aligned}\bar{J}_t(y) &= \min_{x,x\geq y} \mathrm{E}\{\mathrm{h(x-D_t)^+ + p(D_t-x)^+ + c(x-y) + \tilde{J}_{t+1}(x-D_t)}\}\\ &= \min_{x\geq y} \mathrm{h}\int_0^x (\mathrm{x-D_t})\mathrm{f_t(D_t)dD_t} + \mathrm{p}\int_x^\infty (\mathrm{D_t-x})\mathrm{f_t(D_t)dD_t} + \mathrm{c(x-y)}\\ &\quad + \int_0^\infty \left[\mathrm{a_{t+1}(x-D_t)^2} + b_{t+1}(\mathrm{x-D_t}) + c_{t+1}\right]\mathrm{f_t(D_t)dD_t}.\end{aligned} \tag{79.9}$$

Calculate the function values at three points, then use the Lagrange method to get an interpolation polynomial, and use this polynomial to approximate the value function in (79.1). Solve $\bar{s}_t$ by

$$\mathrm{hF_t(x) - p(1-F_t()) + c} + \int_0^\infty [\mathrm{2a_{t+1}(x-D_t) + b_{t+1}}]\mathrm{f_t(D_t)dD_t} = 0, \tag{79.10}$$

i.e.

$$\mathrm{(h+p)F_t(x) + 2a_{t+1}x = p} + 2\lambda_t \mathrm{a_{t+1} - b_{t+1} - c}. \tag{79.11}$$

One solves $\bar{s}_t$ by the above equation. Then let $y = \left[\frac{\bar{s}_t}{2}\right], \left[\frac{3\bar{s}_t}{2}\right], 2\bar{s}_t$, and compute $\bar{J}_t\left(\left[\frac{\bar{s}_t}{2}\right]\right)$, $\bar{J}_t\left(\left[\frac{3\bar{s}_t}{2}\right]\right)$ and $\bar{J}_t(2\bar{s}_t)$. For $y = \left[\frac{\bar{s}_t}{2}\right]$, $x = s_T$,

$$\begin{aligned}\bar{J}_t\left(\left[\frac{\bar{s}_t}{2}\right]\right) &= h\int_0^{\bar{s}_t} (\bar{s}_t - D_t)f_t(D_t)dD_t + p\int_{\bar{s}_t}^\infty (D_t-\bar{s}_t)f_t(D_t)dD_t + c\left(\bar{s}_t - \left[\frac{\bar{s}_t}{2}\right]\right)\\ &\quad + \int_0^\infty \tilde{\mathrm{J}}_{t+1}(\bar{s}_t - \mathrm{D}_t)\mathrm{f}_t(\mathrm{D_t})\mathrm{dD}_t\\ &= \mathrm{h}\int_0^{\bar{s}_t} (\bar{s}_t - \mathrm{D}_t)\mathrm{f_t(D_t)dD_t} + \mathrm{p}\int_x^\infty (\mathrm{D_t} - \bar{s}_t)\mathrm{f_t(D_t)dD_t} + \mathrm{c}\left(\bar{s}_t - \left[\frac{\bar{s}_t}{2}\right]\right)\\ &\quad + \int_0^\infty [\mathrm{a_{t+1}}(\bar{s}_t - \mathrm{D_t})^2 + b_{t+1}(\bar{s}_t - \mathrm{D_t}) + c_{t+1}]\mathrm{f_t(D_t)dD_t}.\end{aligned} \tag{79.12}$$

For $y = \left[\frac{3\bar{s}_t}{2}\right], x = \left[\frac{3\bar{s}_t}{2}\right]$,

$$\bar{J}_t\left(\left[\frac{3\bar{s}_t}{2}\right]\right) = h\int_0^{\left[\frac{3\bar{s}_t}{2}\right]}\left(\left[\frac{3\bar{s}_t}{2}\right] - D_T\right)f_T(D_T)dD_T + p\int_{\left[\frac{3\bar{s}_t}{2}\right]}^{\infty}\left(D_T - \left[\frac{3\bar{s}_t}{2}\right]\right)f_T(D_T)dD_T$$
$$+ \int_0^{\infty}\tilde{J}_{t+1}\left(\left[\frac{3\bar{s}_t}{2}\right] - D_t\right)f_t(D_t)dD_t$$
$$= h\int_0^{\left[\frac{3\bar{s}_t}{2}\right]}\left(\left[\frac{3\bar{s}_t}{2}\right] - D_t\right)f_t(D_t)dD_t + p\int_{\left[\frac{3\bar{s}_t}{2}\right]}^{\infty}\left(D_t - \left[\frac{3\bar{s}_t}{2}\right]\right)f_t(D_t)dD_t$$
$$+ \int_0^{\infty}\left[a_{t+1}\left(\left[\frac{3\bar{s}_t}{2}\right] - D_t\right)^2 + b_{t+1}\left(\left[\frac{3\bar{s}_t}{2}\right] - D_t\right) + c_{t+1}\right]f_t(D_t)dD_t. \tag{79.13}$$

For $y = 2\bar{s}_t, x = 2\bar{s}_t$,

$$\bar{J}_t(2\bar{s}_t) = h\int_0^{\left[\frac{3\bar{s}_t}{2}\right]}\left(\left[\frac{3\bar{s}_t}{2}\right] - D_T\right)f_T(D_T)dD_T + p\int_{\left[\frac{3\bar{s}_t}{2}\right]}^{\infty}\left(D_T - \left[\frac{3\bar{s}_t}{2}\right]\right)f_T(D_T)dD_T$$
$$+ \int_0^{\infty}\tilde{J}_{t+1}\left(\left[\frac{3\bar{s}_t}{2}\right] - D_t\right)f_t(D_t)dD_t$$
$$= h\int_0^{\left[\frac{3\bar{s}_t}{2}\right]}\left(\left[\frac{3\bar{s}_t}{2}\right] - D_t\right)f_t(D_t)dD_t + p\int_{\left[\frac{3\bar{s}_t}{2}\right]}^{\infty}\left(D_t - \left[\frac{3\bar{s}_t}{2}\right]\right)f_t(D)dD_t$$
$$+ \left[a_{t+1}\left(\left[\frac{3\bar{s}_t}{2}\right] - D_t\right)^2 + b_{t+1}\left(\left[\frac{3\bar{s}_t}{2}\right] - D_t\right) + c_{t+1}\right]f_t(D_t)dD_t. \tag{79.14}$$

Fitting the above three (y, x) pairs into quadratic function $\tilde{J}_t(y) = a_t y^2 + b_t y + c_t$, one gets a_t, b_t and c_t.

One loop is finished. Repeating the above procedure, one gets $\{\bar{s}_t, \bar{J}_t\}$ for $t = T - 1, T - 2, \ldots, 1$.

79.4 A Numerical Example

Let p = 10, c = 3, h = 1, T = 12 and D_t follow a Poisson process with a mean rate $\lambda = 4$. Let $J_{13}(x) = -cx$ be the last period salvage value function. From (79.4), in the beginning of the last period: s_{12} satisfies

$$(1 + 10)\mathrm{F}(s_{12}) = 10. \tag{79.15}$$

Thus it deduces that $s_{12} = 7$. Therefore $\left[\frac{s_{12}}{2}\right] = 3$, $\left[\frac{3s_{12}}{2}\right] = 10$, $2s_{12} = 14$. Inputting y = 3, y = 10, y = 14 into (79.1) one gets $J_{12}(3) = 6.9302$, $J_{12}(10) = -5.0698$ and $J_{12}(14) = -11.9560$.

By using the Lagrange interpolation method one gets

$$\tilde{J}_{12}(y) = 0.1833y^2 - 4.8330y + 19.7794.$$

Inputting the above expression into (79.8), and then taking derivatives over x one gets:

$$hF(x) - p(1 - F(x)) + c + 2a_{12}x + b_{12} - 2a_{12}\int_0^\infty D_{11}f(D_{11})dD_{11} = 0, \tag{79.16}$$

i.e. $(h + p)F(x) + 2a_{12}x = p + 8a_{12} - b_{12} - c$, which deduces 11F (x) + 2 * 0.1833x = 10 + 8 * 0.1833 + 4.8330 − 3. Thus $\bar{s}_{11}$ is solved: $\bar{s}_{11} = 7$.

Inputting y = 3, y = 10, y = 14 into (79.8), one gets: y = 3, x = 7,

$$\tilde{J}_{11}(3) = 1 * \sum_0^7 \frac{(7-k)4^k}{k!}e^{-4} + 10\sum_7^\infty \frac{(k-7)4^k}{k!}e^{-4} + 3 * 4 + \sum_0^\infty \left[a_{12}(7-k)^2 + b_{12}(7-k) + c_{12}\right]\frac{4^k}{k!}e^{-4}.$$

By using Matlab one gets $\tilde{J}_{11}(3) = 41.8583$.

y = 10, x = 10,

$$\tilde{J}_{11}(10) = 1 * \sum_0^{10} \frac{(10-k)4^k}{k!}e^{-4} + 10\sum_{10}^\infty \frac{(k-10)4^k}{k!}e^{-4} + \sum_0^\infty \left[a_{12}(10-k)^2 + b_{12}(10-k) + c_{12}\right]\frac{4^k}{k!}e^{-4}.$$

By using Matlab one gets $\tilde{J}_{11}(10) = 27.8862$.

y = 14, x = 14,

$$\tilde{J}_{11}(14) = 1 * \sum_{0}^{14} \frac{(14-k)4^k}{k!} e^{-4} + 10 \sum_{14}^{\infty} \frac{(k-14)4^k}{k!} e^{-4} + \sum_{0}^{\infty} \left[a_{12}(14-k)^2 + b_{12}(14-k) + c_{12} \right] \frac{4^k}{k!} e^{-4}.$$

By using Matlab one gets $\tilde{J}_{11}(14) = 36.0792$.

By using the Lagrange interpolation method one gets $\tilde{J}_{11}(y) = 0.3677y^2 - 6.7756y + 58.8762$.

The data for the following periods are listed in Table 79.1.

Finally, we solved the base stock level for period 1 is 14. It departs largely from the expected mean of one-period demand ($\lambda = 4$). This is because of the accumulative effect of the relatively high penalty cost. The base stock levels are roughly decreasing over time periods, which validates the intuition that the base stock levels grow as the remaining time horizon grows. The base stock level for period 1 is rather high compared with the mean demand in that period. This is because the holding cost is low compared with the penalty cost.

Table 79.1 Data for periods

t	$\bar{s}_t$	y	x	$\tilde{J}_t(y)$
11	7	3	7	$0.3677y^2 - 6.7756y + 58.8762$
		10	10	
		14	14	
10	8	4	8	$0.3875y^2 - 7.4077y + 63.6730$
		12	12	
		16	16	
9	9	5	9	$0.3516y^2 - 8.3598y + 88.0152$
		14	14	
		18	18	
8	10	5	10	$0.2886y^2 - 7.9682y + 105.5914$
		15	15	
		20	20	
7	11	5	11	$0.2354y^2 - 7.2567y + 120.5217$
		16	16	
		22	22	
6	11	5	11	$0.1914y^2 - 6.4681y + 134.7710$
		16	16	
		22	22	
5	11	5	11	$0.1654y^2 - 5.8599y + 149.9170$
		16	16	
		22	22	
4	10	5	10	$0.1374y^2 - 5.3099y + 165.3747$
		15	15	
		20	20	
3	10	5	10	$0.3122y^2 - 9.6663y + 200.5834$
		15	15	
		20	20	

(continued)

Table 79.1 (continued)

t	$\bar{s}_t$	y	x	$\tilde{J}_t(y)$
2	14	7	14	$0.2739y^2 - 9.2883y + 218.9859$
		21	21	
		28	28	
1	14			

79.5 Conclusion

In this paper, a single item/single location inventory system is studied. A computation procedure is devised, and a numerical example is provided. The computation procedure proves to work effectively. Because the value function in multi-item and multi-location systems can be approximated by a quadratic polynomial, the method in this paper will possibly solve stochastic inventory management problems in such systems approximately. This will be a future research direction for the authors.

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Chapter 80
An Inventory Model Considering Credit Cost and Demand Rate Varying with Credit Value

Zi-quan Long and Ran Gao

Abstract The credit of suppliers is influenced by factors such as quality of products, promptness of delivering, service level, etc. Reduction in credit value can lead to suppliers' loss of profit, and this profit loss is named credit cost. Putting forward the concept of credit cost for the first time, this paper, starting from delivering situation, studied how backorder affects credit cost, established two models considering respectively the existence and absence of communication between suppliers and customers, and under the condition that credit loss affects demand rate, verified the existence of credit cost utilizing numerical calculation.

Keywords Credit cost · Credit value · Demand rate · Inventory model

80.1 Introduction

Costs produced by an inventory system in the operational process, which include ordering cost, holding cost, and backorder cost, are a major criterion for the evaluation of inventory controlling policy (Jie et al. 2011; Zhao and Huang 2008). The above three types of cost vary with respect to change in credit of an inventory company: for instance, price discounts and transaction costs differ due to different credits, and demand rate drops while credit declines (Gupta and Vrat 1986; Henery 1990; Hariga 1994; Pando and Garcia-Laguna 2011). Credit cost, the cost brought about by creditability factors, is the hidden cost incorporated in the three types of cost (Ritchie 1980).

A variety of factors, such as price and quality of goods, transportation cost, delivering situation and service level, can affect the major credit of inventory

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E. Qi et al. (eds.), *The 19th International Conference on Industrial Engineering and Engineering Management*, DOI: 10.1007/978-3-642-38391-5_80,

(Paul et al. 1996; Pando 2011; Zhou and Wang 2009). Assume the ideal condition is that when a supplier provides a certain product to a fixed group of customers, the supplier will not take the initiative to increase its credit (for example by advertising), and consequently the system will be constantly involved in a vicious circle where backorder leads to the drop of credit which subsequently cause the reduction in demand rate. Under such premise, the supplier needs to formulate its optimal inventory policy to achieve maximum operating profit. This paper will analyze how backorder affects credit cost, starting from delivering situations.

80.2 Model Assumptions

The following assumptions are made to simplify the researching model: (1) Initial demand rate is a constant (assume it is 1), and loss of accumulative credit caused by backorder directly affects demand rate; (2) Replenishment is made instantaneously and replenishing ability is infinite, i.e. any amount of replenishment can be achieved promptly; (3) There is no lead time for ordering, i.e. goods are replenished instantaneously when orders are made; (4) backorder is allowed; (5) Ordering time of goods is finite, but the operational process begins and ends without backorder; (6) Price discount is not considered.

Definitions of each notation included in the model are as follows:

H = time span of ordering;
c_1 = inventory holding cost per unit per time span;
c_2 = backorder cost per unit per time span;
c_3 = cost per order;
t_i = time point of backorder;
T_i = time point of ordering;
l_i = time span during which we have inventory in hand in the ith cycle, $l_i = t_i - T_{i-1}$;
L_i = total time span of the ith cycle, $L_i = T_i - T_{i-1}$;
α = credit losing coefficient, i.e. the proportion of people who lose faith in the company when backorder occurs, $\alpha \in [0, 1]$;
P_i = the accumulated credit after the ith cycle, and

$$P_i = 1 - \alpha\left[i - \left(\frac{l_1}{L_1} + \frac{l_2}{L_2} + \frac{l_3}{L_3} + \cdots + \frac{l_i}{L_i}\right)\right];$$

λ_i = demand rate in the ith cycle, $\lambda_i = P_{i-1}\lambda$, where λ is the initial demand rate which is a constant;
Q_i = amount of order at T_{i-1};
s = selling price per unit;
k = purchase price per unit.

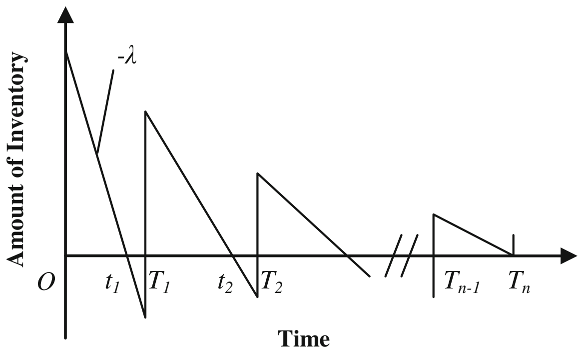

Fig. 80.1 Change of inventory level in Model A

80.3 Mathematical Model

80.3.1 Model A

Assume that there is no exchange of information among customers within a certain cycle of supply, and the customers receive the complete backorder information at the end of the cycle. In this case, demand rate changes in segments with respect to credit. Change of inventory level with respect to time is shown in Fig. 80.1.

The ith order occurs at $t = T_{i-1}$. The storing cost during $T_{i-1} \le t \le T_i$ is:

$$\frac{1}{2}\left[1-(i-1)\alpha+\alpha\left(\frac{l_1}{L_1}+\frac{l_2}{L_2}+\cdots+\frac{l_{i-1}}{L_{i-1}}\right)\right]\lambda c_1 l_i^2;$$

the backorder cost is:

$$\frac{1}{2}\left[1-(i-1)\alpha+\alpha\left(\frac{l_1}{L_1}+\frac{l_2}{L_2}+\cdots+\frac{l_{i-1}}{L_{i-1}}\right)\right]\lambda c_2 (L_i-l_i)^2;$$

and the cost per order is c_3.

Then the total cost during $T_{i-1} \le t \le T_i$ is:

$$\begin{aligned} C(L_i) &= \frac{1}{2}\left[1-(i-1)\alpha+\alpha\left(\frac{l_1}{L_1}+\frac{l_2}{L_2}+\cdots+\frac{l_{i-1}}{L_{i-1}}\right)\right]\lambda c_1 l_i^2 \\ &\quad +\frac{1}{2}\left[1-(i-1)\alpha+\alpha\left(\frac{l_1}{L_1}+\frac{l_2}{L_2}+\cdots+\frac{l_{i-1}}{L_{i-1}}\right)\right]\lambda c_2 (L_i-l_i)^2+c_3 \end{aligned} \tag{80.1}$$

At the end of the ith cycle, the accumulated credit of the supplier is:

$$P_i = 1-\alpha\left[i-\left(\frac{l_1}{L_1}+\frac{l_2}{L_2}+\frac{l_3}{L_3}+\cdots+\frac{l_i}{L_i}\right)\right]$$

Total cost within the time span H is:

$$TC = C(L_1) + C(L_2) + \cdots + C(L_n),$$

and total revenue is:

$$TI = (s - k)\sum_{i=1}^{n} Q_i,$$

thus total profit is:

$$TP = TI - TC.$$

Since TP is a function of t_i, T_i and n, the above problem can be written as the following nonlinear programming problem:

$$\begin{aligned} & \max TP(n, l_i, L_i) \\ s.t.\quad & l_i \le L_i \\ & l_n = L_n \\ & L_1 + L_2 + \cdots + L_n = H \\ & L_i \ge 0,\ l_i \ge 0 \end{aligned} \tag{80.2}$$

80.3.2 Model B

Assume that there is exchange of information among the customers within a certain cycle of supply, and each customer possesses complete information. In this case, demand rate changes continuously with respect to credit. Change of inventory level with respect to time is shown in Fig. 80.2.

The ith order occurs at $t = T_{i-1}$. The storing cost during $T_{i-1} \le t \le T_i$ is:

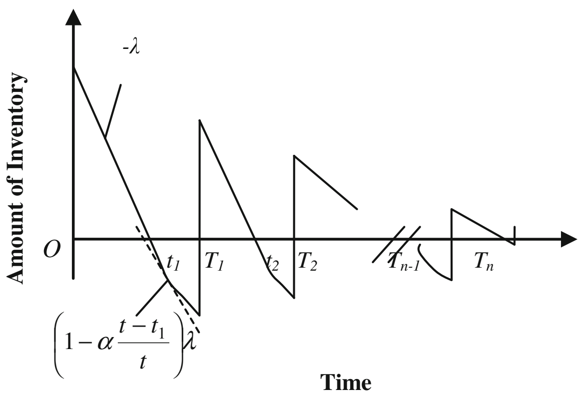

Fig. 80.2 Change of inventory level in Model B

$$\frac{1}{2}\left[1-(i-1)\alpha+\alpha\left(\frac{l_1}{L_1}+\frac{l_2}{L_2}+\cdots+\frac{l_{i-1}}{L_{i-1}}\right)\right]\lambda c_1 l_i^2;$$

the backorder cost is:

$$\lambda c_2\int_{t_i}^{T_i}(T_i-t)\left(1-i\alpha+\alpha\frac{l_1}{L_1}+\alpha\frac{l_2}{L_2}+\cdots+\alpha\frac{l_i}{t-T_{i-1}}\right)dt$$

and the cost per order is c_3.

Then the total cost during $T_{i-1}\leq t\leq T_i$ is:

$$\begin{aligned}C(L_i)=&\frac{1}{2}\left[1-(i-1)\alpha+\alpha\left(\frac{l_1}{L_1}+\frac{l_2}{L_2}+\cdots+\frac{l_{i-1}}{L_{i-1}}\right)\right]\lambda c_1 l_i^2+\\&\lambda c_2\int_{t_i}^{T_i}(T_i-t)\left(1-i\alpha+\alpha\frac{l_1}{L_1}+\alpha\frac{l_2}{L_2}+\cdots+\alpha\frac{l_i}{t-T_{i-1}}\right)dt+c_3\end{aligned}\tag{80.3}$$

At the end of the ith cycle, the accumulated credit of the supplier is:

$$P_i=1-\alpha\left[i-\left(\frac{l_1}{L_1}+\frac{l_2}{L_2}+\frac{l_3}{L_3}+\cdots+\frac{l_i}{L_i}\right)\right].$$

Total cost within the time span H is:

$$TC=C(L_1)+C(L_2)+\cdots+C(L_n)$$

and total revenue is $TI=(s-k)\sum_{i=1}^{n}Q_i$, thus the total profit is $TP=TI-TC$. Same as Model A, it is a nonlinear programming problem.

80.4 Example of Calculation

Here is a specific example of calculation. The numerical values of the systems factors are as follows: $c_1=5$; $c_2=2$; $c_3=2000$; H = 30; $\lambda=200$; $s=130$; and $k=100$.

First, let us consider the situation when $n=2$, i.e., there are two orders within a fixed time period. *LINGO* is used to solve the decision making problem with the value of α varying, and the results are demonstrated in the Table 80.1.

We can observe from Table 80.1 that: 1. The difference between L_1^* and l_1^* decreases as α increases, which indicates that the more stringent are people's requirement to the company, the less backorder will occur; for instance, backorder can lead to considerable loss of customers when a company is facing numerous competitors, hence the company will reduce backorder to the greatest extent; and vice versa. 2. TP^* drops as α rises. When $\alpha=0$, backorder will not cause loss of credit, and this is indeed the inventory model in which credit cost is not considered.

Table 80.1 Sensitivity analysis about α

α	l_1^*		L_1^*		TP^*	
	Model A	Model B	Model A	Model B	Model A	Model B
1	6.9735	8.6109	22.5300	21.4670	63701.16	40458.38
0.9	6.9666	8.4700	22.6835	21.8280	64879.24	43443.88
0.8	6.9501	8.3071	22.8092	22.1378	66074.18	46587.89
0.7	6.9267	8.1275	22.9139	22.4010	67282.84	49874.96
0.6	6.8982	7.9355	23.0023	22.6225	68503.01	53291.80
0.5	6.8657	7.7342	23.0779	22.8073	69733.10	56827.15
0.4	6.8300	7.5265	23.1432	22.9602	70971.95	60471.61
0.3	6.7919	7.3144	23.2001	23.0857	72218.67	64217.29
0.2	6.7517	7.0994	23.2500	23.1876	73472.58	68057.56
0.1	6.7099	6.8832	23.2941	23.2692	74733.17	71986.77
0.0	6.6667	6.6667	23.3333	23.3333	76000.00	76000.00

As α increases from 0 to 1, TP^* declines, and the amount of its reduction is in fact the cost defrayed by the company owing to reduced credit, i.e., the credit cost. 3. When the value of α is fixed, the credit cost in model B is generally larger than that in model A, and this is due to the loss brought about by dissemination of information.

Next, let us consider the situation when $n \geq 3$, i.e., there are more than two orders within a fixed time period. *LINGO* is used to solve the problem with the value of n or α varying, and the results are showed in the Table 80.2.

We can see from Table 80.2 that: 1. When α is fixed and n ascends from 2 to 4, total profit rises. 2. For a fixed value of α, relative credit cost does not increase regularly with the rise of n, but depends on the value of α. When α exceeds the critical point, the opposite situation will occur.

Table 80.2 TP^* and relative credit cost when n or α varies

n	2		3		4	
α	TP^*	Relative credit cost	TP^*	Relative credit cost	TP^*	Relative credit cost
1	63701.16	0.1618	79855.07	0.3218	91820.71	0.3089
0.9	64879.24	0.1463	81041.56	0.3117	92732.61	0.3021
0.8	66074.18	0.1306	82241.15	0.3016	93713.33	0.2947
0.7	67282.84	0.1147	83572.40	0.2903	94744.21	0.2869
0.6	68503.01	0.0986	87004.28	0.2611	95183.13	0.2836
0.5	69733.10	0.0825	91059.03	0.2267	98334.33	0.2599
0.4	70971.95	0.0662	95762.20	0.1867	102209.2	0.2308
0.3	72218.67	0.0498	100823.7	0.1437	103807.6	0.2187
0.2	73472.58	0.0333	106182.1	0.0982	109464.3	0.1762
0.1	74733.17	0.0167	111822.3	0.0503	121840.6	0.0830
0.0	76000.00	–	117750.0	–	132869.6	–

Note Credit cost is TP^* -76000, and relative credit cost is the ratio of credit cost to 76000

80.5 Conclusion

This paper proposed for the first time the concept of credit cost, analyzed how backorder affects credit cost starting with delivering conditions, considered the influence of credit loss to demand rate, and derived an appropriate model which verified the existence of credit cost with specific numerical calculation. The result indicates that suppliers will reduce backorder while the credit losing coefficient α increases; less profit will be achieved in models which take credit cost into consideration compared with those do not, and the reduction in profit is in fact credit cost; rate of change in credit cost descend gradually as α increases; besides, when α is the same, the credit cost in model B is generally larger than that in model A owing to the fact that concealing backorder information will reduce credit cost.

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Chapter 81
An *M/M/1* Queue System with Single Working Vacation and Impatient Customers

Xiao-ming Yu, De-an Wu, Lei Wu, Yi-bing Lu and Jiang-yan Peng

Abstract In this paper, an *M/M/1* queueing system with a single working vacation and impatient customers is considered. In this system, the server has a slow rate to serve during a working vacation and customers become impatient due to a slow service rate. The server waits dormant to the first arrival in case that the server comes back to an empty system from a vacation, thereafter, opens a busy period. Otherwise, the server starts a busy period directly if the queue system has customers. The customers' impatient time follows independently exponential distribution. If the customer's service has not been completed before the customer becomes impatient, the customer abandons the queue and doesn't return. The model is analyzed and various performance measures are derived. Finally, several numerical examples are presented.

Keywords Impatient customers · *M/M/1* queue · Probability generating functions · Single working vacation

81.1 Introduction

Queueing systems with customer impatience such as hospital emergency rooms handling critical patients, and inventory systems that store perishable goods, is very popular. Due to their potential application, many authors are interest in studying the queueing systems with impatient customers and treat the impatience

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E. Qi et al. (eds.), *The 19th International Conference on Industrial Engineering and Engineering Management*, DOI: 10.1007/978-3-642-38391-5_81,

phenomenon by various assumptions. The first to analyze queueing systems with impatient customers seems to be Palm's pioneering work (1953) by considering the $M/M/c$ queue, where the waiting times is assumed to be independent exponential distribution. Daley (1965) studied the GI/G/1 queue with impatient customers, in which customers may abandons the system before starting or completing their service when they have to wait too long. And these results are extended by several authors in many different directions. A customer abandons the queue when he has a long wait already experienced, or a long wait anticipated upon arrival, for example Takacs (1974), Baccelli et al. (1984), Boxma and de Waal (1994), Van Houdt et al. (2003), and Yue and Yue (2009). Recently, the queueing models with server vacation and impatient customers are analized by Altman and Yechiali (2006) .

This work is supported by the Fundamental Research Funds for the Central Universities, No. ZYGX2010J111, No. ZYGX2011J102, and Yunnan Provincial Natural Science Foundation of China under Grant No. 2011FZ025.

In 2002, A class of semi-vacation policies had been introduced by Servi and Finn (2002). In this system the server don't completely stop service but works at a lower rate during a vacation. This system is called a working vacation (WV) system. The vacation time is assumed to be exponentially distributed. The service times during a regular service period and during a working vacation follow exponential distribution but with different rates. Zhao et al. (2008) ultilize the quasi birth and death process and the matrix-geometric solution method to study an M/M/1 queueing system with a single working vacation and obtain various performance measures. An M/G/1 queue with multiple working vacations has been studied by Wu and Takagi (2006). In addition, many authors extended these results such as Baba (2005), Li et al. (2009).

However, there are few literatures which take customers' impatient during a working vacation into consideration. An M/M/1 queueing system with working vacations and impatient customers is considered by Yue and Yue (2011). We extend the research in Yue and Yue 2011 to an M/M/1 queueing system with a single working vacation and impatient customers. For practical application, the single working vacation policy has been widely used in managing science. When the system has relatively few the number of customers, it becomes important to economize operation cost and energy consumption, so the system needs to work at a lower rate operation state. The model (Yue and Yue 2011) is one case of our analysis. We analyze the queueing system where the server has a slow rate to serve during a working vacation and customers become impatient due to a slow service rate in this paper. The server waits dormant to the first arrival in case that the server comes back to an empty system from a vacation, thereafter, opens a busy period. Otherwise, the server starts a busy period directly if the queue system has customers. The customers' impatient time follows independently exponential distribution. If the customer's service has not been completed before the customer becomes impatient, the customer abandons the queue and doesn't return.

We organize the rest of this paper as follows: the model description is given in Sect. 81.2. Then we derive the balance equations for the system. A differential equation for $G_0(z)$ is obtained, where $G_0(z)$ is the generating function of the queue size when the server is on vacation. It is easy to calculate the fractions of time the server being in working vacation or busy period. Various performance measures including the mean system size, the mean sojourn time of a customer served is obtained. Section 81.3 gives are some numerical results.

81.2 Analysis of the Model

81.2.1 Description of the Model

We study an M/M/1 queue with a single working vacation and impatient customers. We assume that arrival process follows Poisson proccess with parameter λ, and the rule of serving is on a first-come first-served (FCFS) basis. If the server returns from a working vacation to find the system empty, he waits dormant to the first arrival thereafter and open a busy period. The working vacation follows exponential distribution with parameter γ, and the service times during a service period and a working vacation follow exponential distribution with parameters μ_b and μ_v, respectively, where $\mu_b > \mu_v$. During the working vacation, customers become impatient and the impatient times follows exponential distribution with parameter ξ. If the customer's service has not been completed before the customer becomes impatient, the customer abandons the queue and doesn't return.

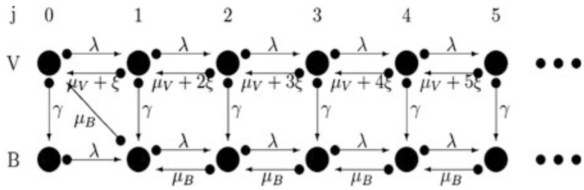
Remark 1. If $\mu_v = 0$, the current model becomes the M/M/1 queueing model which has a single vacation and impatient customers, and was studied by Altman and Yechiali (2006). If $\xi = 0$, the current model has a single working vacation, it was studied by Zhao et al. (2008).

81.2.2 Balance Equations of the Model

The total number of customers in the system and the number of working servers are denoted by L and J, respectively. In other words, when $J = 0$. The server is in a working vacation, and when $J = 1$, the server is in a service period. Then, the pair $\{J, L\}$ constructs a continuous-time Markov process with transition-rate diagram shown in Fig. 81.1. Here, the steady-state transition probabilities are defined by $P_{jn} = P\{J = j, L = n\}$. $j = 0, 1; n = 0, 1, 2, \ldots$.

Then, we can get the set of balance equations as follows:

Fig. 81.1 State transition rate diagram



$$j=0\begin{cases} n=0 & (\gamma+\lambda)P_{00}=(\xi+\mu_v)P_{01}+ \\ & \mu_b P_{11} \\ n\geq 1 & (\lambda+\gamma+\mu_v+n\xi)P_{0n}= \\ & \lambda P_{0,n-1}+[\mu_v+(n+1)\xi]P_{0,n+1}, \end{cases} \tag{81.1}$$

$$j=1\begin{cases} n=0 & \lambda P_{10}=\gamma P_{00} \\ n\geq 1 & (\lambda+\mu_b)P_{1n}=\lambda P_{1,n-1}+ \\ & \gamma P_{0n}+\mu_b P_{1,n+1}. \end{cases} \tag{81.2}$$

The probability generating functions (PGFs) is defined by

$$G_j(z)=\sum_{n=0}^{\infty}P_{jn}z^n, \quad j=0,1.$$

Then, multiplying (81.1) by z^n, summing over n, and rearranging terms, we get

$$\left[\lambda z^2-(\lambda+\gamma+\mu_v)z+\mu_v\right]G_0(z)+\xi z(1-z)G_0'(z)=\mu_v P_{00}(1-z)-\mu_b P_{11}z \ , \tag{81.3}$$

where $G_0'(z)=\frac{dG_0(z)}{dz}$. We also use the same way and obtain from (81.2)

$$\left[\lambda z^2-(\lambda+\mu_b)z+\mu_b\right]G_1(z)+\gamma z G_0(z)=\mu_b P_{10}(1-z)+\mu_b P_{11}z. \tag{81.4}$$

Remark 2.

(1) Letting $\mu_v=0$ in (81.3), we get

$$(\lambda+\gamma)G_0(z)+\xi z G_0'(z)=\lambda z G_0(z)+\xi G_0'(z)+\mu_b P_{11}. \tag{81.5}$$

This agrees with Altman and Yechiali (2006) (see (5.3), p. 274).

(2) Letting $\xi=0$ in (81.4), we get the $M/M/1$ with a single working vacation. This agrees with Zhao et al. (2008).

81.2.3 Solution of the Differential Equation

For $z \neq 0$ and $z \neq 1$, (81.3) can be written as follows:

$$G_0'(z) + \left[-\frac{\lambda}{\xi} - \frac{\gamma}{\xi(1-z)} + \frac{\mu_v}{\xi z}\right] G_0(z) = \frac{\mu_v P_{00}}{\xi z} - \frac{\mu_b P_{11}}{\xi(1-z)}. \tag{81.6}$$

Multiplying both sides of (81.6) by

$$e^{-\frac{\lambda}{\xi}z}(1-z)^{\frac{\gamma}{\xi}} z^{\frac{\mu_v}{\xi}},$$

we get

$$\frac{d}{dz}\left[e^{-\frac{\lambda}{\xi}z}(1-z)^{\frac{\gamma}{\xi}} z^{\frac{\mu_v}{\xi}} G_0(z)\right] = \frac{1}{\xi}\left(\frac{\mu_v P_{00}}{z} - \frac{\mu_b P_{11}}{1-z}\right) e^{-\frac{\lambda}{\xi}z}(1-z)^{\frac{\gamma}{\xi}} z^{\frac{\mu_v}{\xi}}. \tag{81.7}$$

Integrating from 0 to z we have

$$G_0(z) = \frac{-\mu_b P_{11} k_1(z) + \mu_v P_{00} k_2(z)}{\xi e^{-\frac{\lambda}{\xi}z}(1-z)^{\frac{\gamma}{\xi}} z^{\frac{\mu_v}{\xi}}} \tag{81.8}$$

where

$$k_1(z) = \int_0^z e^{-\frac{\lambda}{\xi}x}(1-x)^{\frac{\gamma}{\xi}-1} x^{\frac{\mu_v}{\xi}} dx,$$

$$k_2(z) = \int_0^z e^{-\frac{\lambda}{\xi}x}(1-x)^{\frac{\gamma}{\xi}} x^{\frac{\mu_v}{\xi}-1} dx.$$

Equation (81.8) expresses $G_0(z)$ in terms of P_{00} and P_{11}. Also, from (81.4), $G_1(z)$ is a function of $G_0(z)$, P_{00}, P_{11}. Thus, once P_{00} and P_{11} are calculated, $G_0(z)$ and $G_1(z)$ are completely determined. We derive the probabilities P_{00}, P_{11} and the mean system sizes in the next subsection.

81.2.4 Derivation of Various Performance Measures

Let $P_{j.} = G_j(1) = \sum_{n=0}^{\infty} P_{jn}$ and $E[L_j]. = G_j'(1) = \sum_{n=0}^{\infty} nP_{jn}$ $j = 0, 1, \ldots.$ Then from (81.3) we get

$$\mu_b P_{11} = \gamma G_0(1) = \gamma P_{0.}. \tag{81.9}$$

From (81.8), we have

$$G_0(1) = \frac{e^{\frac{\lambda}{\xi}}}{\xi}[-\mu_b P_{11} k_1(1) + \mu_v P_{00} k_2(1)] \times \lim_{z \to 1}(1-z)^{-\frac{\gamma}{\xi}}, \tag{81.10}$$

since $G_0(1) = P_{0.} = \sum_{n=0}^{\infty} P_{0n} > 0$,

and $\lim_{z \to 1}(1-z)^{-\frac{\gamma}{\xi}} = \infty$, we must have

$$-\mu_b P_{11} k_1(1) + \mu_v P_{00} k_2(1) = 0$$

implying that

$$P_{00} = \frac{\mu_b P_{11} k_1(1)}{\mu_v k_2(1)} = \frac{\gamma G_0(1) k_1(1)}{\mu_v k_2(1)}. \tag{81.11}$$

And (81.4) can be written as

$$G_1(z) = \frac{\gamma z G_0(z) + \mu_b P_{10} z - \mu_b P_{11} z - \mu_b P_{10}}{(\lambda z - \mu_b)(1-z)}. \tag{81.12}$$

By using L'Hopital rule, we derive

$$G_1(1) = \frac{\mu_b P_{10} + \gamma G_0'(1)}{\mu_b - \lambda}, \tag{81.13}$$

implying that

$$E[L_0] = G_0'(1) = \frac{\mu_b - \lambda}{\gamma} P_1 - \frac{P_{00}}{\lambda} \mu_b. \tag{81.14}$$

On the other hand, from (81.3),

$$E[L_0] = \lim_{z \to 1} G_0'(z) = \frac{(\mu_v - \lambda) G_0(1) + \gamma G_0'(1) - \mu_v P_{00}}{-\xi}, \tag{81.15}$$

implying that

$$G_0'(1) = \frac{(\lambda - \mu_v) G_0(1) + \mu_v P_{00}}{\gamma + \xi}. \tag{81.16}$$

Equating the two expressions (81.14) and (81.16) for $E[L_0]$, and using $1 = P_0 + P_1$, we get

$$G_0(1) = \frac{\left(\lambda \xi \mu_b + \lambda \gamma \mu_b - \xi \lambda^2 - \gamma \lambda^2\right) \mu_v k_2(1)}{\eta_1 + \eta_2}, \tag{81.17}$$

$$P_{00} = \frac{\gamma k_1(1)}{\mu_v k_2(1)} G_0(1), \tag{81.18}$$

where

$$\eta_1 = \left(\lambda \xi \mu_b + \lambda \gamma \mu_b - \lambda \gamma \mu_v - \xi \lambda^2\right) \mu_v k_2(1)$$
$$\eta_2 = \left(\mu_b \gamma^2 + \gamma \xi \mu_b + \lambda \gamma \mu_v\right) \gamma k_1(1)$$

From (81.12) we have

$$E[L_1] = \frac{\eta_3}{2(\mu_b - \lambda)^2}, \tag{81.19}$$

where

$$\eta_3 = (\mu_b - \lambda)\gamma G_0^{''}(1) + 2\gamma\mu_b G_0^{'}(1) + 2\gamma\mu_b P_{00}.$$

From (81.3) we get

$$G_0^{''}(1) = \frac{2\lambda G_0(1) + 2(\lambda - \gamma - \xi - \mu_v)G_0^{'}(1)}{\gamma + 2\xi}. \tag{81.20}$$

Thus, the mean system size

$$E[L] = E[L_0] + E[L_1]. \tag{81.21}$$

From (81.14), the necessary and sufficient condition for stability $\lambda < \mu_b$, for otherwise $E[L_0] = -P_{00} < 0$.

81.2.5 Sojourn Times

Denote S the total sojourn time of a customer in the system, which is measured from the moment of arrival to departure, including completion of service and a result of abandonment. By using Little's law,

$$E[S] = \frac{E[L]}{\lambda} = \frac{E[L_0] + E[L_1]}{\lambda} \tag{81.22}$$

Denote S_{served} the total sojourn time of a customer who completes his service. We note that$S_{served}$is more important porfermance measure. Denote S_{jn} the conditional sojourn time of a customer who does not leave the system, and (j, n) is the state on his arrival. Evidently, $E[S_{1n}] = (n+1)/\mu$, but this is for $n = 0, 1, 2, \ldots$ rather than for $n \geq 1$ in (81.15).

Now, we derive $E[S_{0n}]$ by using the method used by Altman and Yechiali (2006), when $J = 0$, for $n \geq 1$,

$$E[S_{0n}] = \frac{\gamma}{\theta_{n+1}}\left(\frac{1}{\theta_{n+1}} + E[S_{1n}]\right) + \frac{\lambda}{\theta_{n+1}}\left(\frac{1}{\theta_{n+1}} + E[S_{0n}]\right) + \frac{n\xi + \mu_v}{\theta_{n+1}}\left(\frac{1}{\theta_{n+1}} + E[S_{0,n-1}]\right), \tag{81.23}$$

where

$$\theta_n = \gamma + \lambda + \mu_v + n\xi$$

for $n = 0, 1, 2, \ldots$. The second term above is derived from the fact that a new arriving customer does not influence the sojourn time of a customer present in the system. The probability $n/(n+1)$in the third term comes from the fact that when one of the $n+1$ waiting customers abandons, our customer is not the one to leave.

Then,

$$[\gamma + (n+1)\xi + \mu_v]E[S_{0n}] = \frac{\theta_n}{\theta_{n+1}} + \frac{\gamma(n+1)}{\mu_b} + (n\xi + \mu_v)E[S_{0,n-1}]. \tag{81.24}$$

We also have

$$E[S_{00}] = \frac{\lambda}{\theta_1}\left(\frac{1}{\theta_1} + \frac{1}{\mu_b}\right) + \frac{\lambda}{\theta_1}\left(\frac{1}{\theta_1} + E[S_{00}]\right) + \frac{\mu_v}{\theta_1^2}, \tag{81.25}$$

implying that

$$E[S_{00}] = \frac{1}{\gamma + \xi + \mu_v}\left(\frac{\theta_0}{\theta_1} + \frac{\gamma}{\mu_b}\right). \tag{81.26}$$

Iterating (81.23) we obtain, for $n \geq 1$,

$$E[S_{0n}] = \frac{1}{\gamma + (n+1)\xi + \mu_v}\left[\frac{\theta_n}{\theta_{n+1}} + \frac{(n+1)\gamma}{\mu_b}\right] + \sum_{i=1}^{n}\left\{\frac{1}{\gamma + (i+1)\xi + \mu_v} \times \left[\frac{\theta_i}{\theta_{i+1}} + \frac{(i+1)\gamma}{\mu_b}\right] \times \prod_{j=i}^{n}\frac{j\xi + \mu_v}{\gamma + (j+1)\xi + \mu_v}\right\}. \tag{81.27}$$

Finally, we use the expression for $E[S_{1n}]$ and drive

$$E[S_{served}] = \sum_{n=0}^{\infty} P_{1n}E[S_{1n}] + \sum_{n=0}^{\infty} P_{0n}E[S_{0n}]. \tag{81.28}$$

implying that

$$E[S_{served}] = \frac{E[L_1] + P_{1.}}{\mu_b} + \sum_{n=0}^{\infty} P_{0n}E[S_{0n}]. \tag{81.29}$$

But the first sum in (81.28) starts from $n = 0$, it's different from [15].

81.3 Numerical Results

In this section, we show the numerical examples for the results obtained in Sect. 81.2.4. The effectes of μ_v and ξ on $E[L_0]$ and $E[L]$ in (81.14) and (81.21) are shown in Fig. 81.2. Evidently, with μ_v increaseing, namely, the server works faster and

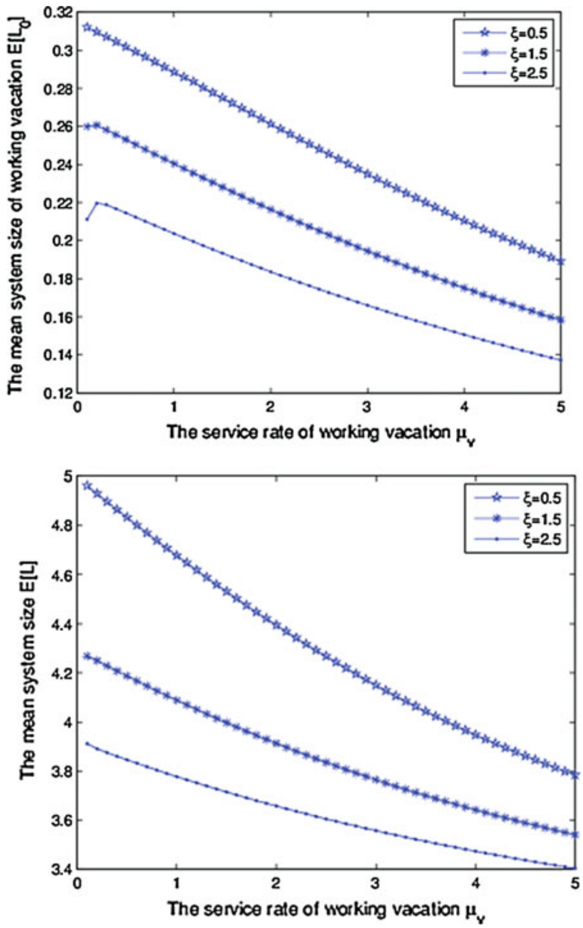


Fig. 81.2 The relation of $E[L_0]$ and $E[L]$ with ξ and μ_v

faster, the mean system size of working vacation $E[L_0]$ and the mean system size $E[L]$ decreases when ξ is fixed. We also find that if ξ is smaller, $E[L_0]$ and $E[L]$ are bigger. From the numerical analysis, the influence of parameters on the performance measures in the system is well demonstrated. The results are suitable to practical situations.

81.4 Conclusions

In this paper, we have studied M/M/1 queueing systems with a single working vacation and impatient customers. In this system, the server has a slow rate to serve during a working vacation and customers become impatient due to a slow service rate. The server waits dormant to the first arrival in case that the server comes back to an empty system from a vacation, thereafter, opens a busy period. Otherwise, the server starts a busy period directly if the queue system has customers. The customers' impatient time follows independently exponential distribution. If the customer's service has not been completed before the customer becomes impatient, the customer abandons the queue and doesn't return. The probability generating functions of the number of customers in the system is derived and the corresponding mean system sizes are obtained when the server was both in a service period and in a working vacation. Also, we have obtained closed-form expressions for other performance measures, such as the mean sojourn time when a customer is served.

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Chapter 82
Analysis of Bank Queueing Based on Operations Research

Liang Li, Jia-lin Wu and Jin-xiang Ding

Abstract This paper considers the bank queueing problem based on M/M/n model. Through the analysis of the special situation of input distribution function and loss of customer, this paper proposes segmented λ input model and the losing customer queueing model. With the actual data collected from the bank, the calculation of the probability of losing customer provides a suggestion for the bank to further improve.

Keywords Changeable customer arrival rate · Changeable input rate · Impatient customer · Queueing model · Stable distribution

82.1 Introduction

With the development of economy, modern finance has become an essential part of the society. Bank, the main body of financial industry, has also become one of the most important service systems. Queueing is a common phenomenon in our daily life, the queueing problems in the bank is also a hot issue that is very much concerned. The queueing makes much contribution to the loss of customers which followed the loss of money. So how to solve the queueing problem efficiently and economically becomes more and more vital (Fan and Yuan 2005).

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E. Qi et al. (eds.), *The 19th International Conference on Industrial Engineering and Engineering Management*, DOI: 10.1007/978-3-642-38391-5_82,

82.2 Queueing Model of the Bank

The queueing theory is a mathematical study of waiting lines, or queues. The classical theory enables mathematical analysis of several related processes, including the arrival process, the queue's discipline, and servers. This paper adopted the data collected form a network of major commercial bank and constructed our system based on M/M/n (Jiang and Yang 2009) model.

82.2.1 The Arrival Process

82.2.1.1 The Probability Distribution of Customer Arrivals

Some standard notations for distributions are Poisson distribution, Erlang distribution with κ phases, degenerate (or deterministic) distribution, general distribution (arbitrary), and a phase-type distribution. One of the most common adopted notations is Poisson distribution (Xiang 2012).

A discrete stochastic variable X is said to have a Poisson distribution with parameter $\lambda > 0$, if for $k = 0, 1, 2\ldots$ the probability mass function of X is given by

$$P(X = k) = \frac{e^{-\lambda}\lambda^{k}}{k!} \tag{82.1}$$

where λ is the mean arrival rate.

Poisson distribution required satisfying the following characteristic (Qin 2008):

(1) Stable. During any period of length t of the time interval, the probability of an event happening is only relevant to the value of t other than the position of it.
(2) Memoryless (or Markov processes). In two mutually disjoint time interval of T1 and T2, the numbers of events are independent.
(3) Generalized. The probability of more than one events (or more than one customer arrived at the bank) happened at the same time can be ignored.

All the above-mentioned characterized in the queueing system for:

(1) The event of single customer reaches the bank is separate and random. Two or more than two customer reaches the bank at the same time is considered to be small probability event which could be ignored.
(2) The interarrival time distribution is random.
(3) The amount of customer is infinite.

Considering only the input process of the formation of steady state condition.

Since the opening time of the bank is from 9:00 am to 5:00 pm and some of the customer arrived at the bank before the network started operating, we selected the data from 8:30 pm to 5:00 am. In the meantime, we picked the statistical unit of the data as 15 min per person.

According to the collected data from Fig. 82.1, more than one peak appeared as the customer arrival reaches a relatively high value. The first peak happened between 9:00 and 10:00 am every day, for the banks opened at 9:00 am, and many customers are in a rush to do business. The second peak is between 1:00 and 2:00 pm as many office workers go to the bank after the lunch during lunch break. The last peak will be between 4:00 and 5:00 pm, as customers want to catch the last chance before the bank closed for the day. During the time other than these three peaks, the amount of customer will be relatively low.

82.2.1.2 The Chi Squared Test of Poisson Distribution

This paper segments the sampling time, and collects, statistics of customer numbers of arrival in different time period as X, and the frequency distribution of customer numbers as n (Liu and Zhang 2008).

The null hypothesis of the test is as followed:

$$H_0 : X \sim P(\lambda) \tag{82.2}$$

The unknown λ uses the maximum likelihood estimation:

$$\hat{\lambda} = \bar{x} = \frac{1}{n}\sum_{i=1}^{\infty} n_i x_i \tag{82.3}$$

The Pearson's Chi squared test is used to test the null hypothesis. Karl Pearson calculated the frequency as $p_i = n_i/n$ (Yao and Liu 2011), and then the value of the test-statistic.

$$\chi^2 = \sum_{i=1}^{n} \frac{(n_i - np_i)^2}{np_i} \tag{82.4}$$

If the distribution function of X in null hypothesis H_0 contains unknown value, this paper calculated the maximum likelihood estimation value using the sample data assuming that null hypothesis H_0 is true, and calculated the estimation of p_i as

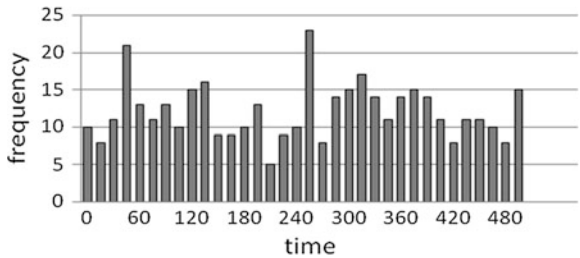

Fig. 82.1 Customer arrival frequency

$\hat{p}_i = \hat{P}(X \in A_i)$ using the maximum likelihood estimation value as parameter.

$$\chi^2 = \sum_{i=1}^{n} \frac{(n_i - n\hat{p}_i)^2}{n\hat{p}_i} \tag{82.5}$$

R. A. Fisher's exact test proved that if the null hypothesis failed to be rejected and the value of n is large enough, the test-statistic generally follows a Chi squared distribution as the degree of freedom being n−r−1 (Wang 2010). The critical region of a significance level α is.

$$W = \left\{\chi^2 > \chi^2_\alpha(k - r - 1)\right\} \tag{82.6}$$

where k is the number of groups, r is the number of unknown values used to calculate the sample data estimation of test-statistics.

Table 82.1 shows the statistics of customer arrival within the length of 15 min as the data had been segmented into different groups.

After calculation and examination, the overall customer arrivals obey the $\lambda = 12.1$ Poisson distribution. Considering the customer arrival frequency, the effect of difference between days can be neglected based on the analysis of long-term data. As for different hours within a day, the changes of parameter cannot be ignored.

It will be more practical and accordant with the status of actual customer arrival of the bank to adopt specific parameter for different hours within a single day.

Since the peaks and the troughs are generally within an hour, the value of λ is considered to be a constant in the 1 h (Yang 2008). To eliminate the influence of the peaks and troughs, we selected an hour as a unit to further analyzes the Poisson flow of parameter variation.

82.2.2 The Servers

Following Kendall's notation it indicates a system conclude two notations involving with servers, which are the service time distribution and the number of servers. In most banks, the number of server will not be limited as one. The service

Table 82.1 Distribution of number and frequency

Number	Frequency	Number	Frequency	Number	Frequency
1	0	9	3	17	1
2	0	10	5	18	0
3	0	11	6	19	0
4	0	12	0	20	0
5	1	13	3	21	1
6	0	14	4	22	0
7	0	15	4	23	1
8	4	16	1		

time is relatively different and independent according to request of the customer. The service time could be considered to be random variables which are mutually independent and followed the same distribution. The analysis of the data shows that the service time of the bank server is exponentially distributed with the parameter μ as follows:

$$F(t) = 1 - e^{-\mu t},\ t \geq 0 \tag{82.7}$$

Let μ be a constant and $\mu > 0$ representing the mean service rate in a unit of time, and $1/\mu$ being the mean service time.

82.2.3 The Queue's Discipline

When the customer arrive at the system, the respond are of three different types. The first type of customer will leave the system if all the servers are occupied. The second type of customer will wait even if the traffic intensity levels exceed the number of servers. The last type of customer will leave the system if the number of waiting customers reached its capacity. In the second and third type, the queueing discipline defines the way the customer will be served, the order in which they are served could be First in first out, Last in first out, Processor sharing or Priority. The queue can also be defined as single queue or multiple queue system.

The queueing discipline in the bank is quite typical second type as mentioned above, and the capacity of queue can be considered to be infinite with loss of customers. With the help of the queueing machine, the queue became single and organized. The customer with priority will be separate from the ordinary customer and be served without much delay in VIP room which cannot serve the ordinary customer. The paper will be focusing on the ordinary customer queue based on First come first serve discipline of single queue.

82.3 Parameters and Evaluations of Queueing System

M/M/c model indicates a system where arrivals are a Poisson process, service time is exponentially distributed with c servers.

The main appropriate parameters are as follows (Deng 2010):

Ls: the number of customer, including the customer being served and in the queue;
Lq: the number of customer waiting;
Tq: the average waiting time of the customer in the system;
λ: the average rate of arrival;
μ: the average rate of service;
ρ: the service intensity, value being the ratio of average arrival rate λ and average service rate μ, $\rho = \lambda/\mu$.

82.4 The Model of Losing Customer in the Bank Queueing System

In the real-life situation, customers continuously arrive at the system, but not all of them enter the system to wait and be served. Some customers arrive at the bank and leave once they think there are too many waiting customers. Some other customers leave the system for being in the queue for too long before they receive service. It has become a serious problem that waiting time and the expected waiting time is too long to cause the loss of customer of the bank. The problem of the loss of customer in the bank's queueing system is not being fully researched which is exactly what the paper wants to study and analyze.

82.4.1 The Queueing Model of a Changeable Input Rate

The first thing a customer will do when he or she arrives at the bank is to decide whether to join the system or not. The decision wasn't made upon the calculation based on previous waiting time before getting service but the expected waiting time calculated based on the number of servers, the average service time and the number of waiting customer. Generally, with the growth of the queue's length, the probability of customer joining the.system will diminish. Also, with the growth of the number of servers, the probability will go up.

Let a_k be the probability of the customer joining the system when the length of queue is k and the number of server is n.

In previous papers, the situation of customer joining the single queue single server system with the probability of $a_k = 1/(k+1)$ (Lu 2009) and $a_k = \sqrt{k+1} - \sqrt{k}$ (Ren 2010) has been discussed.

This paper will introduce the parameter $\beta(\beta > 0)$, and generalize the probability distribution into multiple servers, and the function of customer joining the system as follows:

$$a_k = \frac{n}{\beta k + n}(k \in N, \beta \,\text{as normal}) \tag{82.8}$$

The introduction of the server number n and the parameter β improves the relationship between the probability and the customer number k by making it more realistic.

$$\lambda_k = \lambda a_k = \frac{\lambda n}{\beta k + n} \tag{82.9}$$

The status flow diagram (Thomas 2000) can be drawn as Fig. 82.2.

According to the status flow diagram, k's equation (Tai and Gao 2009) can be applied under equilibrium conditions as follows,

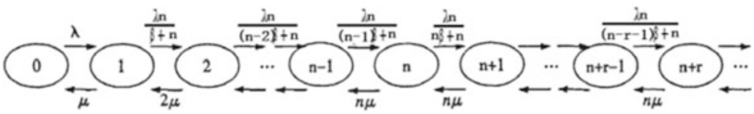

Fig. 82.2 The status flow diagram of the queueing model of a changeable input rate

For status 0,

$$\lambda p_0 = \mu p_1 \Rightarrow p_1 = \frac{\lambda}{\mu} p_0 = \rho p_0; \tag{82.10}$$

For status 1,

$$\frac{\lambda n}{\beta + n} p_1 = 2\mu p_2 \Rightarrow p_2 = \frac{\lambda n}{2\mu(\beta + n)} p_1 = \frac{\rho^2 n}{2(\beta + n)} p_0; \tag{82.11}$$

For status 2,

$$\frac{\lambda n}{2\beta + n} p_2 = 3\mu p_3 \Rightarrow p_3 = \frac{\lambda n}{3\mu(2\beta + n)} p_2 = \frac{\rho^3 n^2}{3!(2\beta + n)(\beta + n)} p_0; \tag{82.12}$$

For status n−1,

$$\frac{\lambda n}{(n-1)\beta + n} p_{n-1} = n\mu p_n \Rightarrow p_n = \frac{\rho^n n^{n-1}}{n!(\beta + n)(2\beta + n)\cdots[(n-1)\beta + n]} p_0; \tag{82.13}$$

For status n,

$$\frac{\lambda n}{n\beta + n} p_n = n\mu p_{n+1} \Rightarrow p_{n+1} = \frac{\rho^{n+1} n^n}{nn!(\beta + n)(2\beta + n)\cdots[n\beta + n]} p_0; \tag{82.14}$$

For status n + r−1,

$$p_{n+r} = \frac{\rho^{n+r} n^{n+r-1}}{n^r n!(\beta + n)(2\beta + n)\cdots[(n + r - 1)\beta + n]} p_0; \tag{82.15}$$

For all status,

$$p_k = \left\{ \begin{array}{c} \dfrac{\rho^k n^k}{k!n(\beta + n)(2\beta + n)\cdots[(k-1)\beta + n]} p_{0,}\, k = 1, 2, \ldots, n \\ \dfrac{\rho^k n^k}{n^{k-n+1} n!(\beta + n)(2\beta + n)\cdots[(k-1)\beta + n]} p_{0,}\, k = n + 1, \ldots \end{array} \right\} \tag{82.16}$$

From the Regularity condition.

$$\sum\nolimits_{k=0}^{\infty} p_k = 1 \tag{82.17}$$

We can get:

$$p_0 = \left\{ 1 + \sum\nolimits_{k=1}^{n} \frac{\rho^k n^k}{k! n(\beta+n)(2\beta+n)\cdots[(k-1)\beta+n]} + \sum\nolimits_{k=n+1}^{\infty} \frac{\rho^k n^k}{n^{k-n+1} n!(\beta+n)(2\beta+n)\cdots[(k-1)\beta+n]} \right\}^{-1} \quad (82.18)$$

It is noteworthy that when $\beta = 1, n = 1$

$$p_0 = \left[1 + \rho + \rho^2/2! + \rho^3/3! + \cdots\right]^{-1} = e^{-\rho} \quad (82.19)$$

$$p_k = \frac{\rho^k}{k!} e^{-\rho}, \quad (k = 0, 1, 2, \ldots) \quad (82.20)$$

which means the stable distribution is Poisson Distribution with parameter ρ.

The value of β can be calculated through the analysis of a sample survey of the customer arrival.

The evaluation can be calculated as follows,

(1) the average rate of customer arrival

$$\bar{\lambda} = \sum_{k=0}^{\infty} \lambda_k p_k = \sum_{k=0}^{n} \frac{\lambda \rho^k n^{k+1}}{k! n(\beta+n)(2\beta+n)\cdots[k\beta+n]} p_0 + \sum_{k=n+1}^{\infty} \frac{\lambda \rho^k n^{k+1}}{n^{k-n+1} n!(\beta+n)(2\beta+n)\cdots[k\beta+n]} p_0 \quad (82.21)$$

(2) the average service intensity of the system

$$\bar{\rho} = \frac{\bar{\lambda}}{\mu} = \sum_{k=0}^{n} \frac{\rho^{k+1} n^{k+1}}{k! n(\beta+n)(2\beta+n)\cdots[k\beta+n]} p_0 + \sum_{k=n+1}^{\infty} \frac{\rho^{k+1} n^{k+1}}{n^{k-n+1} n!(\beta+n)(2\beta+n)\cdots[k\beta+n]} p_0 \quad (82.22)$$

(3) the average length of the waiting queue

$$L_q = \sum_{k=1}^{\infty} k p_{k+n} = \sum_{k=1}^{\infty} \frac{k \rho^{k+n} n^{k+n}}{n^{k+1} n!(\beta+n)(2\beta+n)\cdots[(k+n-1)\beta+n]} p_0 \quad (82.23)$$

(4) the average length of the system

$$L_s = \begin{cases} k, k \le n \\ L_q + n, k > n \end{cases} \quad (82.24)$$

(5) when the customer k + 1 arrives at the bank noticing k customers are in the system, the probability of joining the system is, and the probability of loss is

$$P_{loss} = \sum_{k=0}^{\infty} P(L_s = k) * (1 - a_k) = \sum_{k=0}^{\infty} p_k - \sum_{k=0}^{\infty} a_k p_k = 1 - \bar{\lambda}/\lambda \qquad (82.25)$$

82.4.2 The Queueing Model with Impatient Customer

Let there be a system with servers of n, infinite capacity, customer arrival being Poisson Distribution, average arrival rate of λ. As a customer arrives at the bank with all servers occupied, he or she will wait in the queue. The customer will be impatient and even leave the system when the length of the queue is too long or the average service time is too long while the queue is not too long (He et al 2009).

A research shows that when the waiting time exceeds 10 min, the customer started to feel impatient. When it exceeds 20 min, the customer become irritable, and when it exceeds 30 min, they might leave because of angry (Sun 2010). The research indicates that a precaution to reduce the average waiting time is of importance.

The intensity of customer leaving being α_t is relevant to the waiting time k. Take the simplest model when $\alpha_t = \delta t(\delta > 0)$ into consideration. Collect the data as the customer leave the bank and analyze the pattern in statistics angle. As the establishment of model based on time measurement is too vague, the number of customer may be $k = nt/\mu$ when the leaving customer enter the system considering the average service time is $1/\mu$. The customer waits for time of t and leaves with $\alpha_t = \delta t(\delta > 0)$ can be transformed into leaving the system with $\alpha_k = k\delta/n = \theta k(\delta > 0)$ before entering the system. The status flow diagram can be drawn as Fig. 82.3

Analyze the flow diagram based on k's equation and we can get:

$$p_k = \begin{cases} \dfrac{(n\rho)^k}{k!} p_0, & 0 \le k \le n \\ \dfrac{n^n \rho^k}{n!(1+b)(1+2b)\cdots[1+(k-n)b]} p_0, & k > n \end{cases} \qquad (82.26)$$

where $\rho = \rho_1/n, b = \theta/\mu n$.

$$p_0 = \left\{ \sum_{k=0}^{n} \frac{(n\rho)^k}{k!} + \sum_{k=n+1}^{\infty} \frac{n^n \rho^k}{n!(1+b)(1+2b)\cdots[1+(k-n)b]} \right\}^{-1} \qquad (82.27)$$

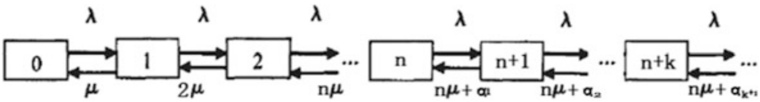

Fig. 82.3 The status flow diagram of the queueing model with impatient customer

And the probability of losing customer is

$$P_{loss} = 1 - \sum_{k=0}^{\infty} p_k a_k = 1 - \sum_{k=0}^{n} \frac{(n\rho)^k}{(k-1)!} \theta p_0 \\ - \sum_{k=n+1}^{\infty} \frac{n^n \rho^k \theta k}{n!(1+b)(1+2b)\cdots[1+(k-n)b]} p_0 \tag{82.28}$$

82.5 Conclusion

The core concept and basic function of the bank is to satisfy the need of customer. Thus the bank should be devoting to improve efficiency or add the number of servers to avoid the situation of customer leaving the system for the expected waiting time being too long. This paper takes the variable parameters into consideration and builds a more real-life concerned model. The customer-losing rate can be used as an evaluation to fulfill the basic function of the bank. The bank can compare the expense of opening a new server with the loss of losing customer to get a customer loss rate in the balance as P. When the actual losing rate is larger than this value, a bank should open a new server to reduce the loss.

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Chapter 83
Application of DEA-Malmquist Index in Analyzing Chinese Banking's Efficiency

Man Ding, Chao-qun Ma, Zhong-bao Zhou and Wen-bin Liu

Abstract The efficiency of commercial banks is important for Chinese banking to prevent risk and improve the competitiveness, and also the core for China to deepen financial reform. By using the DEA-Malmquist indices approach, the efficiency and the efficiency changes of 14 China's commercial banks during the period of 2007–2010 were analyzed in this paper. Results showed that the average efficiency of State-owned commercial banks is generally lower than that of joint-stock commercial banks and the urban commercial banks, the average efficiency of urban commercial banks is the highest; the overall efficiency of 14 banks is improved in 4 year due to efficiency progress and technical advance.

Keywords China's listed commercial banks · DEA · Efficiency · Malmquist index

83.1 Introduction

Commercial banks are the main body of China's financial industry; they play an important role for China's economy development and the improvement of people's living standard. However, after the 1990s, the control of the commercial banks is becoming more relaxed with the globalization of economy and financial freedom in China, especially after China's entry into the WTO which allows foreign banks run the business in China, makes the competition between commercial banks

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E. Qi et al. (eds.), *The 19th International Conference on Industrial Engineering and Engineering Management*, DOI: 10.1007/978-3-642-38391-5_83,

intensified. Since the U.S subprime mortgage crisis, the financial tsunami makes we know that the commercial bank efficiency is the key for them to have a place in the competition. How to improve the efficiency of Chinese commercial banks is the vital problem to be solved for the bank authorities and the bank decision makers. Therefore, evaluating the efficiency situation of China's commercial banks clearly and correctly, exploring the measures and preferences to improve the efficiency of China's commercial banks is priority.

At present, the widespread use of the bank efficiency evaluation method is Data envelopment analysis (DEA) in academia. DEA which is raised by Charnes et al. (1978) is an approach for measuring the relative efficiency of peer decision making units (DMUs) that have multiple inputs and outputs. The essence of DEA is using the "frontier analysis", according to a certain standard to construct a production frontier and the gap between the evaluated bank and the frontier is its efficiency. The advantages of the DEA method are that it need not give the weight of each index by people, also need not given the production function form of frontier in advance, and it can deal the project with multiple outputs and multiple inputs (Chen and Zhu 2004). So this method used in the same industry to analyze the efficiency has its own unique advantages. Penny (2004) investigates X-efficiency and productivity change in Australian banking between 1995 and 1999 using DEA and Malmquist productivity indexes, and finds that regional banks are less efficient than other bank types. Total factor productivity in the banking sector was found to have increased between 1995 and 1999 due to technological advance shifting out the frontier. Zhu et al. (2004) measured the efficiency of China's largest 14 commercial banks over the period 2000–2001 using the super-efficient DEA model and Tobit regression method. The results show that the overall efficiency of the four state-owned commercial banks is far less than 10 joint-stock commercial banks, and the excessive number of employees is a major bottleneck restricting the state-owned commercial banks efficiency. Chen et al. (2005) examine the cost, technical and allocative efficiency of 43 Chinese banks over the period 1993–2000. Results show that technical efficiency consistently dominates the allocative efficiency of Chinese banks, and the large state-owned banks and smaller banks are more efficient than medium sized Chinese banks.

But from most related literature of evaluating the efficiency of commercial banks, we may find that they mainly adopt DEA model to describe the commercial banking efficiency status, but the description is basically a static comparison, or even though the dynamic description, the description is incomplete (Mette and Joseph 2004; Ariff and Can 2008; Laurenceson and Yong 2008). Therefore, to evaluate bank efficiency by DEA based on Malmquist index began to be widely used. Zhang and Wu (2005) analyzed the efficiency change of China's commercial banks during the period of 1999–2003 using all Input-Oriented Malmquist Index approach. Gao (Gao et al. 2009) studies the panel data of primary commercial banks over the period of 1997–2006, and it calculates the total factor productivity and its decomposition indexes based on the DEA-based Malmquist productivity index. Maria et al. (2010) develop an index and an indicator of productivity change that can be used with negative data and use RDM efficiency measures to arrive at a

Malmquist-type index, which can reflect productivity change, and use RDM inefficiency measures to arrive at a Luenberger productivity indicator.

This paper has introduced the theory of related DEA model and Malmquist index and analyzed the inputs and outputs selection of 14 China's listed commercial banks, and measured the efficiency and the dynamic changes of the efficiency of 14 China's listed commercial banks during the period of 2007–2010.

83.2 Methodology

83.2.1 DEA Model

Consider we have n DMUs, and that each DMU_j $(j = 1, 2, \ldots, n)$ has m inputs and s outputs. Suppose X_j, Y_j are the input and output of DMU_j, and $X_j = (x_{1j}, x_{2j}, \ldots, x_{mj})$, $Y_j = (y_{1j}, y_{2j}, \ldots, y_{sj})$, then we can define the DEA model as follows:

$$\begin{aligned} & \min \theta \\ & s.t. \sum_{j=0}^{n} \lambda_j X_j \le \theta X_{j0} \\ & \sum_{j=0}^{n} \lambda_j Y_j \ge Y_{j0} \\ & \lambda_j \ge 0, j = 0, 1, 2, \ldots, n \end{aligned} \tag{83.1}$$

where λ_j are the weights of input/output indexes, θ is the efficiency score. And if $\theta < 1$, the DMU is inefficient; If $\theta = 1$, the DMU is efficient.

83.2.2 Malmquist Index Model

Malmquist index model was brought out by Malmquist in 1953 in the process of analyzing consumption. Nishinizu and Page firstly used this index to measure the change of productivity, since then the Malmquist index model was combined with DEA theory and has a wide use in measuring the efficiency of production (Nishimizu and Page 1982). The Malmquist index is defined as:

$$M^{t,t+1} = tfp = \left[\frac{D^{t+1}(x^{t+1}, y^{t+1})}{D^{t+1}(x^t, y^t)} \times \frac{D^t(x^{t+1}, y^{t+1})}{D^t(x^t, y^t)} \right]^{\frac{1}{2}} \tag{83.2}$$

From model (2) we cam see that Malmquist index is an efficiency index, which represents the efficiency changes from t to $t+1$. If $Malmquist > 1$, then the efficiency of DMU is improved; If $Malmquist = 1$, then the efficiency of DMU is unchanged; If $Malmquist < 1$, then the efficiency of DMU is declined.

Further, Malmquist Index can be decomposed into two components, which is efficiency progress index (effch) and technical change index (tech):

$$\begin{aligned} effch &= \frac{D^{t+1}(x^{t+1}, y^{t+1})}{D^t(x^t, y^t)} \\ tech &= \left[\frac{D^t(x^{t+1}, y^{t+1})}{D^{t+1}(x^{t+1}, y^{t+1})} \times \frac{D^t(x^t, y^t)}{D^{t+1}(x^t, y^t)}\right]^{\frac{1}{2}} \end{aligned} \tag{83.3}$$

Effch is defined as the efficiency improvement part, represented the management level change in two periods—"catching-up effect" which measures the commercial bank management performance is more close to the current production frontier. Tech is defined as part of the technology progress, representing the shift of the production frontier in two periods—"frontier-shift effect". What's more, the effch can also be decomposed into pure technical efficiency (pech) and scale efficiency (sech):

$$effch = pech \times \sec h \tag{83.4}$$

83.3 Empirical Analysis

83.3.1 Data Sources

According to the principle of representative, accessibility and integrity, this paper selects 14 listed commercial banks as research objects during 2007–2010. They are Bank of China (BC), China Construction Bank (CCB), Industrial and Commercial Bank (ICBC), Bank of Construction (BCM), China Merchants Bank (CMB), Industrial Bank (CIB), Citic Bank (CITIC), Shanghai Pudong Development Bank (SPDB), Minsheng Bank (CMBC), Hiaxia Bank (HXB), Shenzhen Development Bank (SDB), Beijing Bank (BOB), Nanjing Bank (NOB) and Ningbo Bank (NBB). The input–output data of the banks is from each listed commercial bank's "Published Financial Statements in 2007–2010" and "Chinese Financial Statistics Yearbook in 2007–2010".

83.3.2 Indexes Selection

Reasonable definition of inputs and outputs of banks is the key problem using DEA model to measure efficiency of the commercial banks. Recently, the generally accepted method in division of inputs and outputs of the bank in international financial academics are three principal schools: production approach, the intermediation approach and asset approach (Zelenyuk 2006; Feng and Serletis 2010; Giokas 2008).

The production method regards banks as producers which use labor force and their own capital to generate deposits and loans. The number of loan and deposit account is usually seen as outputs, while the number of employees and the capital are seen as outputs in this method.

The intermediary approach consider banks as financial intermediaries where deposits are converted into loans, and getting the profits from the income of loans and investment. Therefore, intermediary method takes fixed capital, labor, and various interest cost as the inputs, and takes all kinds of loans and investments as the outputs.

The Asset approach also regards banks as financial intermediaries. Usually the liabilities on the balance sheet are regarded as inputs, and the loans and investments are regarded as outputs.

According to the China's listed commercial banks' characteristics and the requirements of DEA model, the inputs of the China's listed commercial banks in this paper are the number of employees, fixed assets, operating expenses and deposits; the outputs are loans and revenue which can seen in Fig. 83.1.

83.3.3 The Empirical Results

Based on DEA and Malmquist indices, we calculate the efficiency of China's listed commercial banks from 2007 to 2010 which can be seen from Table 83.1 and Efficiency change of China's listed commercial banks' Malmquist index during 2007–2010 which can be seen from Table 83.2 by matlab.

According to the empirical results in Table 83.1, we conduct the following analysis:

First, from the aspect of time window, we can find that the average efficiency scores of 14 China's listed commercial banks are all less than 1, this shows that each listed commercial bank is DEA inefficient. And the overall efficiency of China's banks shows a declined trend, from 0.982 in 2007 down to 0.979 in 2010.

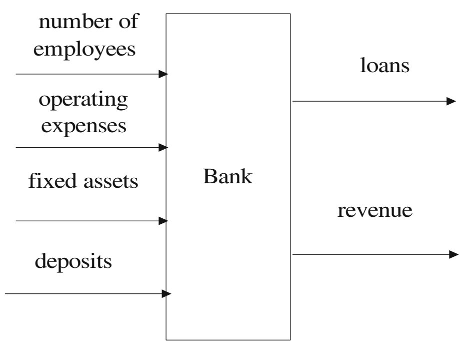

Fig. 83.1 The inputs and outputs of the China's listed commercial banks

Table 83.1 The efficiency score of China's commercial banks during 2007–2010

Banks	2007	2008	2009	2010	Average
BC	0.970	0.938	0.949	0.980	0.959
CCB	0.971	0.901	0.981	1.000	0.963
ICBC	0.930	0.858	0.943	0.900	0.908
BCM	1.000	0.988	1.000	1.000	0.997
CMB	1.000	0.980	0.936	1.000	0.979
CIB	1.000	1.000	1.000	1.000	1.000
CITIC	1.000	0.990	1.000	1.000	0.998
SPDB	0.993	1.000	1.000	1.000	0.998
CMBC	1.000	1.000	1.000	1.000	1.000
HXB	0.935	0.936	0.923	0.962	0.939
SDB	1.000	1.000	1.000	0.992	0.998
BOB	1.000	1.000	1.000	1.000	1.000
NOB	1.000	1.000	1.000	1.000	1.000
NBB	0.947	0.909	1.000	1.000	0.964
Average score of state-owned banks	0.968	0.921	0.968	0.970	0.957
Average score of joint-stock commercial banks	0.990	0.987	0.980	0.994	0.987
Average score of urban commercial banks	0.982	0.970	1.000	1.000	0.988
Average	0.982	0.964	0.981	0.988	0.979

Table 83.2 The Malmquist Index score of China's commercial banks during 2007–2010

Banks	effch	tech	pech	sech	tfp
BC	1.003	1.026	1.000	1.003	1.029
CCB	1.010	1.063	1.000	1.010	1.073
ICBC	0.989	1.039	1.000	0.989	1.028
BCM	1.000	1.027	1.000	1.000	1.027
CMB	1.000	0.995	1.000	1.000	0.995
CIB	1.000	1.034	1.000	1.000	1.034
CITIC	1.000	0.982	1.000	1.000	0.982
SPDB	1.002	0.999	1.000	1.002	1.001
CMBC	1.000	0.832	1.000	1.000	0.832
HXB	1.010	0.991	1.015	0.995	1.001
SDB	0.997	1.042	1.000	0.997	1.048
BOB	1.000	1.015	1.000	1.000	1.015
NOB	1.000	1.023	1.000	1.000	1.023
NBB	1.018	0.989	1.000	1.018	1.007
Average score of state-owned commercial banks	1.001	1.039	1.000	1.001	1.039
Average score of joint-stock commercial banks	1.001	0.982	1.002	0.999	0.985
Average score of urban commercial banks	1.006	1.009	1.000	1.006	1.015
2007–2008	0.981	1.039	1.001	0.981	1.019
2008–2009	1.018	0.936	0.999	1.019	0.953
2009–2010	1.008	1.037	1.004	1.004	1.045
2007–2010	1.002	1.003	1.001	1.001	1.005

At the same time, the efficiency score in 2008 is the lowest which indicates that the financial crisis had more adverse impact on Chinese banking industry and the risk defense ability of Chinese banking industry is insufficient.

Second, from the bank ownership form, we can find that average efficiency score of urban commercial banks is the highest in the 4 years, reach up to 0.988; the average efficiency score of joint-stock commercial banks is the second; The lowest efficiency score is state-owned commercial banks, only 0.957. In addition, we may find that the average efficiency scores of the urban commercial banks all achieve the DEA efficient respectively on 2008 and 2009 which shows the Operation efficiency of urban commercial banks are Overall good.

Third, from the average efficiency score of each commercial bank in 4 years, we can find that all state-owned commercial banks are DEA inefficient. For the joint-stock commercial banks, CIB and CMBC are all DEA efficient in 4 years, BOB and NOB are also DEA efficient. Moreover, ranking in the last three places respectively is BC, HXB and ICBC.

We evaluate the efficiency of 14 China's listed commercial banks above using DEA method, but this method calculates the efficiency of the commercial banks from static goniometer, namely horizontal comparison of the efficiency in the same period of different commercial banks which is not suitable for the longitudinal description of the dynamic changes of the efficiency in a period. So we measure the dynamic changes of the efficiency of the commercial banks in China using the Malmquist index to make the evaluation of the efficiency of Chinese commercial banks more detailed and more comprehensive.

According to the empirical results in Table 83.2, we conduct the following results:

First, the average Malmquist index of the 14 China's listed commercial banks from 2007 to 2010 is 1.005, greater than 1, which means the overall efficiency of China's banks is rising. The overall efficiency during the period of 2007–2008 and 2009–2010 are all rising but the efficiency in 2008–2009 is only 0.953, less than 1 the reason is the negative influence of financial crisis. In addition, the average Malmquist index of joint-stock commercial banks is less than 1, is declined in four yeas. The largest increased efficiency is state-owned commercial banks. The efficiency of CMB, CITIC and CMBC is declined in 4 years, and the efficiency of SPDB and HXB is nearly unchanged, and the others are rising.

Second, the overall improved efficiency of 14 China's listed commercial banks is due to the increase of the efficiency progress (effch) and the technical change (tech). The overall declined efficiency of the joint-stock commercial banks is due to the decrease of the technical change (tech). And the increase of the state-owned commercial banks is mainly due to the decrease of the technical change (tech). Moreover, for the increase of efficiency progress (effch) of the urban commercial banks is mainly due to the increase of scale efficiency (sech).

83.4 Conclusion

The paper has introduced the theory of related DEA model and Malmquist index and analyzed the inputs and outputs selection of 14 China's listed commercial banks, measured the efficiency and the dynamic changes of the efficiency of 14 China's listed commercial banks during the period of 2007–2010. Through the analysis, the results show that the average efficiency scores of 14 China's listed commercial banks are all DEA inefficient. The average efficiency score of urban commercial banks is the highest in the 4 years, the average efficiency score of joint-stock commercial banks is the second and the lowest efficiency score is state-owned commercial banks. The average Malmquist index of the 14 China's listed commercial banks is greater than 1, and the overall improved efficiency of 14 China's listed commercial banks is due to the increase of effch and tech.

Acknowledgments This paper is supported by National Science Fund for Distinguished Young Scholar (70825006); The Funds for Innovation Research Changjiang Scholar (IRT0916) in China and Hunan Provincial Natural Science Foundation of China(09JJ7002).

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Chapter 84
The Improvement on R. G. Bland's Method

Yu-bo Liao

Abstract Cycling may occur when we use the simplex method to solve linear programming problem and meet degeneration. Such cycling problem can be avoided by the Bland method. In this paper, we will present an improved Bland method with more iterative efficiency than the Bland method.

Keywords Bland method · Linear programming · Linear optimization · Simplex method

84.1 Introduction

In plain English one can say that a linear optimization (LO) problem consists of optimizing, i.e., minimizing or maximizing, a linear function over a certain domain. The domain is given by a set of linear constraints. The constraints can be either equalities or inequalities.

The simplex method for linear programming problems was first proposed by Dantzig in 1947 (Dantzig 1948), which can be described as follow:

Supposing that the given standard linear programming problem is

$$\min s = \boldsymbol{c}\boldsymbol{x}$$
$$\begin{cases} \boldsymbol{A}\boldsymbol{x} = \boldsymbol{b} \\ \boldsymbol{x} \geq 0 \end{cases}$$

where $A = \begin{pmatrix} a_{11} & \cdots & a_{1n} \\ \cdots & \cdots & \cdots \\ a_{m1} & \cdots & a_{mn} \end{pmatrix}, \boldsymbol{x} = \begin{pmatrix} \boldsymbol{x}_1 \\ \vdots \\ \boldsymbol{x}_n \end{pmatrix}, \boldsymbol{b} = \begin{pmatrix} \boldsymbol{b}_1 \\ \vdots \\ \boldsymbol{b}_m \end{pmatrix},$

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E. Qi et al. (eds.), *The 19th International Conference on Industrial Engineering and Engineering Management*, DOI: 10.1007/978-3-642-38391-5_84,

$$c = (\lambda_1 \quad \cdots \quad \lambda_n)$$

The rank of $A = (a_{ij})_{m \times n}$ is m, $n \geq m \geq 1$. The steps of the simplex method can be summarized as follow:

- The first step: $\boldsymbol{B} = (\boldsymbol{p}_{j_1}, \boldsymbol{p}_{j_2}, \ldots, \boldsymbol{p}_{j_m})$ is the known feasible basis, and the canonical form and the basic feasible solution $\boldsymbol{x}_{\boldsymbol{B}}^{(0)} = \boldsymbol{B}^{-1}\boldsymbol{b} = (\boldsymbol{b}_{10} \ \cdots \boldsymbol{b}_{\boldsymbol{m}0})^{\boldsymbol{T}}$。
- The second step: Check the testing number. If all testing numbers satisfy $\lambda_j \leq 0, (j = 1, 2, \cdots n)$, the corresponding basic feasible solution $\boldsymbol{x}^{(0)}$ is the optimal solution. All the process is ended, otherwise go to next step;
- The third step: If some testing number $\lambda_r > 0$ and $\boldsymbol{B}^{-1}\boldsymbol{p}_{\boldsymbol{r}} = (b_{1r}, b_{2r}, \cdots, b_{mr})^T \leq 0$, there is no optimal solution for this problem. All the process is ended, otherwise go to next step;
- The forth step: If some testing number $\lambda_r > 0$ and there is a positive number in $(b_{1r}, b_{2r}, \cdots, b_{mr})^T$, make x_r be the entering-basis variable (if there are a few of positive testing numbers, choose the largest one in order to improve the iterative efficiency. This method is named as the largest testing number method), and the minimum ratio is $\min\left\{\frac{b_{i0}}{b_{ir}}\middle| b_{ir} > 0\right\} = \frac{b_{s0}}{b_{sr}}$ Hence the leaving-basis variable x_{js} can be determined (if there are a few same minimum ratios, choose the minimum-subscript variable as the leaving- basis variable). Substitute $\boldsymbol{p}_{\boldsymbol{r}}$ for p_{js}, obtain the new basis $\bar{\boldsymbol{B}}$, and then go to next step;
- The fifth step: Obtain the canonical form and the basic feasible $x_{\bar{B}}^{(1)} = \bar{B}^{-1}b$, corresponding to new basis $\bar{\boldsymbol{B}}$ (which can be realized directly by elementary row transformation of the corresponding simplex tableau in manual calculation). Afterwards, substitute $\bar{\boldsymbol{B}}$ for $\boldsymbol{B}$, substitute $x_{\bar{B}}^{(1)}$ for $x^{(0)}$, and then return to the second step.

For the non-degenerate linear programming problems, using the largest testing number simplex method in iteration, after finite iterative steps, the optimal solution must be obtained or not existed. But for degenerate linear programming problems, this method may not be valid because basis cycling may appear. In 1951, A. J. Hoffman first designed one example where appears cycling in iterations. In 1955, E. M. L. Beale designed a simpler example to show the possible cycling problem (Beale 1955; Tang and Qin 2004; Zhang and Xu 1990).

To avoid infinite cycling, R. G. Bland proposed a new method in 1976 (Bland 1977). In the Bland method the cycling can be avoided in calculation if abiding by two rules which are shown as following (Andersen et al. 1996; Nelder and Mead 1965; Lagarias et al. 1998; Bixby 1994; Herrera et al. 1993; Wright 1996; Han et al. 1994; Hapke and lowinski 1996; Zhang 1999; Terlaky 1985; Terlaky 2000; Terlaky and Zhang 1993; Wagner 1958; Ward and Wendell 1990; Wolfe 1963; Wright 1998; Elsner et al. 1991; Han 2000):

- Rule 1: Once there are a few positive testing numbers, choose the corresponding minimum-subscript basic variable as the entering-basis variable;

- Rule 2: Once a few ratios $\frac{b_{i0}}{b_{ir}}$, in different rows reach the minimum at the same time, choose the corresponding minimum-subscript basic variable as the leaving-basis variable.

Rule 2 determines the leaving-basis variable, and it is same as the forth step of the simplex method. However, the entering-basis variable is determined by Rule 1, but the largest testing number method. The advantage of the Bland method is simple. However because it only considers the minimum subscript, but the decreasing speed of the target function, its iteration times are often much more than those of the largest testing number method. In this paper, we will first prove a theorem, and then use this theorem to propose an improved Bland method with much more computation efficiency.

84.2 The Improvement of Bland's Method

Theorem 1 If the linear programming problem has an optimal solution, there appears degenerate basic feasible solution in some iterative step with the simplex method, but it is not optimal, and only one basic variable is zero in the degenerate basic feasible solution, the degenerate basic feasible solution will not appear again after this iterative step (even if the entering-basis variable is determined by largest testing number method).

Proof First suppose that the corresponding basis is $B = (p_{j_1}, p_{j_2}, \cdots, p_{j_m})$, the corresponding basic feasible solution is $x^{(0)}$, the corresponding simplex tableau is $\boldsymbol{T}(\boldsymbol{B}) = \begin{bmatrix} \boldsymbol{c_B B^{-1} b} & \boldsymbol{c_B B^{-1} A - c} \\ \boldsymbol{B^{-1} b} & \boldsymbol{B^{-1} A} \end{bmatrix}$ 。 in this iterative step. The corresponding canonical form is

$$\min s = s^{(0)} - \sum_{j \neq j_1, j_2 \cdots j_m} \lambda_j x_j$$

$$\begin{cases} x_{j_i} + \sum\limits_{j \neq j_1, j_2 \cdots j_m} b_{ij} x_j = b_{i0} & (i = 1, 2, \cdots m) \\ x_j \geq 0 & (j = 1, 2, \cdots m) \end{cases}$$

There is only one zero in $b_{i0} (i = 1, 2, \cdots m)$, and now assume that $b_{s0} = 0$ and $b_{i0} > 0$. After this iterative step, according to the hypothesis, because only one basic variable is zero, only if the row in which leaving-basis variable locates is not s row, the value of target function will decrease and $x^{(0)}$ will be transferred; Moreover, because the target value will not increase in iteration, $x^{(0)}$ will not appear again. Therefore, if the conclusion is not valid, there is only one case: In the iteration afterwards, The row in which the leaving-basis variable locates is s row, and hence the entering-basis variable will be the leaving-basis variable in each iteration. This kind of variable is only in the set $\{\boldsymbol{x_j} | \boldsymbol{j} = \boldsymbol{j}_1, \boldsymbol{j}_2 \cdots \boldsymbol{j_m}\} \cup \{\boldsymbol{x}_{\boldsymbol{j}_s}\}$.

Because the number of the set is finite, if there appears cycling, there must be some variable x_q which leaves the basis and then enters again. Supposing that the corresponding simplex tableau is $T(B_t)$ when x_q is the leaving-basis variable and the entering-basis variable is $\boldsymbol{x_r}$ in this tableau, $b_{sq}^{(t)} = 1$, $\lambda_q^{(t)} = 0$, $b_{sr}^{(t)} > 0$, $\lambda_r^{(t)} > 0$

Supposing that the corresponding simplex tableau is $T(B_{t+k})$. When x_q is the entering-basis variable, $\lambda_q^{(t+k)} > 0$ (because it's still not optimal). $T(B_t)$ becomes $T(B_{t+k})$ after iteration, and then

$$b_{sq}^{(t+1)} = \frac{b_{sq}^{(t)}}{b_{sr}^{(t)}} > 0, \ \lambda_q^{(t+1)} = \lambda_q^{(t)} - \lambda_r^{(t)} b_{sq}^{(t+1)} < \lambda_q^{(t)} = 0$$

The rest may be deduced by analogy, $b_{sq}^{(t+k)} > 0$, $\lambda_q^{(t+k)} < 0$, which contradicts $\lambda_q^{(t+k)} > 0$, So the conclusion is valid. The proof is ended.

When there appears degenerate case, from **Theorem 1** we can obtain: If only one basic variable is zero in the degenerate basic feasible solution, we can still use the largest testing number method and there will not appear cycling. Therefore, we can modify Rule 1 of the Bland method in order to improve efficiency of iteration:

Improved rule 1: when there are a few of positive testing numbers, if only one basic variable is zero in the corresponding basic feasible solution at most, the entering-basis variable can be determined by the largest testing number; If more than one basic variable is zero in the corresponding basic feasible solution, the entering-basis variable can be determined by Rule 1 of the Bland method.

84.3 Conclusion

In summary, the large testing number method has high iteration efficiency, but it has the cycling problem; the Bland method can avoid the cycling problem, but results in low iteration efficiency. In order to eliminate those two disadvantages, we proposed an improved method which can prevent the cycling theoretically with higher computation efficiency.

Acknowledgments I would like to thank the support provided by East China Jiaotong University Research fund and Jiangxi province Research fund.

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Chapter 85
Influence Mechanism of Lean Production to Manufacturing Enterprises' Competitiveness

Hong-liang Zhang and Zhan-wen Niu

Abstract The success of Toyota as well as other enterprises of Japan has proved that lean production can improve manufacturing enterprises' competitiveness greatly. However, lean production's application in other countries is not ideal. One of the reasons is that lean production is treated as a tool set not as system engineering, so under such background, this paper studies the influence mechanism of lean production to manufacturing enterprises' competitiveness upgrading from systematic perspective. In this paper, lean production is not merely confined to improvement tools, but is treated as a system, including improvement tools, lean culture and staff factor. The direct and indirect effect of the three aspects to manufacturing enterprises' competitiveness is analyzed by SEM using SMOS17.0. Analysis result demonstrates the influence mechanism of LP to competitiveness clearly. The study of this paper has practical sense to lean implementation in China and meanwhile it enriches lean production theory.

Keywords Competitiveness upgrading · Influence mechanism · Lean implementation · SEM

85.1 Introduction

Lean production (short of LP) is from Toyota Production System, whose superiority has been proved by success of Toyota Motor Corporation as well as other Japanese manufacturing corporations. Because it integrates the characters of Ford

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E. Qi et al. (eds.), *The 19th International Conference on Industrial Engineering and Engineering Management*, DOI: 10.1007/978-3-642-38391-5_85,

production Mode and handicraft production mode—low cost with high quality, and can satisfy the diversified need of customer-focused marketing, so it is regarded as the third production mode. After 1990s, especially after the publication of book named the machine that changed the world, more and more enterprises outside of Japan began to learn and apply LP. From theoretical point of view, LP can upgrade manufacturing enterprises' competitiveness greatly, but its 20 years' application process is not smooth, not a few enterprises claim their lean implementation is failure or didn't gain desired outcome. Atkinson, Hines et al., Sim and Rodgers dictated that less than 10 % of UK organizations have accomplished a successful lean implementation (Bhasin 2012). Famous IE expert of China Er-shi Qi also pointed out lack of lean environment, enterprises of China encountered high failure rate in lean implementation process. The reason leading to this phenomenon may be complicated, but the fact that treating LP as merely a tool set may be one of the key factors.

Under such background, this paper will regard LP as an engineering system and aims to study the influence mechanism of lean implementation to competitiveness of manufacturing enterprises, finding out direct and indirect effect of LP's different dimensions to manufacturing enterprises' competitiveness upgrading.

85.2 Related Theory and Hypothesis

LP as one new production mode is not just a set of improvement tools or technology; in essence, it is complicated system engineering. Many researchers have aware that besides improvement tools, lean implementation should include lean culture and staff factor, and some of them have researched single dimension's part to manufacturing enterprises' competitiveness, but few has studied the relation of the three dimensions as well as their synthetic effect to enterprises' competitiveness.

85.2.1 Improvement Tools

The viewpoint that improvement tool is one main component of lean implementation is accepted by many researchers and lean practitioners. Because improvement action must be implemented by some means of tools and lean thought needs improvement tools to identify, so many researchers paid attention to it. Monden (2008) pointed out that LP is the compound of JIT production, including field management, resource management, TQM and information system management (Monden 2008). Shah and Ward (2007) pointed out LP comprises three aspects tools, including tool set about supplier management, tool set about customer management and tool set of inner operation management (Shah and Ward 2007). Fullerton and McWatters (2002) did appraisal to LP using 10 tools, they are focused factory, group technology, Single Minute Exchange of Die, TPM, multi-skills operator, level operation, purchase on time and TQM (Fullerton and McWatters 2002). Kojima and Kaplinsky (2004) thought LP system mainly contain three aspects technology, flexibility, quality and persistence (Kojima and Kaplinsky 2004). Based on the introduction above, this paper gets the following hypothesis.

H1: application of improvement tools has active influence to manufacturing enterprise's competitiveness.

85.2.2 Staff Factor

Famous management expert Peter F. Drucker once said to staff is the only resource of enterprise, thus management's crucial purpose to mine staff's potential. To lean implementation, staff also plays an irreplaceable role, because staff is the executor of improvement tool and the carrier of lean culture. As to its importance, FujioCho once said a sentence "before making car must first made man". Many researchers also support this viewpoint. In Toyota mode, the internal training material of Toyota Corporation, respecting for people and continuous improvement are treated as two pillars of TPS (Ohno 2001). Lander (2007) also pointed out staff is the most valuable resource of Toyota, so training education and career development is every important to enterprises (Lander 2007). Monden (2008) thought in order to satisfy the need of change, the flexibility of staff is very important (Fullerton and McWatters 2002). Besides direct influence, staff also has indirect influence to upgrading of competitiveness. As the carrier of lean tool, staff will develop and adjust lean technology, making it suitable to demand of specific environment and requirement. So based on the extant research, the following hypothesis is put forward.

H2: lean staff has positive effect to manufacturing enterprises' competitiveness.

H3: lean staff has active influence to improvement tool's development.

85.2.3 Lean Culture

Lean culture cultivation is one important factor to propel lean implementation. Without dense lean culture, LP can't be implemented completely for lack of abiding impetus. Cho (2003), former president of Toyota Motor Corporation, said Toyota's strong lies in its shared culture, which means staff of Toyota own the same values and consciousness (Cho 2003). Koole (2005) also pointed out that although LP's outward manifestation is improvement tool, its core is organization's learning ability, so lean implementation effect will be damaged greatly if too much emphasis is put on tools while lean culture is ignored. Liker (2008) said to merely applying lean tools or methods is far from enough, only through setting up

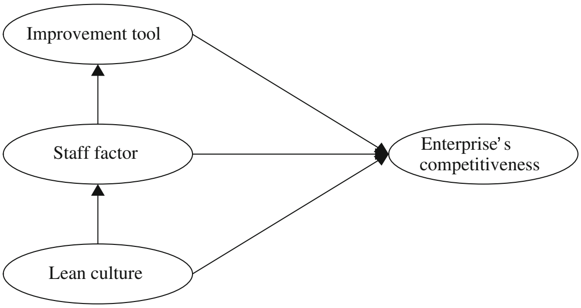

Fig. 85.1 Concept model of study

talent cultivation system and fostering lean culture can enterprises' competitiveness will be improved everlastingly (Liker 2008). Besides this aspect, dense lean culture will make staff more actively taking part in improvement and provide strong dynamic to ensure the improvement is unremitting. On the base of above discussion, this paper put forward one hypothesis:

H4: lean culture cultivation has positive direct effect to manufacturing enterprises' competitiveness.

H5: lean culture will has active influence to lean staff.

Based on the analysis above, the concept model of this paper is got, see Fig. 85.1.

85.3 Methodology

85.3.1 Method

This paper will apply structural equation modeling (short of SEM) to verify above hypothesis. Through seeking variables' inner structure relation, it can verify whether the model assumption is reasonable and if theoretical model has fault, it can point out how to revise. SEM is a group of equations reflecting relation of latent and observed variables, through measuring observed variables it can infer latent variables' relation and verify model's correctness (Gong et al. 2011). Observed variables can be measured directly, which is signified by box in path chart, while due to things' complexity and abstraction, it is difficult to measure latent variables directly and in path chart it is signified by elliptic. SEM can substitute for multiple regression, path analysis, factor analysis as well as covariance analysis and so on (Zhang and Gao 2012), its application began at late of twentieth century in society, psychology, education, management, economy as well as other fields.

In studying relation between LP and manufacturing enterprise's competitiveness, traditional quantitative methods are not applicable, because they can not analysis the relation between multiple latent variables and multiple observed variables as well as the relevance among latent variables, so SEM is used in this paper.

85.3.2 Construction of Variables

Based on extant research and considering the characters of LP and manufacturing enterprises, this paper designs the observed variables. In the process of designing questionnaire, this paper first constructs preliminary questionnaire, and then invests 5 experts of LP and 4 practitioners of LP to give out amendment suggestion, after proper revision, the final questionnaire is got, which adopts 5-rank Likert scale. Based on the acceptance degree, all the items will provide 5 different rank answers, 5-completely agree, 4-basically agree, 3-diffcult to determine, 2-don't quite agree, 1-completely disagree.

As to improvement tools, by referring extant research, this paper deigns 4 indexes to investigate it, including tools in product design, tools of production process, tools of field management and tools about supplier management. Under lean culture, this paper designs the following indexes, supporting of organization, reward system of improvement, improvement atmosphere and sharing of value. To staff factor, the investigation indexes include enthusiasm of participating improvement, career development plan and team work.

As to competitiveness of manufacturing enterprises, not a few researchers got the conclusion that LP can improve enterprises' operation efficiency. Liao (2005) pointed out that lean implementation can make enterprises have many aspects of advantages, such as lowering WIP, upgrading production flexibility, strengthening quality control ability and so on (Liao 2005). Besides operation efficiency, LP also has an active impact on financial performance. Fullerton et al. (2003) got the conclusion that lean implementation can brought enterprise high profitability, including return on assets, return on sales and cash flow margin (Fullerton et al. 2003). The third aspect is non-financial performance. Although this aspect was often ignored by researcher but it relates to enterprise's long term development. M. Barad and D. Even Spair aware that Toyota Corporation had more stable relation with supplier than enterprises of western countries (Barad and Even Spair 2003). Liker also pointed out that putting much attention to business partner and gave them help as could as possible is one main principle of LP. The study of Gary Andrew O' Dell (2003) showed that Japanese manufacturing enterprises implementing LP performed much better on indexes such as pollutant emission, generation of pollutant and other environmental indexes. So In this paper, manufacturing enterprise's competitiveness will be studied from 3 aspects, including operation efficiency, financial aspect and non-financial aspect.

85.3.3 Data Collection

In data collection, three main ways were used. Firstly, the MBA of Tian Jin University, who engaged in production management, are investigated in written form. Secondly, the questionnaire is emailed to potential respondents, located in

Tian Jin, He Bei, Shan Dong, An Hui and Jiang Su province. Thirdly, field survey. In this manner chief of production management and employee engaged in lean improvement are invited to fill the questionnaire. 500 questionnaires are given out, and 245 effective questionnaires are collected, the recovery rate is 49 %.

85.4 Empirical Study

85.4.1 Data Reliability and Validity

Based on application procedure of SEM, we need to check the reliability and validity of data. In this paper software SPSS18.0 is used to check data's reliability and validity. Firstly, factor analysis is realized by SPSS18.0 and the common factors are got by principal component analysis. During this process, KMO and Bartlett's test are chose to analyze every index. The calculation result shows that KMO of data sample is 0.826 and Bartlett's test's F value reaches significance level at 0.001, which means the data is suitable to factor analysis. Meanwhile, all observed variables' loading coefficient is above 0.69 and common factors' reliability coefficient belong to interval (0.709, 0.815), the contribution rate of accumulative total of variance of the 4 common factors is 76.782 %, these means that the data validity and reliability is favorable. Besides, the analysis result shows the coefficient of Cronbach α to every index is above 0.8, which means the internal consistency of data is good. Analysis result is showed in Table 85.1

Table 85.1 Reliability coefficient and factor analysis result

Measurement items	Factors loadings	Loading coefficient	Reliability coefficient	Rate of accumulative total of variance
Improvement tools	Tools in product design	0.723	0.775	76.782%
	Tools of production process	0.832		
	Tools of field management	0.785		
	Tools of supplier management	0.759		
Lean culture	Supporting of organization	0.826	0.709	
	Reward system of improvement	0.867		
	Improvement atmosphere	0.766		
	Sharing of value	0.797		
Staff factor	Participating improvement	0.782	0.815	
	Career development plan	0.771		
	Team work	0.756		
Enterprises competitiveness	Operation efficiency	0.692	0.759	
	Financial performance	0.757		
	Non-financial performance	0.802		

Table 85.2 Test of model fitting goodness

Fit index	$\chi 2/df$	RMSEA	AGFI	IFI	NFI	CFI
Fitted value	2.21	0.042	0.906	0.931	0.917	0.925
Adaptation standard	<3	<0.05	>0.90	>0.90	>0.90	>0.90

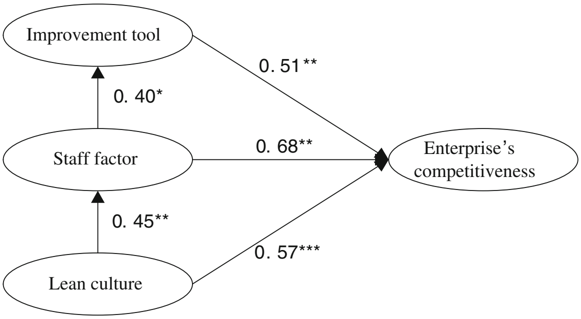

Fig. 85.2 Path loading coefficient

85.4.2 Model-Fitting Degree Analysis

After satisfying measurement requirements, this paper does statistical test to concept model showed in Fig. 85.1, using software AMOS 17.0. Analysis result is listed in Table 85.2, which shows that the fitting degree of concept and the data is favorable.

85.4.3 Path Coefficient Analysis

Figure 85.2 shows that except the path coefficient (045) of staff factor to improvement tool merely arrives a = 0.05 significance level, all other coefficients reach a = 0.01 significance level, especially the coefficient of lean culture to enterprise's competitiveness arrives a = 0.001 significance level. So the five hypotheses put forward in this paper are all supported. The Fig. 85.2 shows both the direct and indirect influence of lean dimension to manufacturing enterprise competitiveness. Concretely, to improvement tool, its direct influence is 0.51 and indirect influence is 0, so its comprehensive influence to competitive is 0.51; to staff factor, its direct influence is 0.68 and indirect influence is $0.40 \times 0.51 = 0.204$, so its comprehensive is 0.884 and to lean culture, its direct influence is 0.57, indirect influence is $0.45 \times 0.68 = 0.306$, so its comprehensive influence is 0.876.

85.5 Conclusion

This paper studies the relation of LP and manufacturing enterprise's competitiveness from systematic angle, which no longer confine LP to improvement tool. The analysis result tells us that all the three dimensions have positive effect to manufacturing enterprises' competitiveness. So in implementing LP, the enterprises should not ignore whichever aspect. As to staff factor, it has both direct and indirect effect to manufacturing enterprises' competitiveness, and its comprehensive influence coefficient is maximal in the three aspects, so the enterprises should put much emphasis on this aspect, taking measures to encourage employee to take part in improvement, perfecting their career development plan and encouraging employee to participate all kinds of improvement team. In order to cultivate lean culture, the organization should actively develop dense atmosphere and adjust traditional award system to adapt to lean implementation. Improvement tool, which has been gave much attention by researcher and enterprises, has direct effect to upgrading enterprise competitiveness, but in lean implementation, the implementer should not limit it to production link merely, much more emphasis should be put to improvement tool about facility layout, supplier and customer management.

In a word, the study of this paper will rich the theory of LP and has an active part for successfully implementing LP in China. But confined to ability and time, the study of this paper is not deep enough, related study can be done further. Firstly, the investigation sample mainly distribute in Tian Jin, He Bei, An Hui, Shan Dong and Jiang Su, so if the range of investigation is enlarged the result may be different. Secondly, the study of this paper is done under comprehensive dimension, so if the study refines to specific index under every dimension, the result will be much richer.

Acknowledgments This work is financially supported by national natural science foundation of China (71071107) as well as education department of An Hui province of China (SK2012B085).

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Chapter 86
Mobile Device User Research in Different Usage Situation

Wei Liu and Jiu-zhou Li

Abstract In this paper, we report the difference of users' cognition and operating efficiency in three typical situations, such as noisy, dark, walking condition. The single-factor experiment's result data suggest noisy effects mobile user's cognition significantly, and walking situation will affect users' performance to some extent, but user experience does not relevant to different situation.

Keywords Mobile device · Operating efficiency · User cognition · User experience

86.1 Introduction

With the rapid development of mobile devices and mobile Internet, user has entered the "experience economy era" (Luo 2010). The great successes of the Apple's range of products proved user-centered-design and great attention paid on user experience are very important for a company. Compared to product in other area, mobile devices are been used in a more complex environment. And user's cognition, operating efficiency and subjective experience are not the same in different situation. Mobile device screen space is also an important factor distinguished from other products in the field. How to improve the user experience is a very challenging task.

In this paper, we study mobile users' cognition, operating efficiency and user experience in there different typical situations, aiming to provide basis to enhance mobile device user experience.

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E. Qi et al. (eds.), *The 19th International Conference on Industrial Engineering and Engineering Management*, DOI: 10.1007/978-3-642-38391-5_86,

86.1.1 User Experience of Mobile Device

An abstract definition of the user experience: users' all aspects of perception when they interact with products and services (UPA 2006). Garrett thinks that the user experience includes brand characteristics, information availability, and functionality, content and other aspects of experience. Mobile user experience involves a wide range, in addition to hardware, now more concern is paid on the operating system, applications, and interface design experience.

86.1.2 User Context Cognitive Psychology

Situated cognition theory thinks the cognitive process is constructed by the situation, guidance and support, and individuals' psychology usually active in the context (Du 2007). When people use mobile devices, their brain is composed by attention, comprehension and retention. Attention can be divided into centralized, decentralized, and transfer. While there is a clear demand or potential interests, user tends to be concentrated. But when there is interference information and time is uncontrollable, they will be distracted. User will transfer their attention to explore information. Fitts's Law suggests that reducing the distance between the starting position to the target distance and increasing the size of target can accelerate the speed user find the target (Luo 2010). User's operation habits and interaction expectation own its unique mental model when they using mobile device.

86.1.3 Operating Ergonomics of Mobile Users

Efficiency is the indicator to measure the relationship between correctness of user task and the degree of completion with the amount of resources used to complete the task. In the field of mobile device interaction, efficiency can be considered as: high efficiency means users complete the task goals with fewer operations and less time (Ingwersen 2000). The methods to evaluating performance on mobile device include focus groups, cognitive path method, and heuristic evaluation. User performance testing is to observe and analyze the performance of the user's actions under the experimental conditions (Du 2007).

86.1.4 Experiment Purposes

This paper studies in different situation mobile device (In this paper, refers to the cell phone) users' cognitive, operating ergonomics and user experience differences, aiming to provide a theoretical basis for the mobile design. This study belongs to the scope of psychology and ergonomics, and we analysis experimental quantitative data and supplemented by qualitative methods in the experiment.

86.2 Methodology

86.2.1 Experiment and Participants

24 participants (11 males and 13 females), who are 22–25 years old, and familiar with mobile phones, with a certain touch-screen mobile phone operating experience, but never use HTC Desire HD, phones with Android 2.3 operating system and 365 curriculum applications. Their vision is normal and corrected visual acuity above 1.0, right-handed. After a brief study, all of them can cooperate with host to complete the test and questioners independently. They never participated in similar experiments.

86.2.2 Experiment Apparatus

In this paper, we use the HTC Desire HD phone which screen size is 4.3 inches, resolution is 480 * 800 px, and operation system is Android 2.3.2. All the experiment is been hold in a lab where participants can walk small-scale.

86.2.3 Experiment Material

Experiment materials include four Icon list picture, 365 curriculums Version1.1 (Android), the availability of subjective evaluation questionnaire and user experience evaluation questionnaire (Figs. 86.1 and 86.2).

86.2.4 Experiment Design

The experiment use single-factor methods to divide participants into three experimental groups and control group by different usage scenarios. Experimental

Fig. 86.1 HTC Desire HD and 365 curriculum applications

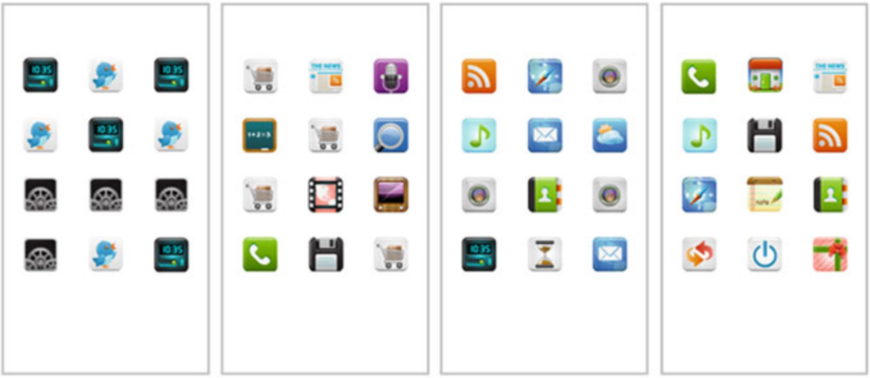


Fig. 86.2 Pictures of icon table

group variables are noisy, dark and waking situation (Yamabe 2007). Control group participants have test in light-sufficient, place-fixed, and quiet indoor. The users just participate in one group. After the experiment, all participants complete subjective assessment questionnaire (Fig. 86.3).

86.2.5 Experiment Procedure

Each participant is tested separately. After completing basic personal information form, host tell participant about the experiment procedure and precautions.

First part of the experiment is icon list testing. Before the start, participant learns icons' meanings. In the formal experiment, participant browse four picture of icon list successively on the phone at a stipulated time. Then they need to

Fig. 86.3 Experiment in four different situations

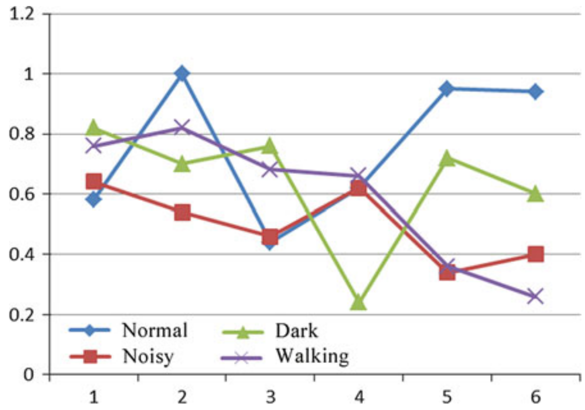
answer some questions about the pictures. Those questions are used to measure participants' cognition.

Experiment second part is testing participants' performance of operating 365 curriculum application. Before the experiment, participants have some time to use the application indecently. In the formal experiment, there are three tasks for participants to complete. The first is to find the timetables of the day, at the meantime host records the time participants used to complete the task. Then participants need to answer two questions about the operation. The second task is to remove the day of a lesson, also host records the time to complete the task. The third task is to set the personal information, and host records the time. After completing those tasks, participants have to fill in the form of testing subjective experience. The form is 7-point scale and has 10 questions.

86.2.6 Data Processing

In this paper, we give task performance and experience evaluation different weights according to participants' interviews (Li 2009). As to operating performance evaluation experiment, task 1, task 2 and task 3 are set to 0.4, 0.2 and 0.4.And Assessment of user experience five measure, icon test experience degrees, test experience degrees, mobile phone experience degrees, mental state, experimental performance of the self-assessment are set to 0.25, 0.35, 0.20, 0.15, 0.05 according to experts suggests. We use SPSS 17 for data management and analysis.

Fig. 86.4 User cognition comparison among four different situations



86.3 Results

86.3.1 The Effect of Situation to Cognition

After standardizing the data of each group answers to objective questions, the result shows in Fig. 86.4. It suggests participants' cognition have certain differences between the four groups, and the best one is control group which are without any interferences, on the opposite side, the noisy group's cognition is lowest.

Table 86.1 shows the result of experiment data to two-tailed T-test. The bilateral Sig $= 0.049 < 0.05$ of noisy group data to the control group data suggests in the 95 % significance level, the noisy group's cognition are significantly different to that of control group. It means noisy satiation impact on user cognition greatly.

86.3.2 The Effect of Situation to Operating Performance

The results of homogeneity of variance, multiple comparisons to the three experiment groups with control group show in Table 86.2. Comparing with three experiment groups' operating time with that of control group, the significances are larger than 0.1. It means noisy, dark and walking environment doesn't impact operating performance significantly.

Figure 86.5 shows the three variables of the experiment don't impact users' operating performance significantly. But walking user need more time to complete the task than other groups.

Table 86.1 User cognition T test in four different situations

	N	AV	SD	Sig
Normal	6	0.755	0.238	None
Noisy	6	0.500	0.121	0.049
Dark	6	0.640	0.209	0.393

Table 86.2 User performance multiple test in four different situation

	N	AV	SD	Sig
Normal	6	10.053	1.676	None
Noisy	6	9.907	2.816	0.049
Dark	6	11.360	3.055	0.393
Walking	6	12.440	3.670	0.246

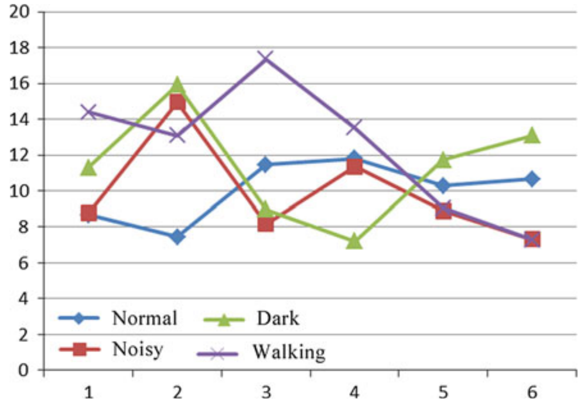


Fig. 86.5 User performance comparison among four different situations

86.3.3 The Effect of Situation to User Experience

In this paper, we use several aspects to assess the degree of the overall user experience by setting weights to aspects.

Figure 86.6 suggests that the overall experience evaluation of the four groups in the experiment is not much difference. Probably the user experience of the evaluation itself is a subjective evaluation, so the evaluation of the product due to different user groups will be very different.

86.4 Discussion

According to the analysis to the experiment data, noisy, dark and walking situation have a certain on mobile users' cognition, operating performance and user experience.

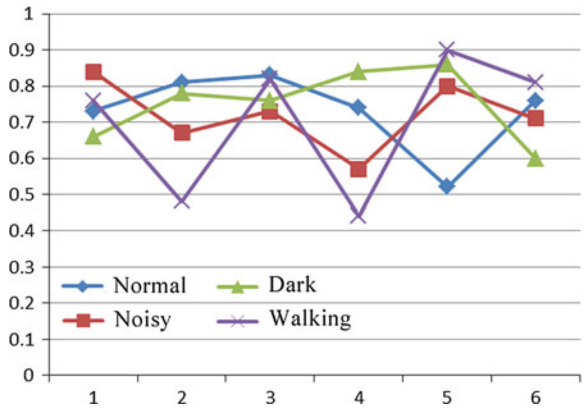


Fig. 86.6 User experience comparison among four different situations

Table 86.3 Comparison between noisy and normal situation

	Cognition	Performance	User experience
Noisy	0.500	9.907	0.720
Normal	0.755	10.053	0.732
Sig	0.049	0.931	0.849

Table 86.4 Comparison between dark and normal situation

	Cognition	Performance	User experience
Noisy	0.640	11.360	0.750
Normal	0.755	10.053	0.732
Sig	0.393	0.444	0.772

In a noisy environment, users' cognition is lower than that of users in normal situation, but there are little difference between operating performance and level of user experience. So designers need to consider users' the lower awareness in noisy situation, and arrange interface information reasonably, such as reducing the information in mobile interface (Table 86.3).

In dark environment, mobile users' cognition, operating performance and the degree of user experience is not much different with those in normal situation, so designer need a more in-depth understanding of the user needs, such as adjusting the screen brightness interface style (Table 86.4).

Table 86.5 shows that in the walking situation operating performance and user experience difference is not significant, but compared to the other two, in walking situation the user's operating performance have significant difference. So designers should focus on users' depth needs in the walking situation, adjusting the structure of the interface, and simplify the task of the interactive process, which can enhance the user experience on the equipment.

Table 86.5 Comparison between walking and normal situation

	Cognition	Performance	User experience
Noisy	0.590	12.440	0.702
Normal	0.755	10.053	0.732
Sig	0.246	0.169	0.748

86.5 Conclusion

The experiment studies in different situation, the difference of mobile device (This article refers to the cell phone) users' cognitive, operating performance and user experience. The experiment uses methods of control groups and the single factor control to analysis the experiment data. And the result of experiment shows the impact of noise on the cognitive situation of mobile device users significantly; while the walking environment has a certain impact on the user's operating performance. The impact of different situations to user experience is not significant. Actual design should analysis the characteristics of the product and the users' own characteristics deeply.

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Chapter 87
Optimal Enterprise Cash Management Under Uncertainty

Xiao-yun Wei and Li-yan Han

Abstract We present a dynamic model for enterprise cash management under uncertainty. The numerical method was used to obtain optimal level of cash holding. The results show that higher yield volatility of financial assets, liquidation cost of financial assets and coefficient of risk aversion will raise the demand for cash. It also shows that the optimal choice of inter-temporal model is different from that of single-period model. The former makes the manager choose to hold more cash. The reason is that long-horizon managers have an intrinsically larger need for cash to quell possible transaction and precautionary demand.

Keywords Cash management · Financial assets · Uncertainty

87.1 Introduction

Optimization models for cash management can be divided into two main groups based on objection function. The first deals with demand by cost-benefit or loss-benefit analysis, pioneered by Baumol–Tobin model (Baumol 1952; Tobin 1956), and extended, among others, by Frenkel and Jovanovic (1980, 1981), Bar-Ilan (1990), Dixit (1991), Ben-Bassat and Gottlieb (1992), Chang (1999) and Perry and Stadje (2000). In this approach the optimal demand for cash is decided by the trade-off between opportunity cost and benefits of cash holding. The second category of models concerns the demand by drift control theory, pioneered by Miller and Orr (1966), and extend by Bar-Ilan et al. (2004), Bar-Ilan and Lederman (2007).

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E. Qi et al. (eds.), *The 19th International Conference on Industrial Engineering and Engineering Management*, DOI: 10.1007/978-3-642-38391-5_87,

However, the authors above mainly consider cash only and they consider either single period or infinite horizons only. In this paper, we present a model to obtain the optimal allocation ration between cash and financial assets based on utility maximization for different horizons. The model departs from portfolio choice theory (Barberis 2000), Aizenman and Lee (2007) and multi-period newsboy model (Matsuyam 2006), and instead emphasizes the importance of cash in providing insurance for bankruptcy.

The rest of paper is organized as follows. In Sect. 87.2 we introduce the framework of cash management. A numerical example is presented particularly to calibrate our model in Sect. 87.3. Section 87.4 offers some concluding remarks.

87.2 The Model

We assume the manager, as a centralized decision maker in the enterprise, determines the split of the given level of assets W_t between cash and financial assets, where R_t and S_t denote two assets in the end of t period respectively. The enterprise has to meet the demand for payments such as transaction and debt repayment thus to reduce the probability of a possible bankruptcy. Then enterprise generally put its cash in commercial bank or purchase government bonds in order to seek greater security and liquidity but lower risk-free return. In contrast, the manager will typically pursue higher return by investing the remaining assets in risky long-term assets such as longer-term government bonds, stocks, corporate bonds, oil, minerals and real estate. The objective of the manager is to earn more profit on the basis of enterprise stability. The question, which is concerned, is to maximize the enterprise's utility function. In order to formulate this problem, the dynamics of the total assets W_t of enterprise will be introduced.

Consider we are at initial time 0 and want to write down the allocation problem for a manager with a horizon of t periods. We suppose the real annually interest rate on cash is $r_{f,t}$. The return on financial assets $r_{s,t}$ is assumed to follow an independently identical distribution, and $\mathrm{cov}\left(r_{s,s}, r_{s,t}\right) = 0,\ \forall s \neq t, s, t = 1, 2, 3\ldots$ Except the fundamental function of cash for transaction and debt payments, another function is to enhance confidence of investors, which is not considered by Bar-Ilan et al. (2004). This is the paradox of cash management—the more cash holdings, the lower may be the demand for them. Then the real demand for cash in period t, Y_t is given by

$$Y_t = g(X_t,\ R_{t-1}, S_{t-1}) \tag{87.1}$$

where X_t, with a corresponding density function $f(X_t)$, is the value of demands when the enterprise has no cash and financial assets. Then we have $g(X_t,\ 0,\ 0) = X_t$. And Y_t is a strictly increasing function of X_t and decreasing function of R_{t-1} and S_{t-1}. The joint density function for $(X_1, X_2, X_3, \ldots, X_t)$ is given by

$$f(X_1, X_2, X_3, \ldots, X_t) = \prod_{n=1}^{t} f(X_n) \tag{87.2}$$

In other words, the distributions of X_n and $X_m (n \neq m)$ are independent each other. We assume that L_t and C_t are lower and upper bound of demand X_t, and $l_t = L_t / W_{t-1}$, $c_t = C_t / W_{t-1}$.

If cash holding R_{t-1} at the end of period $t - 1$ or at beginning of period t is higher than the demand Y_t in period t, the remaining cash $R_{t-1} - Y_t$ will earn $r_{f,t}$ rate of return and financial assets S_{t-1} earn $r_{s,t}$ rate of return. When R_{t-1} is lower than Y_t, the liquidation takes place and the level of cash reduces to zero. θ_t is the liquidation cost which must be paid for a unit of cash when the demand can't be complied with. Then $(Y_t - R_{t-1})(1 + \theta_t)$ units of financial assets must be liquidated to obtain $Y_t - R_{t-1}$ units of cash. We denote $\omega_t = R_{t-1}/W_{t-1}$ is the allocation ratio to the cash at the beginning of period t. $y_t = Y_t / W_{t-1}$ is the proportion of demand for cash to total assets W_{t-1} at the end of period $t - 1$. Thus if t is larger than 1, ω_t is decided passively. Then W_t is given by the following expressions (87.1)–(87.3), where the first subscript of W_t and ω_t denotes the period and the second subscript denotes the scenario.

(1) $t = 1$

$$\begin{aligned} y_1 \leq \omega_1 &\Rightarrow W_{1,1} = W_0\left[(\omega_1 - y_1)\left(1 + r_{f,1}\right) + (1 - \omega_1)\left(1 + r_{s,1}\right) + y_1\right]; \\ y_1 > \omega_1 &\Rightarrow W_{1,2} = W_0\left\{[(1 - \omega_1) - (y_1 - \omega_1)(1 + \theta_1)]\left(1 + r_{s,1}\right) + y_1\right\}; \end{aligned}$$

(2) $t = 2$

$$\begin{aligned} & y_1 < \omega_1,\ y_2 < \omega_{2,1} \Rightarrow \\ & \omega_{2,1} = \frac{W_0(\omega_1 - y_1)\left(1 + r_{f,1}\right)}{W_{1,1}}; \\ & 1 - \omega_{2,1} = \frac{W_0(1 - \omega_1)\left(1 + r_{s,1}\right)}{W_{1,1}}; \\ & W_{2,2} = W_{1,1}\left\{\left[\left(1 - \omega_{2,1}\right) - \left(y_2 - \omega_{2,1}\right)(1 + \theta_2)\right]\left(1 + r_{s,2}\right) + y_2\right\}; \end{aligned}$$

$$y_1 > \omega_1,\ y_2 < \omega_{2,2} \Rightarrow$$
$$\omega_{2,2} = 0;$$
$$1 - \omega_{2,2} = \frac{W_0 \begin{bmatrix} (1-\omega_1)- \\ (y_1 - \ \omega_1)(1+\theta_1) \end{bmatrix} \left(1 + r_{s,1}\right)}{W_{1,2}};$$
$$W_{2,3} = W_{1,2} \begin{bmatrix} \left(\omega_{2,2} - y_2\right)\left(1 + r_{f,2}\right) \\ + \left(1 - \omega_{2,2}\right)\left(1 + r_{s,2}\right) + y_2 \end{bmatrix};$$

$$y_1 > \omega_1,\ y_2 > \omega_{2,1} \Rightarrow$$
$$\omega_{2,2} = 0;$$
$$1 - \omega_{2,2} = \frac{W_0 \begin{bmatrix} (1-\omega_1)- \\ (y_1 - \ \omega_1)(1+\theta_1) \end{bmatrix} \left(1 + r_{s,1}\right)}{W_{1,2}};$$
$$W_{2,4} = W_{1,2} \left\{ \begin{bmatrix} \left(1 - \omega_{2,2}\right)- \\ \left(y_2 - \omega_{2,2}\right)(1+\theta_2) \end{bmatrix} \left(1 + r_{s,2}\right) + y_2 \right\};$$

$$y_1 > \omega_1,\ y_2 > \omega_{2,1} \Rightarrow$$
$$\omega_{2,1} = \frac{W_0(\omega_1 - y_1)\left(1 + r_{f,1}\right)}{W_{1,1}};$$
$$1 - \omega_{2,1} = \frac{W_0(1 - \omega_1)\left(1 + r_{s,1}\right)}{W_{1,1}};$$
$$W_{2,1} = W_{1,1}\left[(\omega_{21} - y_2)\left(1 + r_{f,2}\right) + \left(1 - \omega_{2,1}\right)\left(1 + r_{s,2}\right) + y_2\right];$$

(3) t

Let a set R^+ be defined by

$$R^+ = \{a | a \geq 0, a \in R\}$$

Where R denotes a set of all real numbers. Moreover, A_t and B_t, $t = 1, 2, 3\ldots$, are defined by

$$A_t = \{y_t | y_t \leq \omega_t, y_t \in R\},\ B_t = R^+ - A_t$$

Then we denotes

$$\begin{aligned}
&\Omega_1 = A_1 \times A_2 \times \cdots \times A_t \ , \\
&\Omega_2 = A_1 \times A_2 \times \cdots \times A_{t-1} \times B_t \ , \\
&\cdots \\
&\Omega_{2^t-1} = B_1 \times B_2 \times \cdots \times B_{t-1} \times A_t \ , \\
&\Omega_{2^t} = B_1 \times B_2 \times \cdots \times B_t .
\end{aligned}$$

$$y = (\mathbf{y}_1, y_2, \ldots, y_t)^T$$

$$\begin{aligned}
&\mathbf{y} \in \boldsymbol{\Omega}_1 \Rightarrow \\
&\omega_{t,1} = \frac{W_{t-2,1}\left(\omega_{t-1,1} - y_{t-1}\right)\left(1 + r_{f,t-1}\right)}{W_{t-1,1}}; \\
&1 - \omega_{t,1} = \frac{W_{t-2,1}\left(1 - \omega_{t-1,1}\right)\left(1 + r_{s,t-1}\right)}{W_{t-1,1}}; \\
&W_{t,1} = W_{t-1,1}\left[\begin{array}{l} \left(\omega_{t,1} - y_t\right)\left(1 + r_{f,t}\right) \\ + \left(1 - \omega_{t,1}\right)\left(1 + r_{s,t}\right) + y_t \end{array}\right];
\end{aligned}$$

$$\begin{aligned}
&y \in \boldsymbol{\Omega}_2 \Rightarrow \\
&\omega_{t,1} = \frac{W_{t-2,1}\left(\omega_{t-1,1} - y_{t-1}\right)\left(1 + r_{f,t-1}\right)}{W_{t-1,1}}; \\
&1 - \omega_{t,1} = \frac{W_{t-2,1}\left(1 - \omega_{t-1,1}\right)\left(1 + r_{s,t-1}\right)}{W_{t-1,1}}; \\
&W_{t,2} = W_{t-1,1}\left\{\left[\begin{array}{l} \left(1 - \omega_{t,1}\right) - \\ \left(y_t - \omega_{t,1}\right)\left(1 + \theta_t\right) \end{array}\right]\left(1 + r_{s,t}\right) + y_t\right\};
\end{aligned}$$

……

$$\begin{aligned}
&y \in \boldsymbol{\Omega}_{t-1} \Rightarrow \\
&\omega_{t,2^{t-1}} = 0; \\
&1 - \omega_{t,2^{t-1}} = \frac{W_{t-2,2^{t-2}}\left[\begin{array}{l} \left(1 - \omega_{t-1,2^{t-1}}\right) - \\ \left(y_{t-1} - \omega_{t-1,2^{t-1}}\right)\left(1 + \theta_{t-1}\right) \end{array}\right]\left(1 + r_{s,t-1}\right)}{W_{t-1,2^{t-1}}}; \\
&W_{t,2^t-1} = W_{t-1,2^{t-1}}\left[\begin{array}{c} \left(\omega_{t,2^{t-1}} - y_t\right)\left(1 + r_{f,t}\right) \\ +\left(1 - \omega_{t,2^{t-1}}\right)\left(1 + r_{s,t}\right) + y_t \end{array}\right];
\end{aligned}$$

$$y \in \Omega_t \Rightarrow$$
$$\omega_{t,2^{t-1}} = 0;$$
$$1 - \omega_{t,2^{t-1}} = \frac{W_{t-2,2^{t-2}}\left[\begin{array}{c}\left(1-\omega_{t-1,2^{t-1}}\right)- \\ \left(y_{t-1}-\omega_{t-1,2^{t-1}}\right)\left(1+\theta_{t-1}\right)\end{array}\right]\left(1+r_{s,t-1}\right)}{W_{t-1,2^{t-1}}} = 1;$$
$$W_{t,2^t} = W_{t-1,2^{t-1}}\left\{\left[\begin{array}{c}\left(1-\omega_{t,2^{t-1}}\right)- \\ \left(y_t-\omega_{t,2^{t-1}}\right)\left(1+\theta_t\right)\end{array}\right]\left(1+r_{s,t}\right)+y_t\right\};$$

The manager's preferences over terminal wealth are described by constant relative risk-aversion utility functions of the form

$$u(W_t) = \frac{W_t^{1-A}}{1-A} \tag{87.3}$$

The manager's problem is to solve equation

$$\begin{aligned} V(W_t) &= \max_{\omega_1} E\left(E_0\left(u(W_t)\middle| r_{s,1}, r_{s,2}, \ldots, r_{s,t}\right)\right) \\ &= \max_{\omega_1} E\left\{\left[\begin{array}{c} \int_{\Omega_1} u\left(W_{t,1}\right)h(y)dy \\ + \int_{\Omega 2} u\left(W_{t,2}\right)h(y)dy\ldots \\ + \int_{\Omega_{2^t}} u\left(W_{t,2^t}\right)h(y)dy \end{array}\right] | r_{s,1}, r_{s,2}, \ldots, r_{s,t}\right\} \end{aligned} \tag{87.4}$$

Where $\max\limits_{\omega_1}$ denotes the problem is solving the optimal ω_1^*, and denotes the fact that the manager calculates the expected return from the beginning of period 1 on. E is the expectation operator of $r_{s,t}$. $h(y)$ is the joint density function for $(y_1, y_2, y_3, \ldots, y_t)$.

When budget constraint binds, that is, $(1-\omega_t) - (y_t - \omega_t)(1+\theta_t) < 0$, the final wealth in period t is 0. Now even though the manager liquidates all financial assets, they could not satisfy the payments, the bankruptcy is likely to occur.

87.3 Numerical Example

The numerical solution is solved as follows. We assume

$$\begin{aligned} &P(X_t = i) = 0.25,\ i = 1, 2, 3, 4\ , \\ &P\left(r_{s,t} = 0.03\right) = P\left(r_{s,t} = 0.08\right) = 0.5,\ L_t = 1,\ H_t = 4\ , \\ &Y_t = X_t - 0.005R_{t-1} - 0.002S_{t-1} \text{ and } W_0 = 12\ , \\ &r_{f,t} = 0.04,\ \theta_t = 0.5,\ A = 5,\ \ t = 1, 2, 3, 4, 5, 6. \end{aligned}$$

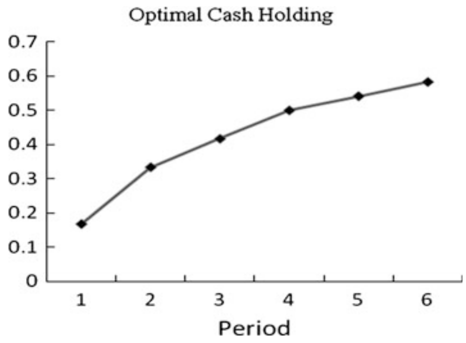

Fig. 87.1 Optimal allocation to cash for different horizons

The simulation results are reported in Fig. 87.1. The optimal ω_1 maximizes the function (87.4).

The results show that the optimal choice of inter-temporal model is different from that of single-period model. The former makes the manager choose to hold more cash. The reason is long-horizon managers has an intrinsically larger need for cash to quell possible transaction and precautionary demand. And we also conclude that higher yield volatility of financial assets, liquidation cost of financial and coefficient of risk aversion will raise the demand for cash. For saving space, we omitted the figure in the paper.

87.4 Concluding Remarks

This paper presents a dynamic model for enterprise cash management under uncertainty. The numerical method was used to obtain optimal level of cash holdings. The results show that higher yield volatility of financial assets, liquidation cost of financial assets and coefficient of risk aversion will raise the demand for cash. It also shows that the optimal choice of inter-temporal model is different from that of single-period model. The former makes the manager choose to hold more cash. The reason is long-horizon managers has an intrinsically larger need for cash to quell possible transaction and precautionary demand.

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Chapter 88
Problem Analysis and Optimizing of Setting Service Desks in Supermarket Based on M/M/C Queuing System

Chun-feng Chai

Abstract Queuing problem is an important factor that affects operation level and efficiency of the supermarket. To solve the queuing issue properly through effective measures has become a top priority for supermarket. This paper provides reference for decision at the issue of optimizing the quantity of service cashier desks, improving service efficiency and decreasing operating costs. It analyses Supermarket cashier system queuing issues through establishing M/M/C queuing model on basis of operation research.

Keywords M/M/C queuing model · Operation research · Optimization of queuing system · Queuing theory

88.1 Introduction

In general we do not like to wait. But reduction of the waiting time usually requires extra investments. To decide whether or not to invest, it is important to know the effect of the investment on the waiting time. So we need models and techniques to analyze such situations (Adan and Resing 2001). Going shopping in the supermarket during spare time has become a kind of our life habit today popular with supermarket. We enjoy the life of shopping, also are worried about the problems of supermarket cashier service system. Less opening number of cashier desks will lead to more customers waiting for too long service, which will cause the customer dissatisfaction and running away. If the supermarket opens too many service desks, it can reduce customer's waiting time and length of line, but this will increase the supermarket operating costs. The supermarket operator must

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E. Qi et al. (eds.), *The 19th International Conference on Industrial Engineering and Engineering Management*, DOI: 10.1007/978-3-642-38391-5_88,

consider how to balance the two factors. As the deal terminal between supermarket and consumer, the service desk has a direct influence on the image of the service quality and efficiency. Also it can affect the operation level and efficiency of the whole supermarket. Therefore, how to dynamically and reasonably arrange the number of service desks according to the customer flow and the time needed and how to balance the customer satisfaction and operational cost, are the problems which should be solved by the enterprise.

88.2 Methodology

88.2.1 M/M/C Queuing Models

Queuing theory, as a branch of the operational research, is a mathematical theory and method which research system of gather phenomenon and random service system work process, also called the stochastic service system theory. M/M/C queuing model (see Fig. 88.1) assume service system having the following features (Mandelbaum and Hlynka 2009).

The interval of customer reaching the service desks stochastically obeys parameter λ (>0) index distribution. That means that a single customer reached service desks independently at random according to Poisson Distribution, by Poisson distribution definition, there are λ average arriving customers in unit interval. When customer approach to the desk, if the desk is spare, customers immediate get the service, and if the service desk are busy, the customer wait in line until a desk gets leisure. Queuing rules obey first-come- first- service, and customers leave after getting service. Assuming service system capacity is infinite, and there are C desks working independently for each other, and service time obeys negative exponential distribution with parameters μ (>0). Generally speaking, evaluation index are average length of line and the average waiting time (Hlynka 2010; Takacs 1962).

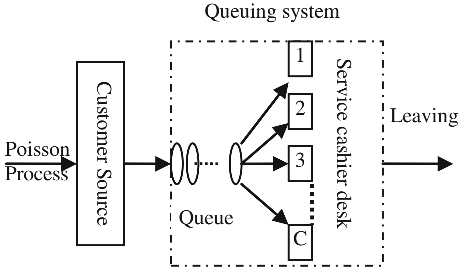

Fig. 88.1 M/M/C queuing model

88.2.2 Model Assumption

Any queuing system is consist of three parts. They are respectively input process, queuing discipline and service agency. From these three parts, a hypothesis for Supermarket cashier service system can be made (Yan 2012).

88.2.2.1 Input Process

The hypothesis of input process is mainly for the customer getting to the supermarket cashier service system (Zheng and Gu 2005). First of all, customer source is infinite. Secondly, in the description of the features, customer reaching cashier desk is random and independent. Besides, the following features can be learned: the arrival of the customer numbers any time has nothing to do with arriving moments, but only with the time interval; the probability of the arrival of two customers at the same time is almost zero. Through the above analysis, it can assume that the input process of supermarket cashier service system is a Poisson process and that the number of arrival customers in unit interval meets Poisson distribution with parameters λ.

88.2.2.2 Queuing Discipline

The customer to the supermarket cashier service system is random. If there is free service, then into service; if not, then the customers wait in line. If Supermarket layout rationally, the space is enough without jams, the customers will generally choose the shortest lines to wait for service (Wang and Miao 2012). When the other lines get shorter while waiting, the customers will change the line immediately, so the queuing discipline of cashier service system in supermarket is the rules of first- come- first- service in waiting rules (Huang and Xiao 2009).

88.2.2.3 Service Agency

There are C check stands in the supermarket and work independently among each other. Based on customer order of line up service customer, one customer is served once. Because the goods kinds and number customers brought are different, the service time of check stand is random. The service time of check stand of supermarket can be assumed to meet the negative exponential for the μ parameter (Liu and Liu 2009).

88.2.3 Establishing the Model

According to the above analysis and assumptions established, we know that in the system there are C working check stands, arrival of the customer meet the λ Poisson distribution. The service time of every customer is independent and meets the negative exponential for the μ parameter. System capacity infinite. If the service window is busy when customer arrives, then wait. The Supermarket cashier queuing system is a M/M/C queuing system (Deng 2000; Liu et al. 2011).

According the Little formula to set parameters ρ service intensity, λ as customer arrival rate, μ as average service time, c is the number of cashier open. When $\rho < 1$, the system can achieve a steady state, and has a smooth distribution (Li et al. 2000; Zhou 2011).

$$P_0 = \left[\sum_{k=0}^{c-1} \frac{1}{k!} \left(\frac{\lambda}{\mu} \right)^k + \frac{1}{c!} \cdot \frac{1}{1-\rho} \cdot \left(\frac{\lambda}{\mu} \right)^c \right]^{-1} \tag{88.1}$$

$$P_k = \begin{cases} \frac{c^k}{k!} \rho^k P_0 & 0 \le k < c \\ \frac{c^c}{c!} \rho^k P_0 & k \ge c \end{cases} \tag{88.2}$$

Through analysis of the system, the following corresponding target parameters can be drawn (Sun 2007).

Average waiting length of team:

$$L_q = \frac{(c\rho)^c \rho}{c!(1-\rho)^2} P_0 \tag{88.3}$$

The average of system length of team (or the average number of customers waiting in the system)

$$L = L_q + \frac{\lambda}{\mu} = \frac{(c\rho)^c \rho}{c!(1-\rho)^2} P_0 + \frac{\lambda}{\mu} \tag{88.4}$$

Average waiting time for the customer in the system:

$$W_q = \frac{L_q}{\lambda} \tag{88.5}$$

Average staying time for the customer in the system

$$W = \frac{L}{\lambda} = W_q + \frac{1}{\mu} \tag{88.6}$$

When the system is stable, if less than the longest average waiting time and team length customer can endure, the supermarket opened the least service desks, which not only can get customer satisfaction, and also reduce the operation cost of the supermarket. Here firstly supposing the longest waiting time is T1, the longest team length customer can endure is L1, from the above analysis, the conclusion is as follows (Miller 1981; Zhang et al. 1997).

The system can run normally, that is, service intensity $\rho < 1$; the waiting time is less than the longest waiting time, that is $W_q \leq T_1$; the wait queue length is smaller than the longest, that is $L_q \leq L_1$.

Only the minimum service unit who meet the three requirements will be the best. Among them, C is unknown and λ, μ, T1, L1 is known, so P_0 is known. The model of checkout counter can be described by the following model is:

$$c^* = \min\left\{ c \,\middle|\, \rho = \frac{\lambda}{c\mu} < 1, W_q = \frac{(c\rho)^c \rho}{\lambda c!(1-\rho)^2} P_0 \leq T_1, L_q = \frac{(c\rho)^c \rho}{c!(1-\rho)^2} P_0 \leq L_1 \right\} \tag{88.7}$$

The constraint condition is:

$$\begin{cases} \rho = \dfrac{\lambda}{c\mu} < 1 \\ W_q = \dfrac{(c\rho)^c \rho}{\lambda c!(1-\rho)^2} P_0 \leq T_1 \\ L_q = \dfrac{(c\rho)^c \rho}{c!(1-\rho)^2} P_0 \leq L_1 \\ \lambda, c, \mu, T_1, L_1 \geq 0 \end{cases} \tag{88.8}$$

Among them, λ, μ, T1, L1 are all known and c is unknown. c* is the best number of service units. After optimization, the average wait time and average wait queue length in the system respectively are:

$$W_q = \frac{(c^*\rho)^{c^*} \rho}{\lambda c^*!(1-\rho)^2} P_0 \tag{88.9}$$

$$L_q = \frac{(c^*\rho)^{c^*} \rho}{c^*!(1-\rho)^2} P_0 \tag{88.10}$$

88.3 Data Collect and Analysis

88.3.1 Data Collect

According to the survey of customer flow and service time in the supermarket, the supermarket whose business hour is from 8 to 22, for a total of 14 h, had 50 checkout counters. The research time was various parts of the day in weekend and weekdays. In each time slot, we conducted random surveys of 200 unit time (each

Table 88.1 Arrival rate of customers in each time slot and the number of available checkout counters

Time interval	Arrival rate of customers(people/h)		Number of service desks	
	Weekday	Weekend	Weekday	Weekend
8:00 ~ 9:00	756	840	15	16
9:00 ~ 10:00	984	1116	15	16
10:00 ~ 11:00	1332	1536	22	24
11:00 ~ 12:00	1524	1560	24	24
12:00 ~ 13:00	1296	1620	22	25
13:00 ~ 14:00	1380	1656	22	25
14:00 ~ 15:00	1524	1884	24	27
15:00 ~ 16:00	1680	2052	26	30
16:00 ~ 17:00	1716	1668	26	25
17:00 ~ 18:00	1668	1908	26	28
18:00 ~ 19:00	1680	1992	26	30
19:00 ~ 20:00	1776	1800	27	27
20:00 ~ 21:00	1980	1524	27	25
21:00 ~ 22:00	1416	852	22	16

unit time is 5 min), the Table 88.1 below is the statistics of the customer arrival situation.

88.3.2 *Data Analysis*

According to the survey, the service time of cashier desk obeys negative exponential distribution with the parameters μ ($\mu = 58.32$). Discussing the working time interval from 9:00 to10:00 as an example, according to the data in Table 88.1, the average service strength of the system for this moment is:

$$\rho = \frac{\lambda}{n\mu} = \frac{984}{15 \times 58.32} = 1.125 > 1 \tag{88.11}$$

This shows that the system has been very crowded at this time, and the customers have to wait for a long time to get service. Now the customers must be not satisfied with the system very much. The reality of the situation is the same, which should be improved.

88.4 Designing of the Prioritization Scheme

In the system, only the service strength $\rho < 1$ the system will reach the balance.

Table 88.2 Service index

Number of service desks	ρ	P_0	L_q	L	W	W_q
17	0.992	$3.8*10^{-9}$	119.5	136.4	0.139	0.121
18	0.937	$2.35*10^{-8}$	10.6	27.47	0.028	0.011
19	0.888	$3.41*10^{-8}$	4.11	20.98	0.021	0.004
20	0.844	$4*10^{-8}$	2.01	18.88	0.019	0.004

When $\rho = \frac{\lambda}{n\mu} < 1$, with $\frac{984}{58.32n} = \frac{16.87}{n} < 1$, got n $\geq$ 17, this means that at least 17 service desks should be open to achieve the system balance state from 9:00 to 10:00.

Taking 9:00–10:00 as an example, according to the state equation of service desks negative exponential distribution queuing system, it can work out the probability of system free, the team length of average waiting and the relationship expression of service desk number C. And put C = 17 $\lambda = 984$ $\mu = 58.32$, $\rho = 0.992$ into formula (88.1–88.6), the final solution:

$$P_0 = 3.8 \times 10^{-9}, \quad L_q = 119.5, \quad L = 136.4, \quad W_q = 0.121, \quad W = 0.139.$$

Bring the parameters into formula (88.7–88.10):

$$c^* = \min\left\{ c | \rho < 1, W_q \leq \frac{1}{12}, L_q \leq 4 \right\}$$

Then got the system service model in the time interval from 9:00 to 10:00. Compared with different C value, the optimal number of cashier dest c* can be obtained, and the detailed analysis is as follows:

Then got the following various system service indexes (see Table 88.2) with different number of service desks from 9:00 to 10:00.

According to the above the data we can clearly see that with the increasing opening number of cashier desks, the service strength of whole system declined gradually and the team length also reduce gradually, so that the customer needs the less time to wait. when the cashier desk opening number reaching 20, a customer almost don't have to wait for getting service. In the actual investigation, the longest waiting time of customers T1 equals 5 min, and put the longest team length of customers waiting L1(L1 = 4) into formula, the final solution: C = 18.

That means that it is reasonable to open 18 cashier desks, as the service strength is 0.937, the customer waiting time is 0.011 h, and the average waiting customers is less than two. It not only makes the customer get fast service, but also saves the operation cost as much as possible and the cashier service strength is moderate.

Similarly, by the above optimization methods and standards in each time intervals for optimized design in our workdays and weekend, the optimal service cashier numbers in each time slot can be obtained, as follows (see Table 88.3).

Table 88.3 Optimization number of service desks

Time interval	Customer arrival rate(number/h)		Number of opening cashier desks	
	Workday	Weekend	Workday	Weekend
8:00 ~ 9:00	756	840	14	15
9:00 ~ 10:00	984	1116	18	20
10:00 ~ 11:00	1332	1536	24	27
11:00 ~ 12:00	1524	1560	28	28
12:00 ~ 13:00	1296	1620	23	29
13:00 ~ 14:00	1380	1656	24	29
14:00 ~ 15:00	1524	1884	28	33
15:00 ~ 16:00	1680	2052	30	36
16:00 ~ 17:00	1716	1668	31	29
17:00 ~ 18:00	1668	1908	30	34
18:00 ~ 19:00	1680	1992	30	35
19:00 ~ 20:00	1776	1800	32	32
20:00 ~ 21:00	1980	1524	36	27
21:00 ~ 22:00	1416	852	25	15

After optimization, the Numbers of service desks in various time interval reach the optimal, as the customer do not need long queue for leave, and customer service satisfaction for supermarkets will increase, the loyal customers of supermarket will be more and more customers, so that the income will increase as well.

88.5 Conclusion

This paper utilizes the classic queuing theory to solve the queuing problem and optimize service strategy. According to different passenger flow volume in different time, the opening number of cashier number should be set in a flexible way, so as to shorten the waiting time of customers, improve customer satisfaction, reduce the cost and improve the competitive power of enterprises.

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Chapter 89
Proposed a Novel Group Scheduling Problem in a Cellular Manufacturing System

Y. Gholipour-Kanani, N. Aghajani, R. Tavakkoli-Moghaddam and S. Sadinejad

Abstract This paper presents a new integrated mathematical model for a cellular manufacturing system and production planning. The aim of this model is to minimize machine purchasing, intra-cell material handling, cell reconfiguration and setup costs. The presented model forms the manufacturing cells and determines the quantity of machines and movements at each period of time that minimizes the aforementioned costs. It is so difficult to find an optimal solution in a reasonable time. Thus, we design and develop a meta-heuristic algorithm based on a genetic algorithm (GA). This proposed algorithm is evaluated, and the related results confirm the efficiency and effectiveness of our proposed GA to provide good solutions, especially for medium and large-sized problems.

Keywords Cellular manufacturing system · Genetic algorithm · Intra-cell material handling

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E. Qi et al. (eds.), *The 19th International Conference on Industrial Engineering and Engineering Management*, DOI: 10.1007/978-3-642-38391-5_89,

89.1 Introduction

Most of production environments involve the changes in the input parameters, such as demands over time. In such a case, managing production resources and balancing them between successive time periods with the aim of minimizing production costs are known as production planning. Cellular manufacturing systems (CMSs) are one of the well-known and efficient alternatives for production environments with high variety and high volume of products. The main goal of CMSs is to minimize the material handling costs in the shop floor.

Various manufacturing production planning and inventory control problems have been studied extensively by many production management researchers. Different models and methods developed to solve these problems can be found in widely used textbooks of production engineering or manufacturing systems (Riggs 1981; Singh 1996). Inventory control models from the simple EOQ to more complicated MRP, kanban and CONWIP models (Monden 1983) have been developed and widely used in today's manufacturing industries. Some of them are very successful in practical applications. Prominent manufacturing and features, such as production flexibility and manufacturing cell formation, are not usually considered in developing cellular manufacturing production (Chen 1998).

A comprehensive review of the DCMS's literature can be found in Safaei et al. (2008). Production planning in the CMSs was discussed in Chen (2001) and Olorunniwo (1996). Schaller et al. (1998) proposed a two-stage approach named CF/PP for integrating the cell formation and production planning in a cellular manufacturing system. Chen and Cao (2004) proposed an integrated model for production planning in a CMS minimizing the inter-cell material handling cost, fixed charge cost of setting up manufacturing cells, cost of holding the finished items over the planning horizon, cost of setting up the system to process different parts in different time periods, and machine operating cost. Defersha and Chen (2006a) proposed a mathematical model for the design of cellular manufacturing systems. The model incorporates a dynamic cell configuration, alternative routings, lot splitting, sequence of operations, multiple units of identical machines, machine capacity, workload balancing among cells, operation cost, and cost of subcontracting part processing, tool consumption cost, cell size limits, and machine adjacency constraints (Defersha and Chen 2006b).

The main contributions of this paper are as follows:

1. The intra cell handling is done in the form of batching and the intra cell handling cost for each batch of the kind of parts is determinate separately.
2. The set up cost was added to other costs related to cellular manufacturing and this shows the integration of production planning and cellular manufacturing system.
3. The intra cell handling constraint is also shown in this model.

89.2 Problem Formulation

This section presents a new integrated pure integer linear programming model of the CMS and PP under following assumptions.

89.2.1 Assumptions

1. The processing time for all operations of a part type is known and deterministic.
2. The capabilities and time-capacity of each machine type are known and constant over the planning horizon.
3. Parts are moved in a batch within cells. Intra cell batch handling cost is known and constant. It independent on distance.
4. The number of cells is known and constant over the planning horizon.
5. The upper and lower bounds of cell sizes are known and constant.
6. Relocation cost of each machine type from one cell to another between periods is known. All machine types can be moved to any cell. Relocation cost is the sum of uninstalling and installing costs. Note that, if a new machine is added to system, we have only the installation cost. On the other hand, if a machine is removed from the system, we have only the uninstallation cost.
7. The set up cost for all parts is known.
8. The batch sizes for all parts and in each period are constant.
9. The independent demand of parts is deferent from period to another period.

89.2.2 Descriptions and Symbols

k Time period index
i Part type index
j *Index of operations*
f Machine index
c Cell index

89.2.3 Parameters

d_{ik} Known demand of part type i for time period k
λ_{ji} Time processing of part i
s_i Set up cost to produce part type i
P_f Purchase cost of machine f
D_f Available capacity of machine f

r_f^+ Install cost of machine f
r_f^- Remove cost of machine f
V_i Unit cost to move part type i in batches
LB_c Minimum number of machines in cell c
UB_c Maximum number of machines in cell c
M Large positive number Batch: batch size

89.2.4 Decision variables

n_{fck} Number of machine type f in cell c during period k
y_{fck}^+ Installed number of machine type f in cell c during period k
y_{fck}^- Removal number of machine type f in cell c during period k

$$r_{fck} = \begin{cases} 1; & \text{if one unit of machine type f is placed in cell c, at periodk} \\ 0; & \text{otherwise} \end{cases}$$

$$z_{ik} = \begin{cases} 1; & \text{if part type i isprocessed during period k} \\ 0; & \text{otherwise} \end{cases}$$

$$X_{jick} = \begin{cases} 1; & \text{if operation j of part i to be processed is done in cell cduring period k} \\ 0; & \text{otherwise} \end{cases}$$

$$b_{jick} = \begin{cases} 1; & \text{ifoperation j of part ito be intra cell handled is done in cell cduring period k} \\ 0; & \text{otherwise} \end{cases}$$

89.2.5 Mathematical Model

Consider a manufacturing system consisting of a number of machines to process different part types. Each part type may require some or all of the machines for processing. In addition, consider the manufacturing system in a number of time periods k, where $k = 1,\ldots,T$, with $T > 1$. One time period could be a day, a week, or a month. Demands for different part types are assumed to be known from work orders or from forecast.

$$\text{Minz} = \sum_{\text{k}} \sum_{\text{i}} s_i z_{ik} + \sum_{\text{k}} \sum_{\text{c}} \sum_{\text{f}} \left(r_f^+ y_{fck}^+ + r_f^- y_{fck}^- \right) + \sum_{\text{k}} \sum_{\text{c}} \sum_{\text{f}} P_f n_{fck} + \sum_{\text{k}} \sum_{\text{i}} \sum_{\text{j}} \sum_{\text{c}} V_i b_{jick} \left(\frac{d_{ik}}{\text{batch}} \right) \tag{89.1}$$

$$\sum_{c} n_{fck} - \sum_{c} n_{fc,k-1} \geq 0;\ \forall(f,k) \tag{89.2}$$

$$\sum\nolimits_{c} X_{jick} = z_{ik};\ \forall(j,i,k) \tag{89.3}$$

$$\sum\nolimits_{i} \sum\nolimits_{j} d_{ik}\lambda_{ji}X_{jick} \leq D_f n_{fck};\ \forall(c,k) \tag{89.4}$$

$$LB_c \leq \sum\nolimits_{f} n_{fck} \leq UB_c;\ \forall(c,k) \tag{89.5}$$

$$n_{fck} = n_{fc,k-1} + y^{+}_{fck} - y^{-}_{fck};\ \forall(f,c,k) \tag{89.6}$$

$$X_{jick} + X_{j+1,ick} - b_{jick} \leq 1;\ \forall(j,i,c,k) \tag{89.7}$$

$$z_{ik} = \begin{cases} 1; & if\ d_{ik} > 0 \\ 0; & if\ d_{ik} = 0 \end{cases} \tag{89.8}$$

$$r_{fck} \leq n_{fck};\ \forall(f,c,k) \tag{89.9}$$

$$n_{fck} \leq M.r_{fck}; \forall(f,c,k) \tag{89.10}$$

$$X_{jick}, b_{jick}, r_{fck}, z_{ik} \in \{0,1\};\ \forall(j,i,f,c,k) \tag{89.11}$$

$$n_{fck}, y^{+}_{fck}, y^{-}_{fck} \in \{0,\ 1,\ 2,\ldots\};\ \forall(f,c,k) \tag{89.12}$$

A mathematical programming model is developed to solve this cellular manufacturing production planning problem. Owing to the above problem features. The mathematical programming model becomes a pure integer programming model. The objective function of this model is to minimize machine purchasing, intra cell material handling, cell reconfiguration, and set up costs.

Model objective function: The objective function given in Eq. (89.1) comprises several cost terms. The firs term of the objective function is the machine purchase cost. The second term of the objective function is the intra cell material handling cost. The third term is cell reconfiguration cost and the last term in the function is the set up cost. The minimization of this cost function is subject to certain conditions.

Capacity limitations of the machines are expressed in Eq. (89.2). Equation (89.4) implies that the number of type k machines used in any time period is greater than or equal to that in the previous period. This means that the model is not going to remove extra machines of any type if that type of machines happens to be in excess in a certain time period. The presence of extra machines in the system increases system flexibility and reliability by providing alternative routes during machine breakdown.

One constraint (89.3) is to ensure that, if operating j of part type i will be processed in one of the cells in time period k, then the corresponding binary variable for system set up must be 1. Normally there is an upper limit to the number of machines in each cell due to the limit of the physical space. In additional, there should be at least one machine in each cell; otherwise the cells disappear. Equation (89.5) specifies the lower and upper bounds of cell sizes. Equation (89.6) states that the number of type k machines in the current period in a particular cell is equal to the number of machines in the previous period, adding the number of machines being moved in, and subtracting the number of machines being moved out of the cell. Equation (89.7) specifies the intra cell material handling. Equation (89.8) specifies the corresponding binary variable for system set up. Equations (89.9) and (89.10) set the value of equal to 1 if at least one unit of type k machine is placed in cell l during period t or 0 otherwise. Equations (89.11) and (89.12) are integrality constraint.

89.3 Genetic Algorithm Implementation

The genetic algorithm (GA) is a population-based algorithm that uses analogies to natural, biological, and genetic concepts including chromosome, mutation, crossover, and natural selection. Basically, it consists of making a population of solutions evolve by mutation and reproduction processes. The best fitted solutions of the population survive while the worse fitted are replaced. After a large number of generations, it is expected that the final population will be composed of highly adaptable individuals, or in an optimization application, high-quality solutions of the problem at hand. The basic steps of a canonical GA are as follows (Tavakkoli-Moghaddam et al. 2008).

Step 1. Initialize the population and enter Step 2.

Step 2. Select individuals for recombination and enter Step 3.

Step 3. Recombine individuals generating new ones and enter Step 4.

Step 4. Mutate the new individuals and enter Step 5.

Step 5. If the stopping criterion is satisfied, STOP; otherwise, replace old individuals with the new ones restructure the population tree and return to Step 2.

89.3.1 Solution Representation

The first step in the proposed GA is to consider a chromosome representation or solution structure. We use a presented structure in Fig. 89.1 to represent the solution of the extended model. The chromosome representation in this study represents each job in the schedule as a gene in a chromosome; in which each chromosome consists of $((k + c) \times f)$ genes. An example to depict this definition is provided in Fig. 89.1 (for 2 period, 3 cells and 8 machines).

Fig. 89.1 Chromosome encoding

Period 1	Cell 1	1	0	0	7	8
	Cell 2	0	2	3	0	0
	Cell 3	6	5	4	0	0
Period 2	Cell 1	0	3	4	8	0
	Cell 2	5	0	1	7	0
	Cell 3	0	6	0	0	2

89.3.2 Create Population

This procedure creates the initial population (Pop), which must be a wide set consisting of disperse and good solutions. Several strategies can be applied to get a population with these properties. The solutions to be included in the population can be created, for instance, by using a random procedure to achieve a certain level of diversity. In this study, an initial population of the desired size is generated randomly. For example, when there are five parts, the algorithm generates 10 solutions randomly, depending on the problem size.

89.3.3 Fitness

Each solution has a fitness function value, which is related to the objective function value (OFV) of the solution. However, the population can have feasible and infeasible solutions. An option to manage the infeasibility is to use both cost and feasibility. This can be written as fitness cost feasibility; where s is the solution, cost of the objective function value. Feasibility is equals to 1 if the solution is feasible; otherwise it is zero. Therefore, the fitness is not one value; however it is two, namely the cost and the feasibility of the solution.

89.3.4 Parent Selection Strategy

The parent selection is important in regulating the bias in the reproduction process. The parent selection strategy means how to choose chromosomes in the current population that will create offspring for the next generation. Generally, it is better that the best solutions in the current generation have more chance to be selected as parents in order to create offspring. The most common method for the selection mechanism is the “roulette wheel” sampling, in which each chromosome is assigned a slice of a circular roulette wheel and the size of the slice is proportional to the chromosome’s fitness.

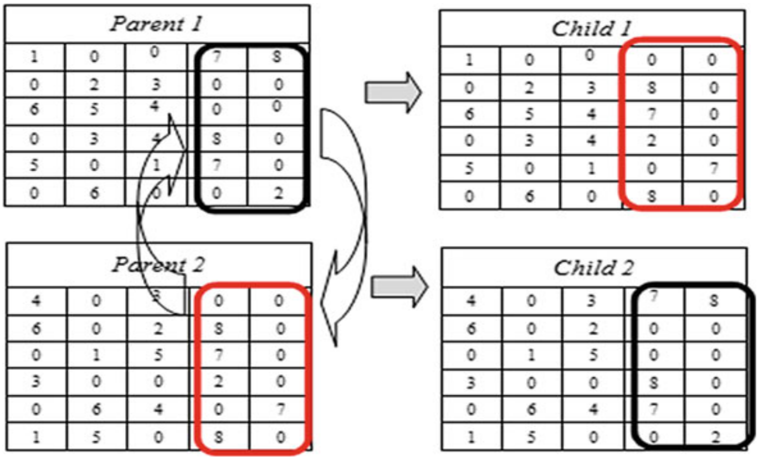

Fig. 89.2 Create new solution

89.3.5 Crossover Operator

The "Improve Solutions" method is applied every solution, *S*, generated by the combination method. This method aims at restoring the feasibility of solutions from the diversification method and enhancing these solutions and those solutions obtained from the combination method. The solutions to be combine and the crossing points are to be selected randomly. In this study, we use single point crossover. For example consider a problem with 10 parts and 3 cells. To create a new solution, we exchange element positioning at the right hand of the cut point in a solution. Figure 89.2, shows a typical example to create a new solution.

89.3.6 Mutation Operators

The main task of the mutation operator is to maintain the diversity of the population in the successive generations and to exploit the solution space. In this paper, a mutation operator, called Swap Mutation, consist of swapping any two randomly chosen genes in a chromosome (Torabi et al. 2006). At first, we define "mutation strength", demonstrator of the maximum number of swap moves performed. If the strength of the mutation is chosen to be one, then it performs a single swap move, provided a given probability P(M). So the strength of the mutation shows the number of consecutive swaps on the individual chromosome.

89.4 Computational Results

Delphi7 program was used for designing algorithm Genetic. The executer processor of algorithm Genetic and Lingo is a computer with characteristic of 1.8 GHz and 768 MB. The calculation of optimal value especially in large dimensions is difficult because CMS planning model solution is complicated. So, the answers of Lingo8 software are an answer near to optimal. The answers are shown in Table 89.1. We compare the obtained objective value from genetic algorithm and Lingo software methods in small dimensions problems. We determine the difference percentage from Lingo answer and study memory size and CPU time. We can see the results of the problem solution by genetic algorithm and lingo software are the same in small dimension problems. So, this thing shows the efficiency of algorithm. Lingo software does not be able to solve the large problems in acceptable time that genetic algorithm make optimised answer or near it in most proper time. The result of some test problem is shown in Table 89.1 and also Growth of solution time for genetic algorithm and lingo software are compared in Fig 89.3.

Table 89.1 Comparison of LINGO and GA algorithm solutions

Problem	Integer variables no.	Constraints no.	Solution method	OFV	CPU time (s)	Memory size	Gap (%)
1	176	220	GA	530695	197	201	0
			LINGO	530695	1	35	
2	176	220	GA	775355	203	201	0
			LINGO	775355	1	36	
3	264	280	GA	939142.5	199	201	0
			LINGO	939142.5	4	37	
4	936	1468	GA	1913705	220	201	2
			LINGO	1876115	22	44	
5	1872	2487	GA	3550545	231	201	5
			LINGO	3038832	362	53	
6	1856	2601	GA	2396190	236	201	7
			LINGO	2229278	297	59	
7	2088	3623	GA	2895435	250	201	2
			LINGO	2836348	66	56	
8	2784	4025	GA	4135362.5	266	201	10
			LINGO8	3769162	504	60	
9	2784	4833	GA	3654797.5	251	201	10
			LINGO8	323348	2989	60	
10	3328	4462	GA	4284182.5	253	201	6
			LINGO8	4045608	15151	69	

89.5 Conclusion and Future Extensions

The model considered in this article is the model for minimizing machine purchasing, intra cell material handling, cell reconfiguration, and set up costs. According to the researches done, this problem is the type of NP-hardness that is it is solution with the optimisation software will be impossible if dimension of the problem increases. The approaches such as branch & bound and dynamic planning have computational time limitation and saving limitation in company. So, using of heuristic algorithm would be effective. The results obtained are as follows:

- With the extension of problems, the computational time will be increase by Lingo while this increase would be little in comparison with Lingo in case of using heuristic algorithm.
- Variation of the productions increases and industry moves toward using of cellular manufacturing for using of its benefits. So using of usual methods in planning of variation of the productions increases and industry moves toward using of cellular manufacturing for using of its benefits. So using of usual methods in planning of cellular manufacturing systems doesn't have good performance and it should be pay attention to the heuristic methods.

Followings are some suggestion for the future research.

- Some of the parameters of this problem can be considered in the fuzzy and converted to the fuzzy cellular manufacturing systems.
- Multiple routes do not be considered in this problem considering multiple routes can make closer the problem to the real condition. So that investigation can be valuable.
- Inventory cost does not be considered in the article. That can be considered in the future article.

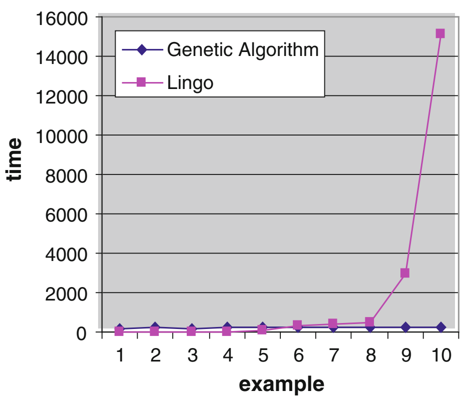

Fig. 89.3 Diagram of computational time respect to the problem

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Chapter 90
Regional Eco-Environment Optimization Based on Multiple Parallel Sub-Systems' Efficiency

Li Wang and Ning Li

Abstract With the rapid growth of economy, China evidence sharp increase on its GDP. But at the same time it feels more and more pressure from industry wastes in its environment. To relieve the pressure on environment while still maintaining the sustainable development in China, decision makers starts to focus more on measuring the efficiency of waste treatment process. Because the industry wastes are divided into three classes (i.e. waste water, waste gas and solid wastes), we should apply different treatments to deal with them. In this paper, we propose a multiple parallel DEA methodology and apply it to calculate the efficiency for the treatment of these three kinds of wastes. By formulating the three types of treatments as three parallel sub-systems in ecological environment optimization, the efficiency of overall, as well as of individual wastes' treatment can be calculated. The statistic data from 30 individual provinces of China in 2010 are used to demonstrate the effectiveness of our approach. Suggestions on optimizing the ecological environment in different regions based on our measurement are given at the end of the paper.

Keywords Ecological regions · Overall efficiency · Parallel DEA · Sub-system efficiency · Treatments of wastes

90.1 Introduction

In the past, China relies mainly on the former Soviet mode to fuel its own economy development, which focuses on increasing the inputs, especially labor and capital investment. In that process, we scarified our environment and limited resources for

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E. Qi et al. (eds.), *The 19th International Conference on Industrial Engineering and Engineering Management*, DOI: 10.1007/978-3-642-38391-5_90,

the economy growth. With the influence of global greenhouse effect and serious pollution, decision makers begin to shift from traditional production mode and lay more emphasis on the treatments of wastes. Generally, we can classify the wastes into three types, i.e. waste gas, waste water and solid wastes. The treatments of three types of wastes are pivotal measures to build environmental-friendly regions. Clarke et al. (1991) discussed water quality management issues in Oregon, USA and proposed constructive measures to enhance the capability of waste water's treatment. At the same time, other two types of wastes, viz. waste gas and solid wastes also play important roles in ecological environment. Guan et al. (2011) proposed a coordination of Energy-Economy-Environment System to express the close relationship between energy, economy and environment.

The evaluation of wastes' treatment should be applied to identify the development level of ecological optimization (Wu et al. 2005). Murtaugh (1996) proposed a statistical methodology with ecological indicators. However, the treatment process of waste gas, waste water and solid wastes can be modeled as parallel system with almost no interaction among them. At the same time, the three processes cover all aspects of wastes' treatment. In this paper, we applied parallel DEA model to calculate the efficiency of each individual treatment and the overall efficiency for whole region.

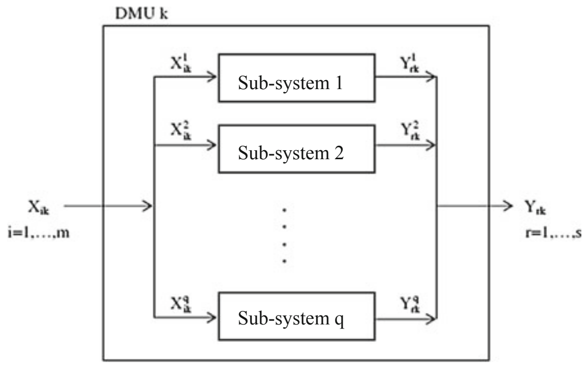
The rest of this paper is organized as follows. In Sect. 90.2, the parallel DEA models are introduced. In Sect. 90.3, we identified the indicators for efficiency calculation and illustrate the collection of the corresponding data. The calculation results are presented in Sect. 90.4.

90.2 Parallel DEA Methodology

DEA model CCR was proposed by (Charnes et al. 1978), which applied an optimal linear programming formula to calculate efficiency of DMUs. Suppose we have n DMUs, and that kth DMU_k (k = 1, 2, …, n) has m inputs, denoted as x_{ik} (i = 1, 2, …, m), and s outputs, denoted as y_{rk} (r = 1, 2, …, s). The traditional CCR DEA model can be expressed by the following formula (90.1).

$$\mathrm{E}_k = \max \sum_{r=1}^{s} u_r y_{rk}$$
$$s.t.\begin{cases} \sum_{i=1}^{m} v_i x_{ik} = 1 \\ \sum_{r=1}^{s} u_r y_{rj} - \sum_{i=1}^{m} v_i x_{ij} \le 0, j = 1, \ldots, n \\ u_r, v_i \ge \varepsilon \\ r = 1, \ldots, s; i = 1, \ldots, m \end{cases} \tag{90.1}$$

Fig. 90.1 Parallel structure for DMU



By calculating with DEA models, the optimal weights can be allocated for each DMU, denoted as $v_i^* = (v_{1j}^*, v_{2j}^*, \ldots, v_{mj}^*)$, $u_r^* = (u_{1j}^*, u_{2j}^*, \ldots, u_{sj}^*)$, which guarantee the kth DMU with the maximum efficiency value. If the objection of model (90.1) equals to 1, then the DMU is denoted as DEA efficient DMU. If the objection of model (90.1) is less than 1, then the DMU is denoted as DEA inefficient DMU. DEA models have obvious advantages in measure the performance of multiple inputs and outputs system. However, traditional DEA model take system as a black box and ignores the internal structure of system.

In general, the inside of DMU can be classified into different structures and the internal structure can affect the overall efficiency of whole system. For each of sub-systems, its efficiency has strong impact on the system's overall efficiency. In this paper, we will use the DEA model to deal with parallel sub-system structures.

To overcome the shortcomings of traditional DEA models, Kao (2009) proposed parallel DEA model for measure the relationship between sub-systems and DUM. Figure 90.1 shows the diagram for "Parallel structure" DEA model for a DMU.

For the kth DMU, there are q sub-systems and each of sub-system has the same number and types of inputs and outputs. The q sub-systems are denoted as sub-system 1, sub-system 2,…, sub-system q. we use X_{ik}^p and Y_{rk}^p to express the ith input and rth output, respectively, of the pth sub-system. The relative inefficiency of a set of n DMUs, each has q parallel sub-systems, can be calculated by following formula:

$$\min \sum_{p=1}^{q} s_k^p$$
$$s.t.\begin{cases} \sum_{i=1}^{m} v_i X_{ik} = 1 \\ \sum_{r=1}^{s} u_r Y_{rk}^p - \sum_{i=1}^{m} v_i X_{ik}^p + s_k^p = 0 \\ \sum_{r=1}^{s} u_r Y_{rj}^p - \sum_{i=1}^{m} v_i X_{ij}^p \leq 0 \\ u_r, v_i \geq \varepsilon; p = 1, 2, \ldots, q; \\ j = 1, \ldots, n; j \neq k \\ r = 1, \ldots, s; i = 1, \ldots, m \end{cases} \tag{90.2}$$

The model (90.2) above should be calculated for n times to obtained the inefficiency slacks of systems as well as their sub-systems. However, the inefficiency slacks is not equal to inefficiency scores because $\sum_{i=1}^{m} v_i X_{ik}^w$ is not equal to 1 for kth DMU with wth sub-systems. Therefore, the inefficiency score calculated by s_k^w should be divided by $\sum_{i=1}^{m} v_i X_{ik}^w$. Hence, the final efficiency score is $1 - \left(s_k^w / \sum_{i=1}^{m} v_i X_{ik}^w \right)$.

90.3 Structure Analysis of Eco-Environment Optimization

90.3.1 Development of Eco-Environment Optimization in China

Within the framework of "Society-Nature-Environment", these three factors are closely related and influence each other. During 1978–2000, China's economy development is largely resources based, in which the development relies on enlarging both inputs and outputs. Although GDP of China increased rapidly, we also got the penalty from eco-environment. The pollutions of waste water, waste gas and solid wastes obviously affect eco-environment in China.

Since 2000s, Chinese government realized the problem and began to shift from previous resource based development mode into environmental friendly development mode. The government increased its investment in treating environmental pollution (i.e. waste water, waste gas, solid wastes). Figure 90.2 shows the trend for government's investment on protecting eco-environment (Liu et al. 2005).

As Fig. 90.2 shows, the total investment amount of in treatment of environmental pollution and the investment in urban environment infrastructure facilities from

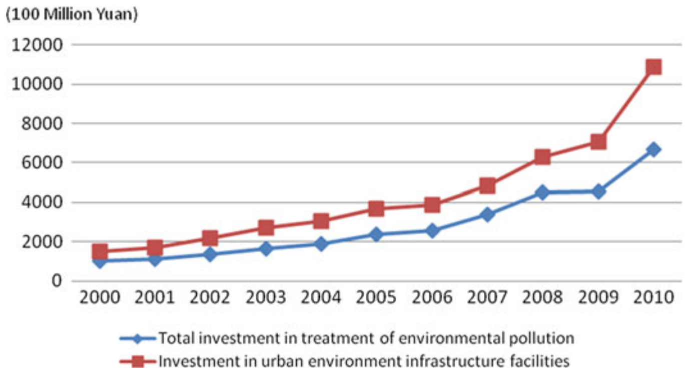


Fig. 90.2 2000–2010 the investment in eco-environment

Chinese government is increasing year by year (Guo et al. 2007). The investment in the environment infrastructure not only enhances the capability to treat environment pollutions for now but also for future. It is clear that Chinese government is putting in more and more resources and effort on optimize eco-environment. In order to effectively optimize the eco-environment, we need to know what the efficiency of treatment pollution in China is. As we are evaluating the efficiency of treatment in eco-environment, we need analyze the structure of wastes' treatment.

90.3.2 Structure and Indexes of Wastes' Treatments

In general, the wastes are divided into three types: (a) waste gas, waste water and solid wastes. To optimize the eco-environment, we should also apply corresponding treatment measures for these three types of wastes. In our model, we divided the optimization of eco-environment into three parallel processes, i.e. waste gas treatment, waste water treatment and solid wastes' treatment. If we represent each waste treatment as a sub-system, there are multiple indexes, which can be listed to measure the efficiency of each process of waste treatments in the view of multiple inputs and outputs. The indexes are shown in Table 90.1 (Bao et al. 2006).

For waste gas treatment, we use 1-in-4-out indexes to interpret the sub-system's efficiency. For waste water treatment, we design 2-in-2-out to explain the efficiency of sub-system. For solid wastes' treatment, we apply 1-in-3-out to measure the sub-system's efficiency.

Table 90.1 Indexes for each of waste treatments

Treatment	Indexes	
	Inputs	Outputs
Waste gas treatment	Total volume of industrial waste gas emission (100 million cu.m)	Number of facilities for treatment of waste gas (set)
		Volume of industry Sulphur Dioxide removed (10,000 tons)
		Volume of industrial Soot removed (10,000 tons)
		Volume of industrial dust removed (10,000 tons)
Waste water treatment	Total volume of waste water discharge in industry (10,000 tons)	Number of facilities for treatment of waste water (set)
	Consumption waste water discharge (10,000 tons)	Industrial waste water meeting discharge standards (10,000 tons)
Solid wastes treatment	Volume of industrial solid wastes produced (10,000 tons)	Volume of industrial solid wastes utilized (10,000 tons)
		Volume of industrial solid wastes in stocks (10,000 tons)
		Volume of industrial solid wastes treated (10,000 tons)

90.4 Calculation and Results

Based on those indexes listed on Table 90.1, we collect 30 provinces' corresponding statistic data from "*China Statistic Year Book 2011*". With 30 provinces as DMUs and three treatments as sub-systems, the CCR DEA efficiency and overall efficiency for each system are calculated. The results are shown in Table 90.2. The third column in Table 90.2 shows the CCR efficiency scores for all 30 provinces using traditional CCR DEA model. Since the CCR efficiency score for all regions are equal to 1, we can't differentiate the performance of eco-environment optimization in each of regions. CCR model is not effective for evaluating those regions eco-environment optimization level. The first and second columns in Table 90.2 show the inefficiency and efficiency score using our 3-way parallel structure DEA model. Our model is able to give different efficiency/inefficiency scores for different regions. Therefore, our model is demonstrated as an effective way to measure the performance of eco-environment development level for each province.

Fourteen regions, 47 % of 30, reach 1 for the overall efficiency value. Those regions perform well in the eco-environmental optimization. Among these efficient regions, Beijing, Tianjin and Zhejiang are advanced developed regions with large amount of inputs in the treatments process (Xu and Tang 2005), i.e. emission of waste gas, discharged waste water and produced solid wastes. The main reason for their high score is the capability of treatments for all three types of wastes.

Table 90.2 Efficiencies of 30 Regions in Wastes' Treatments

Regions	Inefficiency score	Efficiency score	CCR efficiency
Beijing	0	1	1
Tianjin	0	1	1
Hebei	0.0029	0.9971	1
Shanxi	0.0389	0.9611	1
Inner Mongolia	0.0888	0.9112	1
Liaoning	0.0704	0.9296	1
Jilin	0	1	1
Heilongjiang	0	1	1
Shanghai	0.0107	0.9893	1
Jiangsu	0.0079	0.9921	1
Zhejiang	0	1	1
Anhui	0.0130	0.987	1
Fujian	0	1	1
Jiangxi	0	1	1
Shandong	0.0038	0.9962	1
Henan	0.0057	0.9943	1
Hubei	0.0270	0.973	1
Hunan	0.0350	0.965	1
Guangdong	0.0501	0.9499	1
Guangxi	0.0110	0.989	1
Hainan	0	1	1
Chongqing	0.0473	0.9527	1
Sichuan	0.0257	0.9743	1
Guizhou	0	1	1
Yunnan	0.0706	0.9294	1
Shaanxi	0	1	1
Gansu	0	1	1
Qinghai	0	1	1
Ningxia	0	1	1
Xinjiang	0	1	1

Therefore, the three regions have the characteristics of large inputs and lager outputs.

For Jilin, Heilongjiang, Fujian and Hainan, they are efficient regions too (efficiency score = 1). Those regions are middle developed regions. Heilongjiang and Jilin locate in the northeast part of China. Although these regions are industry basement in 1980s, the center of industry development has transferred into coastal regions. Therefore, the transformation relieved the pressure of eco-environment in those regions. Fujian and Hainan are coastal provinces, who are not industry centers or basements. Therefore, the pollution in Fujian and Hainan are relatively less than other coastal regions.

The other 7 efficient regions are Jiangxi, Guizhou, Shaanxi, Gansu, Qinghai, Ningxia and Xinjiang, which are located on the west part of China. Those regions' development of industry lagged behind other eastern regions.

Fig. 90.3 Eco-environmental optimization efficient regions' map

Figure 90.3 shows the efficient regions on the map of China. The green provinces in the map are the efficient regions with high performance on eco-environmental optimization.

In Table 90.2, there are 16 regions whose efficiency scores are less than 1. To optimize eco-environment and keep sustainable development mode in China, we should empower the treatment capability in the next few years. At the same time, we notice that the average efficient values are more than 0.9. The means the gaps between different regions in eco-environmental optimization are small. Therefore, it is quite feasible to optimize the overall eco-environment in China.

90.5 Conclusions

Over the past 30 years, China enjoy economy booming at the expense of environment pollution. How to enhance the capability of deal with those wastes should be important measures to make our environment friendly. Now, Chinese government recognized the importance of protecting eco-environment and invests heavily on improving environment. To quantify the results of eco-environmental optimization, comprehensive evaluation method should be applied to measure the efficiency accurately. In this work, we propose the parallel DEA model and apply it to analyze the eco-environment efficiency for 30 individual provinces of China. Our results demonstrate that with our model, the government can get accurate eco-environmental optimization levels for those 30 regions and make corresponding measures to enhance optimization capability of eco-environment in China.

Acknowledgments The main work of this paper is supported and sponsored by Young Foundation of Ministry of education, humanities and social science research projects (11YJC630100), project of Shandong Economic and Information Technology Committee (No. 2012EI107) and the Fundamental Research Funds for the Central Universities (11CX04031B).

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Chapter 91
Research on Brand Strategy to Small and Medium-Sized Enterprises

Xin-zhu Li

Abstract Based on the analysis of brand attributes, from the perspective of value chain theory, this paper presents that brand strategy is a significant strategy for the small and medium-sized enterprises (SMEs) to realize higher additional value of products and gain competitive advantage in market. Formation of scientific brand development strategy planning, clear definition to core brand value, cultivation of self-owned brand, occupation of competitive advantage by correct brand positioning, selection of correct brand appeal, and adoption of innovative brand operational model are the important approaches and means for SMEs to realize brand strategy, extricate from operational predicament, and promote additional value of products.

Keywords Brand strategy · Small and medium-sized enterprise (SME) · Smiling curve · Value chain

91.1 Introduction

Brand, as the symbol and identification to the enterprise and its product and service, delivers specific information to consumers. As an important link in the value chain, brand plays a decisive role in promotion of the whole value. Favorable brand innovation strategy is a powerful force to increase the additional value of product and service, and to contribute to enhance competitive advantage and cultivate core competitive competence.

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E. Qi et al. (eds.), *The 19th International Conference on Industrial Engineering and Engineering Management*, DOI: 10.1007/978-3-642-38391-5_91,

91.2 Relevant Theories Review on Brand and Value Chain

Philip Kotler, an expert in modern marketing, defines brand as a name, mark, design or their combination, which is used to distinguish the products and even the enterprise from other competitors. For the enterprise, brand stands for potential competitiveness and profitability. For consumers, it is a warranty of quality and credit, which can reduce purchasing cost and risk, and eliminate information asymmetry. Brand is an important intangible asset for the enterprise and has direct relation with its competitive power.

In the "value chain" theory proposed by Michael Porter, a professor of Harvard University, it is supposed that value creation can be realized in all operating activities, which include basic activities and supportive activities. The former one mainly refers to the production and sale of products, with five elements involved, i.e. internal logistics, production and operation, external logistics, marketing and after-sale service; and the latter one refers to those supportive basic activities inside the enterprise with four elements involved, i.e. enterprise infrastructure, human resource management, technological development and purchasing. All links of value chain are interactive and interrelated, and they integrally work to create corporate value (Porter 2005) (Fig. 91.1).

Extending the value chain of enterprise to the whole industrial chain, Stan Shih, with his "smiling curve" theory proposed in *Rebuilding of Acer* in 1992, regards that, in the smiling curve, the upward ends indicate higher additional value at both ends in the industrial chain, i.e., design and sales, and while the lowest point in the middle part indicates that the lowest additional value happened at the intermediate link, i.e., manufacture. In the future, the industry shall focus the development at both ends to strengthen research, development and design on the left side to gain

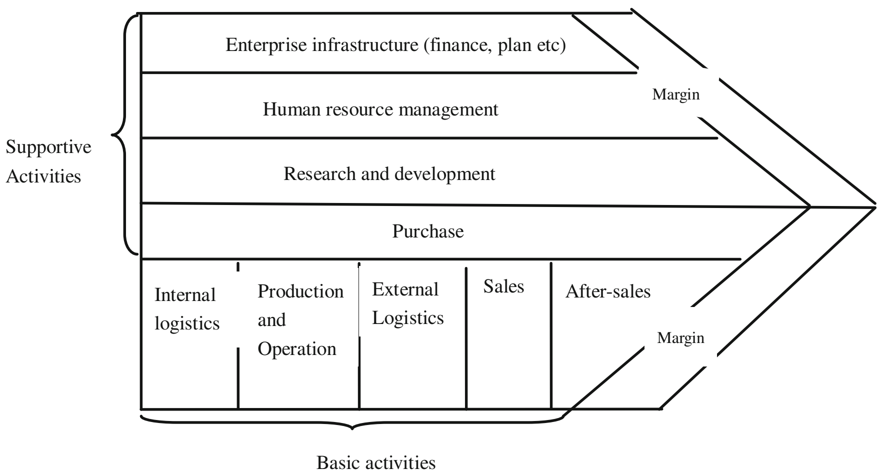
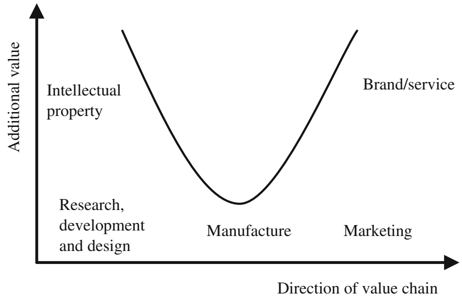


Fig. 91.1 Model of value chain

Fig. 91.2 Model of smiling curve



competitive advantage by intellectual property and to strengthen customer-oriented brand and service to dominate the market with sales (Shih 2005) (Fig. 91.2).

91.3 Attributes of Brand

The attributes of brand can be divided into material attributes and social attributes. The material attribute embodies use value of commodity, which belongs to its essential attributes and exists before purchased, reflecting the relationship between human being and commodity. For example, Jetta and Benz both represent vehicle in respect to their material attribute.

The social attribute embodies symbol value of commodity, which belongs to social derived attributes and is not shown until purchased and used, reflecting the relationship between human beings and the commodity. For example, Jetta is only regarded as a convenient and fast vehicle, while Benz is the symbol of nobleness, success and social status.

91.4 Functions of Brand

91.4.1 Embodiment of Marketing Signal

The essential function of brand is to distinguish commodity and eliminate purchasing information asymmetry as a marketing signal. It embodies the quality of commodity and creates discrepant value for customers. According to "Lemon Market" theory, a commodity without brand locates in the middle or lower end of consumers' expected price, and premium only occurs at commodity with a favorable brand.

Brand strategy is not necessary for all enterprises or commodities, which is the case for commodities with premium inferior to promotion cost, commodities inferior to that at consumers' expected price, commodities with unnoticeable quality difference (such as river sand used for building), and commodities independently priced for monopoly (such as water, power, and coal gas) (Aker 1990).

91.4.2 Tool for Independence in Market

Brand not only refers to a name or signal, but also represents many-sided commitment an enterprise make and a major communication channel between the enterprise and consumers. The brand with good image reflects consumers' trust to the enterprise.

For enterprises without brands, they lose an opportunity to earn consumers' trust as well as to demonstrate their strength. Owning to lack of trust, many SME's may become scapegoat for dominant large enterprises in the value chain and be confronted with enormous market risks. Without the support of brand, it is difficult for SMEs to directly display their competitive advantage, losing many communication opportunities (Bhat and Reddy 2001). As a result, SMEs can only attach themselves to the lower end of the value chain and hardly obtain independence in market only with small margin.

91.4.3 Warranty for Long-Term Development

For SMEs that are satisfied with a small margin in the manufacture value chain and even without trademark, as their competitive edge relying on low-cost labor and resource is shrinking, the original extensive operation model cannot guarantee long-term development. Therefore, to increase additional value, transform operation model and pursue long-term development, brand strategy is a practical choice for enterprises to expand the market, get rid of price competition and enhance competitiveness.

91.5 Implementation Strategy of Brand

91.5.1 Formation of Scientific Brand Development Plan

In the process of SMEs transition from low end to high end of value chain, brand building shall be recognized as a systematic strategy project featured by integrity, constancy and total involvement, and shall be regarded as the core component of SMEs development strategy. All operation activities shall be designed, launched, maintained, managed, guided, and coordinated by centering on the brand, to enhance brand equity through long-term and dedicated work.

91.5.2 Clear Definition of Core Brand Value

Brand embodies the relationship between the enterprise and consumers. By offering unique values demanded by consumers, brand is applied to establish firm relationship with consumers, rather than to endow a good name or earn popularity in a short time at a high promotion cost. Core brand value shall be defined based on demands of target consumers, in addition to correct perception of the brand (Smith 2001).

Many enterprises, for lack of correct cognition of the brand, equate brand building and advertising, and believe that well-known brand and even strong brand can be built in a short period through advertisement. Many such enterprises as Qin Chi, Sanzhu and Aidor, once pursued for popularity by overspreading advertisement; however, these brands piled up by high advertising costs have vanished in the market for a long time. The lessons they leave to later generations are very profound.

91.5.3 Clear Brand Positioning

As important idea of market competition, the concept of positioning proposed by Al Ries and Jack Trout has been recognized by the market (Ries and Trout 2004). Brand is the image to the enterprise just like the image to a person. Correct brand image is just the image the enterprise reveals in front of consumers, so clear brand positioning is required based on the consumers' requirements. By brand positioning the core value and competitive advantage of the brand shall be demonstrated, to help consumers to seize intention of enterprise brand and aware the special interest the brand offers.

For SMEs with limited resources, brand positioning contributes to pursuit for competitive edge and focus on meeting specific consumption demand, so as to improve operation efficiency of the brand. For "concentration, precision and uniqueness" are the main sources of competitive advantage for SMEs, brand positioning not only serves for definition of own brand target, but also works to accurately convey their competitive edge to target consumers (Shao 2005). For example, "Fotile" has always been devoted to providing high-quality cooking utensil to "make better feeling of home", and improving product design and brand building, and thus acquires consumers' acceptance.

91.5.4 Correct Choice of Brand Appeal

For products of industrial equipment which face specific users, they are the raw materials, accessories or production means for users, so the material attributes are emphasized in brand promotion with focuses laid on safety, quality, practical and other use value, and the brand appeal is usually to create value for users.

To ordinary consumer goods, the social attributes embody the symbolic value which is more appealing to the consumers and reflects the relationship among human beings. For example, the brand promotion for food and beverage emphasize on cheerfulness, exercises, and vitality, that for high-end automobiles emphasize on dignity and elegance, and that for telecommunications and home appliances emphasize on harmony, family love and convenience (Christensen 2010).

Due to the restrictions of various objective situations, there are many practical difficulties for many enterprises to maintain long-term leading edge in technology and quality, thus homogenization of product function is basically inevitable. In order to differentiate their products from competitors', provide differentiated product value and obtain consumer's sustained favor, the emotional communication with consumers appears very important (David 1991).

However, many enterprises are often restricted to attract consumers by functional benefits of the brand while ignoring the expression of emotional benefits. Purely functional benefits appeal is likely to make the brand in dilemma of homogenization competition. In order to avoid the price competition brought about thereby, the consumers' satisfaction and loyalty to the band can be promoted through emotional communication.

91.5.5 Unification of Brand Image

Professor Don Schultz deems that the investment philosophy of brand building shall transfer from media-oriented model to one focusing on brand connection or brand contact points (Schultz and Schultz 2005). While the problem many enterprises encounter during the brand building is the confusion of brand images and lack of unified brand image in the mind of consumers, which seriously affects consumers' cognition of the brand.

In fact, brand building is a systematic project. The enterprises shall start from the research on consumer behavior to find out the contact point of the brand and deliver a consistent brand message and create a unified brand image through effective management of brand contact point. By studying the media contact habits of the target customers, the enterprises can choose the specific approach for brand communication and improve communication efficiency by precise work. Especially for SMEs lacking of funds, effective management of brand contact points to deliver a unified brand image is an important means to reduce the brand promotion cost and improve efficiency.

91.5.6 Innovative Brand Operational Model

Innovation is an important guarantee of the sustainable development of the brand. Featured by flexible organization mechanism and market adaptability, SMEs shall adjust measures to local conditions and actively take innovative operation mode and sales mode of the brand in the process of brand building to earn their own competitive advantages (Porter 2002).

Many former small enterprises stand out and grow by taking distinctive brand operational models. Some examples can be taken here, online shopping, TV shopping and other non-traditional store-free direct selling is an innovation for marketing channel model and is gradually nibbling the traditional retail market; Canon replaces Xerox to be the leader of copier market, which is an innovation of redefining the customer market; the "straight-thorough processing" of Dell is an innovation of computer customization (Kreinsen 2008). The rapid development of social economy and the complexity of consumer demand request the innovation of brand operational model. Adapting to this changing trend, it is possible to create a miracle within the industry by brand management and operational mode innovation.

91.6 Optimization Effect of Value Chain Theory on Brand Strategy

Profit is the ultimate goal of enterprises in the value chain theory. In the increasingly competitive market and growing product homogenization, brand is an important tool to provide differentiated value to consumers and plays an increasingly significant role in market competition. Enterprises may optimize their value chain to achieve long-term development of the brands (Pavitt 1984). The optimization effects of value chain on multi-brand strategy are reflected in the following aspects:

First, the value chain analysis can be applied to enhance the brand value. Through analysis of value chain to identify the elements which can enhance product functions and features and factors that may affect brand image, the production costs can be reduced and the optimal resource allocation can be realized (Xu 2009).

Second, the systematic management of brand based on detailed elements and links of the value chain can improve the value of enterprise image. The brand value is reflected just due to the asymmetry of consumers' understand of product information. Meanwhile the enterprises shall concentrate on exploring the brand culture, creating product differentiation and forming their own characteristics to meet the customers' emotional demands and create personalized brand image.

Third, the differentiation of products can be employed from the perspective of value chain to define enterprise strategy. Each link in the value chain is independent and also interact each other. Through the analysis of various value chains, the enterprise can recognize whether these chains are separated or coordinated each other to achieve synergy effect and realize product and enterprise brand optimization (Chen and Zheng 2009).

91.7 Conclusions

To change the position from low end of the value chain, extend from the bottom of the "smiling curve" to both ends, improve the additional value of the product and enhance the competitiveness, brand construction is one important link for the small and medium-sized enterprises. Brand strategy is a request for adaptation to economic restructuring and also a strategic issue for sustainable development.

Brand is the image of the enterprise as well as its products, just like the image of a person. To promote overall value creational capability, SMEs shall apply the tool of brand strategy through formulation of appropriate brand strategy, establishment of scientific brand development plan, definition of clear brand position, choice of correct brand appeal, and adoption of innovative brand operation model in accordance with their own operational situations.

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Chapter 92
Research on Information Mining About Priority Weight of Linguistic Judgment Matrix

Cai-feng Li

Abstract The thesis makes mining information of decision maker as the breakthrough point, puts forward a ranking method involving parameter based on the linguistic judgment matrix, whose different value corresponds to different priority weight. It is necessary to add parameter in ranking method based on the linguistic judgment matrix, and there are three methods to select parameter, whose practicality and efficiency can be demonstrated by numerical examples.

Keywords Linguistic judgment matrix · Method to select parameter · Parameter · Preference

92.1 Introduction

In multi-attribution decision making, due to complexity and uncertainty of objective thing, and fuzziness of human thinking pattern, even for specialists, it is difficult to evaluate the attribute of any project, so it is convenient and reliable to make decision on some attributions with linguistic phrase. In accordance with existed research, there are two kinds of methods to make decision on linguistic information, one is ranking method based on the consistency of linguistic judgment matrix, and the other is applying operators to assemble decision-making information and ranking projects. Based on consistent linguistic judgment matrix or satisfactory linguistic judgment matrix, through shift formula, the first method which can rank transforms linguistic judgment matrix to real-value matrix. Literature (Chen and Hwang 1992) puts forward the shift scale method, and literature (Chen and Fan 2004) provides the method of transforming linguistic matrix to

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E. Qi et al. (eds.), *The 19th International Conference on Industrial Engineering and Engineering Management*, DOI: 10.1007/978-3-642-38391-5_92,

positive reciprocal matrix. The second method involves the induced ordered weighted averaging (IOWA) operator put forward by literature (Yager 2003), linguistic ordered weighted averaging (LOWA) operator in literature Herrera et al. (1996), linguistic weighted arithmetic averaging (LWAA) and extensive ordered weighted averaging (EOWA) operator in literature (Xu 1999),and other operators in literatures (Herrera et al. 1995, 1996, 2000; Herrera and Herrera-Viedma 2000; Umano et al. 1998; Wang and Fan 2002, 2003).

In ranking methods based on the consistency of linguistic judgment matrix, few literatures add parameters into ranking methods, although there is parameter in shift formula of literature (Chen and Fan 2004), it contains no active substance. The paper puts forward a ranking method of linguistic judgment matrix involving parameters, called parameter ranking method based on linguistic judgment matrix. The information of decision maker would be mined in methods, and then decision maker gets the better priority weights of linguistic judgment matrix.

92.2 Linguistic Judgment Matrix and its Consistence

Literature (Chen and Fan 2004; Fan and Jiang 2004) describes linguistic judgment matrix and its consistency. Assuming there is linguistic phrase set $S = \{S_\alpha | \alpha = -t, \ldots, -1, 0, 1, \ldots, t\}$, and decision-making problem is limited to finite set $A = \{a_1, a_2, \ldots, a_n\}$, where a_i denote the project i. Decision maker uses a matrix $P = (p_{ij})_{n \times n}$ to describe the information of the project set A, where p_{ij} evaluate project a_i and project a_j, when $p_{ij} = \{S_1, S_2, \ldots, S_t\}$, project a_i is better than project a_j, the more p_{ij} is, the greater project a_i is superior to project a_j, in contrast, $p_{ij} \in \{S_{-t}, \cdots, S_{-1}\}$, project a_j is better than project a_i, the smaller p_{ij} is, the greater project a_i is inferior to project a_j, while $p_{ij} = S_0$, project a_i is as good as project a_j, matrix P is called as linguistic judgment matrix.

Definition 1 (Herrera et al. 1995) Let $S = \{S_\alpha | \alpha = -t, \ldots, -1, 0, 1, \ldots, t\}$ denote natural language set, where S_i is the i-th natural language, the subscript i and the corresponding natural language can be obtained from following function I and I^{-1}:

$$I : S \to N, \quad I(S_i) = i, \quad S_i \in S$$

$$I^{-1} : N \to S, \quad I^{-1}(i) = S_i$$

Definition 2 (Chen and Fan 2004) With respect to $P = (P_{ij})_{n \times n}$, $\forall i, j, k \in J$, its elements satisfy with the following equation:

$$I(p_{ij}) + I(p_{jk}) + I(p_{ki}) = 0 \tag{92.1}$$

Then the linguistic judgment matrix is consistent.

$$I : S \to N, \quad I(S_i) = i, \quad S_i \in S$$

$$I^{-1}: N \to S, \quad I^{-1}(i) = S_i$$

92.3 Parameter Ranking Method Based on Linguistic Judgment Matrix

The logistic relation between linguistic judgment matrix and priority weight is put forward in this chapter, called as the parameter ranking method based on linguistic judgment matrix in the paper.

Theorem 1 A sufficient and necessary condition of the consistent linguistic judgment matrix $P = (p_{ij})_{n \times n}$ is that there exist a positive normalized vector $\omega = (\omega_1, \omega_2, \ldots, \omega_n)^T$ and θ, which satisfy the following formula:

$$I(p_{ij}) = \log_\theta \frac{\omega_i}{\omega_j}, \ i,j \in J, \ where \ \theta > 1. \tag{92.2}$$

Proof: Necessary condition Assume $\theta > 1$, let

$$\omega_i = \theta^{\frac{1}{n}\sum_{k=1}^{n} I(pik)} / \sum_{i=1}^{n} \theta^{\frac{1}{n}\sum_{k=1}^{n} I(pik)}, \ i \in J \tag{92.3}$$

then $\forall i \in J, \ \omega_i > 0$, it is obvious to exist $\sum_{i=1}^{n} \omega_i = 1$.

Because p_{ij} is related to ω_i and ω_j, it is reasonable to assume $I(p_{ij}) = \eta(\omega_i) - \eta(\omega_j)$, where $\eta(\omega_i) = (i \in J)$is monotonously increasing function. If the linguistic judgment matrix $P = (p_{ij})_{n \times n}$ is consistent, $\forall i,j \in J$, $I(p_{ij}) = \eta(\omega_i) - \eta(\omega_j)$, $I(p_{ij}) = -I(p_{ji})$ from Eq. (92.1), $I(p_{ij}) = I(p_{ik}) - I(p_{jk})$, Therefore, $\omega_i/\omega_j = \theta^{\frac{1}{n}\sum_{k=1}^{n} I(p_{ik})}/\theta^{\frac{1}{n}\sum_{j=1}^{n} I(p_{jk})} = \theta^{I(p_{ij})}$, also $I(p_{ij}) = \log_\theta \frac{\omega_i}{\omega_j}, i,j \in J$.

Sufficient condition

If p_{ij} of linguistic judgment matrix satisfies with $I(p_{ij}) = \log_\theta \frac{\omega_i}{\omega_j}, i,j \in J$, where $\theta > 1$, $\omega_i > 0$, $\omega_i > 0$, and $\sum_{i=1}^{n} \omega_i = 1$, it is easy to draw the following conclusion: $I(p_{IJ}) + I(p_{jk}) + I(p_{ki}) = 0$, $\log_\theta \frac{\omega_i}{\omega_j} + \log_\theta \frac{\omega_i}{\omega_k} + \log_\theta \frac{\omega_k}{\omega_i} = \log_\theta \left(\frac{\omega_i}{\omega_j} \cdot \frac{\omega_i}{\omega_k} \cdot \frac{\omega_k}{\omega_i} \right)$ $= \log_\theta 1 = 0$. So, the linguistic judgment matrix $P = (p_{ij})_{n \times n}$ is consistent. From formula (92.2) and $\theta > 1$, it is not difficult to draw the following conclusion: $p_{ij} \in \{s_1, s_2, \ldots, s_t\} \Leftrightarrow I(p_{ij}) > 0 \Leftrightarrow \frac{\omega_i}{\omega_j} > 1 \Leftrightarrow \omega_i > \omega_j$, the more p_{ij} is, the more $\frac{\omega_i}{\omega_j}$ is, in other word, the project a_i is prior to the project a_j to greater extent; $p_{ij} \in \{s_{-t}, \cdots, s_{-1}\} \Leftrightarrow I(p_{ij}) < 0 \Leftrightarrow \frac{\omega_i}{\omega_j} < 1 \Leftrightarrow \omega_i < \omega_j$, the smaller p_{ij} is, the smaller $\frac{\omega_i}{\omega_j}$ is, in other word, the project a_i is inferior to the project a_j to greater extent; $p_{ij} = s_0 \Leftrightarrow I(p_{ij}) = 0 \Leftrightarrow \frac{\omega_i}{\omega_j} = 1 \Leftrightarrow \omega_i = \omega_j$ which demonstrate that it is reasonable to regard the positive normalized vector $\omega = (\omega_1, \omega_2, \ldots, \omega_n)^T$ as the priority weighty of evaluation the project. From theorem 1 and formula (92.3), it is easy to draw the following conclusion: under the condition of the same linguistic scale and consistency, the priority vectors are a family of ranking vectors involving parameter, the priority should changed with parameter, which provides some suggestions how to establish the priority vector of project from linguistic judgment matrix, meanwhile, which puts forward a new method of defining the priority vector of project.

92.4 The Necessity of Selecting Parameter

The following example 1 demonstrates that different parameter may induce different ranking project.

Example 1 There are two selectable projects with two attributes u_1, u_2. After a decision maker grades every attribute from 0 to 100, the decision-making matrix B can be obtained, whose normalized matrix is R. The decision maker constructs the linguistic judgment matrix H through pairwise comparison in accordance with linguistic scale $S = \{S_\alpha | \alpha = -5, \ldots, -1, 0, 1, \ldots, 5\}$, $H = \begin{bmatrix} S_0 & S_4 \\ S_{-4} & S_0 \end{bmatrix}$, it is obvious that the judgment H is consistent.

Next, we consider the following two situations. First, assuming $\theta = 1.4953$, from formula (92.3), $\omega = (0.8333,\ 0.1667)$ can be obtained, through utilizing simply weighing method, the evaluation of above two projects is $Z =$ (0.5056, 0.4944), so $a_1 \succ a_2$ (Tables 92.1, 92.2).

Secondly, assuming $\theta = 1.6818$, from formula (92.3), $\omega = (0.8889,\ 0.1111)$ can be obtained, through utilizing simply weighing method, the evaluation of above two projects is $Z =$ (0.4926, 0.5074), so $a_2 \succ a_1$. Example 1 demonstrates that different parameter may induce different ranking result under multiple standards, so it is necessary to select reasonable parameter and to put forward ranking method by introducing parameter in the decision based on judgment matrix.

Table 92.1 Decision-making matrix B

	u_1	u_2
a_1	70	70
a_2	80	30

Table 92.2 Normalized matrix of R from B

	u_1	u_2
a_1	0.4667	0.7
a_2	0.5333	0.3

92.5 The Method to Select Parameter

In accordance with above analysis, in order to have reasonable weight, it is essential to obtain suitable parameter, the paper puts forward following three methods.

92.5.1 The First Comprehensive Weight Method Based on Linguistic Judgment Matrix

When there are less than 5 selectable projects, it is considerable to apply the first comprehensive weight method, whose stages are as follows. First, the decision maker selects two projects from projects $A_1, A_2, \ldots, A_n$, such as A_1, A_2. Secondly, the decision maker gives the two projects real-valued weight $\omega'_1, \omega'_2 \left(\sum_{i=1}^{2} \omega'_i = 1\right)$. Thirdly, insert ω'_1, ω'_2 into the formula (92.2), and obtain the following formula:

$$I(p_{12}) = \log_\theta \frac{\omega'_1}{\omega'_2} \tag{92.4}$$

Fourthly, from formula (92.4), it is not difficult to solve the parameter θ which embodies the preference of the decision maker. Finally, it is important to insert the value of θ into the formula (92.3) to solve the priority weight which embodies the preference of decision maker to greater extent.

Example 2 If decision maker gives following linguistic judgment matrix A and real-value matrix A' induced from A.

$$A = \begin{vmatrix} S_0 & S_{-1} & S_0 & S_0 \\ S_1 & S_0 & S_1 & S_1 \\ S_0 & S_{-1} & S_0 & S_0 \\ S_0 & S_{-1} & S_0 & S_0 \end{vmatrix}, \quad A' = \begin{vmatrix} 1 & \theta^{-1} & 1 & 1 \\ \theta & 1 & \theta & \theta \\ 1 & \theta^{-1} & 1 & 1 \\ 1 & \theta & 1 & 1 \end{vmatrix}$$

The decision maker gives the projects A_1, A_2 the weight $(\omega'_1, \omega'_2) = (0.4, 0.6)$, it is obvious that $A_{2\times2}$ is consistent, principle submatrices of A_1, A_2also are consistent.

From formula (92.4), $I(p_{12}) = \log_\theta \frac{\omega'_1}{\omega'_2}$, $-1 = \log_\theta \frac{0.4}{0.6}$, obtain parameter $\theta = 1.5$, then insert $\theta = 1.5$ into formula(92.3): $\omega_i = \theta^{\frac{1}{n}\sum_{k=1}^{n} I(p_{ik})} / \sum_{i=1}^{n} \theta^{\frac{1}{n}\sum_{k=1}^{n} I(p_{ik})}$, so

$$\omega_1 = \frac{\theta^{-1/4}}{\theta^{-1/4} + \theta^{3/4} + \theta^{-1/4} + \theta^{-1/4}} = \frac{1.5^{-1/4}}{1.5^{-1/4} + 1.5^{3/4} + 1.5^{-1/4} + 1.5^{-1/4}}$$
$$\omega_2 = \frac{\theta^{3/4}}{\theta^{-1/4} + \theta^{3/4} + \theta^{-1/4} + \theta^{-1/4}} = \frac{1.5^{3/4}}{1.5^{-1/4} + 1.5^{3/4} + 1.5^{-1/4} + 1.5^{-1/4}}$$
$$\omega_3 = \frac{\theta^{-1/4}}{\theta^{-1/4} + \theta^{3/4} + \theta^{-1/4} + \theta^{-1/4}} = \frac{1.5^{-1/4}}{1.5^{-1/4} + 1.5^{3/4} + 1.5^{-1/4} + 1.5^{-1/4}}$$
$$\omega_4 = \frac{\theta^{-1/4}}{\theta^{-1/4} + \theta^{3/4} + \theta^{-1/4} + \theta^{-1/4}} = \frac{1.5^{-1/4}}{1.5^{-1/4} + 1.5^{3/4} + 1.5^{-1/4} + 1.5^{-1/4}}$$

The priority vector of the project is

$$\omega = (0.2222,\ 0.3333,\ 0.2222,\ 0.2222).$$

92.5.2 The Second Comprehensive Weight Method Based on Linguistic Judgment Matrix

If there are more selectable projects whose number is between 5 and 9, considering the complexity and diversity of decision making and human thinking, it is possible to have deviation, so the paper puts forward the second comprehensive weight method based on the consideration that the weight obtained from formula (92.3) and the subjective weight of decision maker should be smaller. The stages of the above method are as follows: First, every decision maker gives the subjective weight to arbitrary three projects in order to obtain more preference information. Secondly, the optimization model should satisfy with the following equation:

$$\min f(\theta) = \sum_{i=1}^{3} \left(\theta^{\frac{1}{3}\sum_{k=1}^{3} I(p_{ik})} - \omega_i' \sum_{i=1}^{3} \theta^{\frac{1}{3}\sum_{k=1}^{3} I(p_{ik})} \right)^2,$$
$$s.t\ \theta \geq 1$$

where $\omega_1', \omega_2', \omega_3'$ is the subjective weight, and $\sum_{i=1}^{3} \omega_i' = 1$

Thirdly, the parameter can be obtained from above model, and is inserted in the formula (92.3), the priority weight of project can be found.

Let $d_i = \frac{1}{3}\sum_{k=1}^{3} I(p_{ik}),\ i = 1, 2, 3,$ then the above model can be simplified.

$$\min f(\theta) = \sum_{i=1}^{3} \left(\theta^{d_i} - \omega_i' \sum_{i=1}^{3} \theta^{d_i} \right)^2$$
$$s.t\ \theta \geq 1$$

Example 3 If decision maker gives following linguistic judgment matrix A and real-value matrix A' induced from A.

$$A = \begin{vmatrix} S_0 & S_{-1} & S_0 & S_0 & S_{-3} \\ S_1 & S_0 & S_1 & S_1 & S_{-2} \\ S_0 & S_{-1} & S_0 & S_0 & S_{-3} \\ S_0 & S_{-1} & S_0 & S_0 & S_{-3} \\ S_3 & S_2 & S_3 & S_3 & S_0 \end{vmatrix}, \quad A' = \begin{vmatrix} 1 & \theta^{-1} & 1 & 1 & \theta^{-3} \\ \theta & 1 & \theta & \theta & \theta^2 \\ 1 & \theta^{-1} & 1 & 1 & \theta^{-3} \\ 1 & \theta & 1 & 1 & \theta^{-3} \\ \theta^3 & \theta^{-2} & \theta^3 & \theta^3 & 1 \end{vmatrix}$$

If one specialist gives the projects A_1, A_2, A_3 the subjective weight $(w'_1, w'_2, \omega'_3)^T = (0.25, 0.5, 0.25)$, it is reasonable to minimize the difference between the weight obtained from formula (92.3) and subjective weight $\omega'_1, \omega_2,' \omega'_3$, and to construct mathematical model:

$$\min f(\theta) = \sum_{i=1}^{3} \left(\theta^{d'_i} - \omega'_i \sum_{i=1}^{3} \theta^{d'_i} \right)^2$$
$$s.t\, \theta \geq 1$$

where $d'_i = \frac{1}{3} \sum_{k=1}^{3} I(p_{ik}), \ i = 1, 2, 3,$

$$\min f(\theta) = 2\left[\theta^{-1/3} - 0.25(\theta^{-1/3} + \theta^{2/3} + \theta^{-1/32})\right]^2 + \left[\theta^{2/3} - 0.5(\theta^{-1/3} + \theta^{2/3} + \theta^{-1/32})\right]^2, \quad s.t\, \theta \geq 1$$

$\theta = 1.833$, insert $\theta = 1.833$ into formula (92.3), and obtain the priorityvector $\omega = (0.124, 0.3047, 0.124, 0.124, 0.3882)$.

92.5.3 *The Third Comprehensive Weight Method Based on Linguistic Judgment Matrix*

If there are more selectable projects whose number is between 5 and 9, considering the deviation of decision maker understanding the scale, the paper puts forward the third comprehensive weight method based on the linguistic judgment matrix, whose stages are as follows. First, every decision maker gives the subjective weight to arbitrary three projects. Secondly, insert the weight into formula (92.3) to obtain three equations, and solve the unknown parameters $\theta_1, \theta_2, \theta_3$. Thirdly, compute the average θ of $\theta_1, \theta_2, \theta_3$, $\theta = \frac{1}{3}(\theta_1 + \theta_2 + \theta_3)$. Finally, after inserting θ into the formula (92.3), the priority weight of project can be found. If the decision maker gives the subjective weight w'_1, w'_2, ω'_3 to the projects A_1, A_2, A_3, the following three equations can be obtained from formula (92.3).

$$\omega_1 = \theta^{\frac{1}{3}\sum_{k=1}^{3} I(p_{1k})} \Big/ \sum_{i=1}^{3} \theta^{\frac{1}{3}\sum_{k=1}^{3} I(p_{ik})} \tag{92.5}$$

$$\omega_2 = \theta^{\frac{1}{3}\sum_{k=1}^{3} I(p_{2k})} \Big/ \sum_{i=1}^{3} \theta^{\frac{1}{3}\sum_{k=1}^{3} I(p_{ik})} \tag{92.6}$$

$$\omega_3 = \theta^{\frac{1}{3}\sum_{k=1}^{3} I(p_{3k})} \Big/ \sum_{i=1}^{3} \theta^{\frac{1}{3}\sum_{k=1}^{3} I(p_{ik})} \tag{92.7}$$

Through applying the third method, the example 3 also can be solved.

92.6 Conclusion

The paper discusses the problem about parameter of priority of linguistic judgment matrix, demonstrates the necessity of adding parameter in the sorting method based on linguistic judgment matrices, puts forward the conclusion of obtain the parameter value through mining information of decision maker, and some methods of selecting parameter through making full use of the preference information which can be reflected by the subjective weight.Project supported by the Scientific Research Foundation of the Higher Education Institutions of Guangxi Zhuang Autonomous Region (Grant No. 201204LX394).

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Chapter 93
Research on the Project Hierarchy Scheduling for Domestic Automobile Industry

Peng Jia, Qi Gao, Zai-ming Jia, Hui Hou and Yun Wang

Abstract To improve the accuracy and performability of the vehicle R&D project scheduling of domestic automobile enterprises, a "4 + 1" hierarchy process system of domestic automobile enterprises is analyzed and summarized. A corresponding four levels scheduling management mode of the vehicle R&D project is presented based on the hierarchy process system, and a planning approach of three-month rolling schedule for the fourth level is proposed. Schedule minor adjustment and modification are given to solve the different extent change of rolling schedule.

Keywords Hierarchy process · Hierarchy scheduling · Rolling schedule · Schedule minor adjustment · Schedule modification

93.1 Introduction

The research and development (R&D) of automobile products is complicated system engineering. The automobile R&D has a long cycle, and involves wide range of knowledge. At present, the R&D of a new model on a new platform

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E. Qi et al. (eds.), *The 19th International Conference on Industrial Engineering and Engineering Management*, DOI: 10.1007/978-3-642-38391-5_93,

generally requires 36–48 months, even on an existing platform it still requires 18–32 months (Wang 2009). The R&D process involves lots of knowledge and technology, such as mechanics, aerodynamics, structural mechanics, aesthetics, electrotechnics, electronics, cybernetics, computer science, etc. (Lin 2008). Therefore, professionals from different functional departments and different subject areas need to collaborate with each other to complete the R&D work.

For such a complicated huge system engineering, how to develop automobile products which meet the market and customer demands in limited time? This puts forward higher request to R&D process and R&D project management of new products. In recent years, Chinese automobile enterprises continue to learn from international leading enterprises, and many management tools and management methods such as advanced product quality planning (APQP) (Chrysler Corporation, Ford Motor Company, and General Motors Corporation 1995; Chen 2008) and project management (Liu 2009; Ju 2008; Zhang 2008; Sun 2004) are introduced to local automobile R&D process. They build their own R&D process based on learning from the standard R&D process of foreign enterprises.

However, due to the shortage of time, data and experience, immaturity of management and many other reasons, the R&D process cannot be properly implemented in domestic automobile enterprises, and the advanced management theory of project management cannot be well applied in the automobile R&D process management. Therefore, this paper analyzes and summarizes the current product R&D process of domestic automobile enterprises, presents corresponding management mode of the vehicle R&D project scheduling, and gives the solution to schedule decomposition problem caused by the long cycle and wide range of products R&D.

93.2 The Hierarchy Process of Vehicle R&D

Most domestic automobile enterprises have adopted hierarchy process to manage the R&D process. The vehicle R&D flow is divided layer by layer following a coarse-to-fine sequence in order to facilitate the process management. According to the R&D process, the vehicle R&D flow is divided into four levels: company quality gates (Q-Gates) level (the first level flow), cross majors/fields level (the second level flow), cross departments level (the third level flow), department level (the fourth level flow). The enterprises usually define a level with foundational fixed flow to implement of the four levels of R&D flow smoothly. So the flow system of automobile enterprises is the four levels of R&D flow plus a level of foundational fixed flow.

(1) Company Q-Gates level. Based on the quality requirements of APQP and the management theory of Stage-Gate, the vehicle R&D process is divided into several stages, and the R&D quality of products is ensured through setting up a

Q-Gate between two stages. These R&D stages and Q-Gates constitute the flow of company Q-Gates level.

(2) Cross majors/fields level. On the basis of division of stages and Q-Gates, all the flow nodes of company Q-Gates level are subdivided according to majors or fields which are involved by automobile products, and the second level subflow of cross majors or fields is defined.
(3) Cross departments level. The flow nodes of cross majors/fields level are subdivided to departments which are involved by all majors or fields, and the third level subflow of cross departments is defined.
(4) Department level. The R&D flow is defined within the departments according to their business scope in the vehicle R&D process. The flow is also the subdivision of cross departments flow nodes, so it is the fourth level flow in the vehicle R&D process system.
(5) Foundational fixed level. In order to improve the R&D efficiency, the enterprises establish many fixed flows for certain R&D activities, as the basic supporting of the vehicle R&D process system. The flows can realize the automatic transfer among different steps of flow activities, avoid repeated hand labor and reduce manual workload.

Figure 93.1 Shows the "4 + 1" process system of Q automobile Co., Ltd. which is established based on their new product R&D manual (http://doc.mbalib.com/view/d9fd9a8d5538f64af4cfb3; http://www.docin.com/p-220283401.html; http://wenku.baidu.com/view/dd7f9633a32d7375a4178066.html). In the first level, the vehicle R&D process is divided into eleven stages from P0 to P10, and eleven Q-Gates are set up, such as new project research instruction, project R&D instruction, engineering start instruction, digital prototype and so on. In the second, the stages are subdivided according to the involved majors or fields. Taking P2 sculpt design stage as an example, it's divided into many tasks belong to mechanical design, manufacturing process, marketing, and other majors. In the third level, the flow of cross majors or fields is subdivided to departments. Taking the first round structural design as an example, the flow is divided to platform technology department, battery system department, CAX design simulation department and others. In the fourth level, the R&D flow in every department is defined. Take the first round assembly design as an example, the flow defines four flow steps that are the definition of system function and performance, the design of system parts and components, the definition of parts and components function and performance and the summary of system data. Document approval flow is a foundational fixed flow, and the typical procedures include compile-proofread-audit-approve.

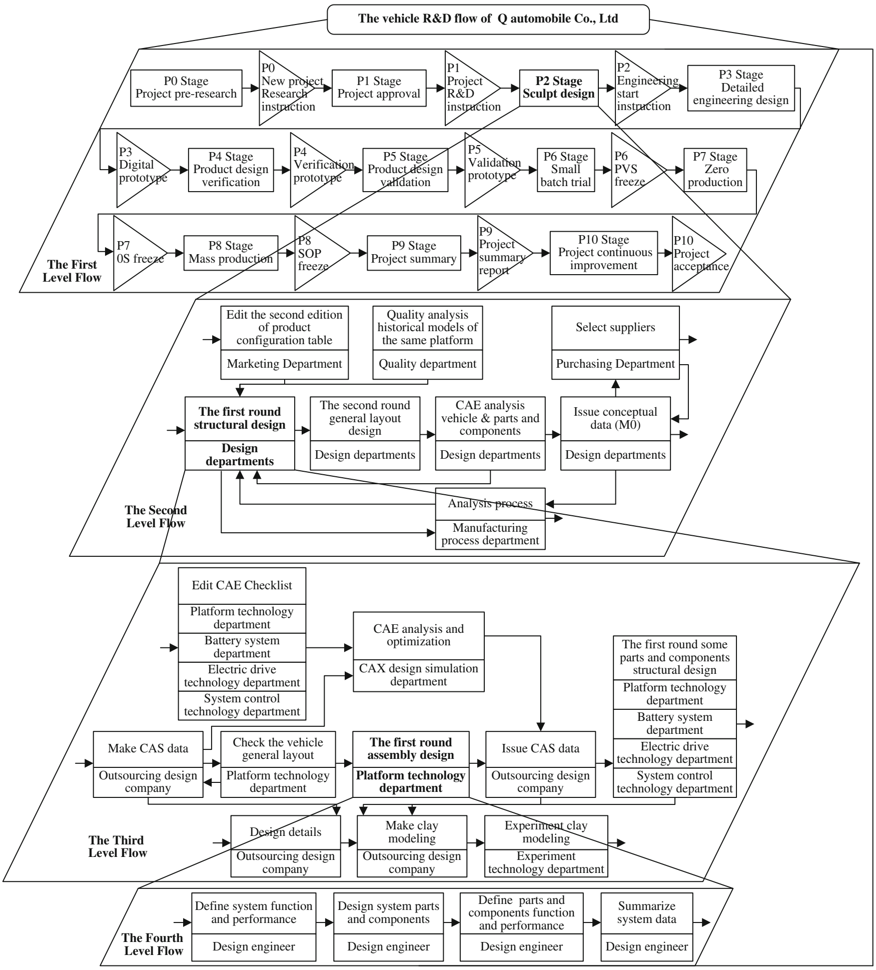


Fig. 93.1 "4 + 1" process system of Q automobile co., ltd

93.3 The Scheduling of Vehicle R&D Project

93.3.1 Hierarchy Schedule

In automobile enterprises, the thought of project management is introduced to manage the vehicle R&D process. The hierarchy schedule is developed for the vehicle R&D project corresponding to the hierarchy R&D flow model of automobile products to help enterprises implement the automobile R&D process more convenient. Based on the four-level R&D flow, the vehicle development project schedule can be decomposed into four levels: the first level schedule (big schedule), the second level schedule (cross majors/fields schedule), the third level

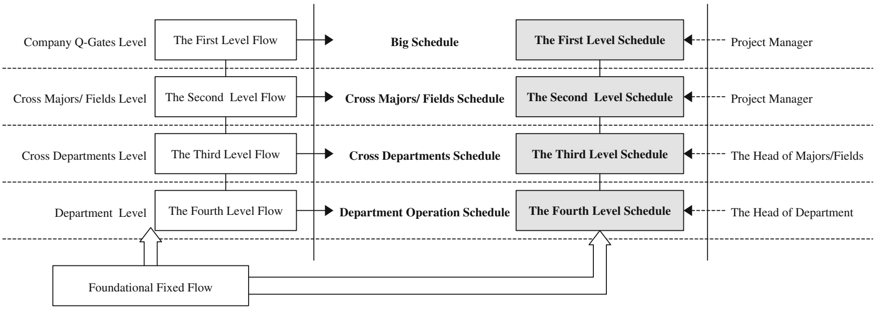


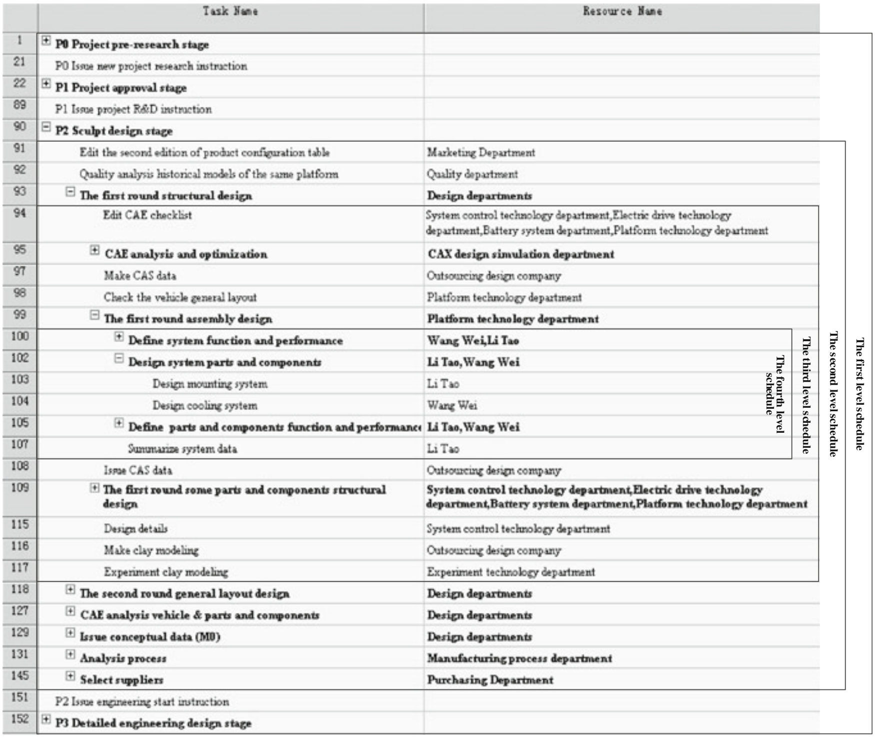
Fig. 93.2 Corresponding relationship between hierarchy R&D process and hierarchy schedule of automobile

schedule (cross departments schedule) and the fourth level schedule (department operation schedule). It is corresponding layer by layer between the four-level R&D flow and the four-level schedule, as shown in Fig. 93.2.

(1) The first level schedule, also known as big schedule, is planned by project manager based on the vehicle R&D Q-Gates flow. The vehicle R&D stages correspondingly constitute the stage summary tasks in the first level schedule The Q-Gates correspondingly constitute the milestones.
(2) The second level schedule is cross majors/fields schedule. It is planned by project manager based on the vehicle R&D cross majors/fields flow. The flow nodes correspondingly constitute the tasks in the second level schedule, and are put under the phase tasks which correspond to the high level flow nodes of the second level flow nodes, so this level schedule is also the decomposition of the first level stage schedule. In addition, the second level schedule tasks will be assigned to the appropriate majors or fields.
(3) The third level schedule is cross departments schedule in the project. These tasks of this level schedule are the decomposition of the majors or fields tasks by the head of majors or fields based on the cross departments flow, and the tasks will be assigned to departments. The third level flow nodes correspondingly constitute the tasks in the third level schedule.
(4) The fourth level schedule is operation schedule within the departments. The head of departments decomposes the work of the third level schedule tasks based on the department flow and the functions and responsibilities of the department. The fourth level flow nodes correspondingly constitute the fourth level schedule tasks, and the tasks will be assigned to the project members.

There is no direct relationship between the foundational fixed flow and the decomposition of the project schedule, but the flow can support the implementation of the schedule tasks.

Figure 93.3 shows the four-level R&D project schedule of Q automobile Co., Ltd. which is planned based on the company's four-level vehicle R&D flow.



	Task Name	Resource Name
1	⊞ **P0 Project pre-research stage**	
21	P0 Issue new project research instruction	
22	⊞ **P1 Project approval stage**	
89	P1 Issue project R&D instruction	
90	⊟ **P2 Sculpt design stage**	
91	Edit the second edition of product configuration table	Marketing Department
92	Quality analysis historical models of the same platform	Quality department
93	⊟ **The first round structural design**	**Design departments**
94	Edit CAE checklist	System control technology department,Electric drive technology department,Battery system department,Platform technology department
95	⊞ **CAE analysis and optimization**	**CAX design simulation department**
97	Make CAS data	Outsourcing design company
98	Check the vehicle general layout	Platform technology department
99	⊟ **The first round assembly design**	**Platform technology department**
100	⊞ **Define system function and performance**	**Wang Wei,Li Tao**
102	⊟ **Design system parts and components**	**Li Tao,Wang Wei**
103	Design mounting system	Li Tao
104	Design cooling system	Wang Wei
105	⊞ **Define parts and components function and performance**	**Li Tao,Wang Wei**
107	Summarize system data	Li Tao
108	Issue CAS data	Outsourcing design company
109	⊞ **The first round some parts and components structural design**	**System control technology department,Electric drive technology department,Battery system department,Platform technology department**
115	Design details	System control technology department
116	Make clay modeling	Outsourcing design company
117	Experiment clay modeling	Experiment technology department
118	⊞ **The second round general layout design**	**Design departments**
127	⊞ **CAE analysis vehicle & parts and components**	**Design departments**
129	⊞ **Issue conceptual data (M0)**	**Design departments**
131	⊞ **Analysis process**	**Manufacturing process department**
145	⊞ **Select suppliers**	**Purchasing Department**
151	P2 Issue engineering start instruction	
152	⊞ **P3 Detailed engineering design stage**	

Fig. 93.3 Vehicle R&D project schedule of Q automobile co., ltd

93.3.2 Rolling Scheduling

The vehicle R&D project has long project cycle, involves wide majors and fields range, needs many coordinated interaction among departments, exists more uncertainty factors. Therefore, in the stage of project approval, the schedule cannot be decomposed exhaustively, only the first, the second and the third level schedule can be initially decomposed based on the standard R&D stages, the involved departments and overall R&D requirements. The detailed fourth level specific operation schedule within department is difficult to accurately plan.

The method of rolling scheduling (http://baike.baidu.com/view/1359753.htm) can effectively solve the above problem as it can regularly revise future schedule. The schedule is planned based on the principle of detailed recent and coarse forward. It means to plan detailed specific recent schedule and the coarse forward schedule at first, and then regularly make the necessary adjustments and revision to the schedule according the situation of implementation and the technical problems. The method combines recent scheduling and forward scheduling. On the one hand, it can plan the next R&D tasks in advance. On the other hand, it can solve the contradiction between the relative stability of schedule and the uncertainty of actual situation better, and effectively improve the accuracy and performability of schedule.

The R&D cycle of domestic automobile products is usually 3–5 years, so the three-month rolling period for domestic automobile enterprises is reasonable and easy to manage and achieve. Therefore, it is needed to plan three-month rolling schedule in the period of vehicle R&D project. It means that the fourth level schedule of the next 3 months is planed in every month.

In the process of planning three-month rolling schedule, the schedule will be adjusted and revised according to the actual situation. It may lead to different extent change of the schedule. Two ways can be used to deal with different extent change.

(1) Schedule minor adjustment. The project managers can adjust the project schedule for small change of schedule which does not affect the milestone tasks and the key tasks on the critical path.
(2) Schedule modification. When the change affects the milestone tasks and the key tasks on the critical path, the project managers must modify the project schedule. The schedule modification will be achieved through implementing the change flow of project schedule, and then increase the version of the schedule.

93.4 Conclusion

Based on the management status of the vehicle R&D of domestic automobile enterprises, the paper analyzes and summarizes the "4 + 1" flow system of domestic automobile enterprises, which includes company quality gates(Q-Gates) flow, cross majors/fields flow, cross departments flow, department flow, and a level of basic foundational fixed flow. According to the four levels R&D process of vehicle, the paper presents corresponding four levels schedule management mode of the vehicle R&D project, which includes big schedule, cross majors/fields schedule, cross departments schedule, department operation schedule. The paper proposes a planning way of three-month rolling schedule as the fourth level schedule is difficult to detailly and accurately plan. Finally, the paper gives two ways, which are schedule minor adjustment modification to deal with different extent change of rolling schedule.

Acknowledgments The project is supported by the National High Technology Research and Development Program of China (through grant No. 2012AA040910) and the Natural Science Foundation of Shandong Province (through grant No. ZR2012GM015).

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Chapter 94
SVM-Based Multi-Sensor Information Fusion Technology Research in the Diesel Engine Fault Diagnosis

Jian-xin Lv, Jia Jia and Chun-ming Zhang

Abstract According to engine's characteristics of running mechanism and prone to failure, using integration based on the sub-module decision-making output multi-sensor information fusion model, this paper discusses the use of SVM-based multi-sensor information fusion technology on the diesel engine fault diagnosis. As the real data of the fault vehicles experiment shows, compared to the traditional diagnostic methods, SVM-based multi-sensor information fusion technology is more effective on identifying the agricultural diesel failure type.

Keywords Diesel engine · Fault diagnosis · Multi-sensor information fusion · Support vector machine (SVM)

94.1 Introduction

The vigorous development of the automotive market has led to the improvement of diesel engine fault diagnosis technology has become the mainstream of diesel engine fault diagnosis, diagnostic techniques based on sensor signals. Traditionally, the relative maturity of the spectrum-based signal analysis algorithms, but such methods due to lack of time local analysis function, and is not suitable to analyze non-stationary signals. The diesel engine vibration signal contains a large number of high-frequency, low frequency and its harmonic components. By Vapnik's support vector machine (SVM) (Vapnik 1995) is a new learning machine

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E. Qi et al. (eds.), *The 19th International Conference on Industrial Engineering and Engineering Management*, DOI: 10.1007/978-3-642-38391-5_94,

based on statistical learning theory. Compared to the neural network, which will use heuristic learning methods in the implementation with a lot of experience in composition. SVM avoid the local minimum problem, and not overly dependent on the quality and quantity of the sample, greatly improving its generalization ability. Multi-sensor information fusion technology can improve the integration and integration of information between the different sensors, information redundancy, complementarity, timeliness and accuracy. The theory of SVM is introduced into the multi-sensor information fusion technology, and applied in the agricultural diesel engine fault diagnosis, and achieved good results.

94.2 Information Fusion Based on SVM

94.2.1 The Concept of Support Vector Machines SVM

For a linearly separable sample set N, N is $(x_i, y_i),\ldots, (x_k, y_k)$, $x_i \in R^n$, $y_i \in (k,\ k)$, $i = 1, 2, \ldots, k$. Seeking an optimal hyper-plane $\omega \cdot x + b = 0$ will be two types of separation and spacing of the $2/\|\omega\|^2$ largest. The relaxation factor $\xi_i \geq 0\,(i = 1, 2, \ldots, k), \sum_{i=1}^{k} \xi_i$ that allows the sample to the degree of misclassification, and its minimum. That is, solving: min $\frac{1}{2}\|\omega\|^2 + C\sum_{i=1}^{k} \xi_i, C$ penalty coefficient, to correct the misclassification sample caused by deviation in accordance with the degree of importance. When the sample linear non-time-sharing, decision function $K(x, x_i)$ can be divided into the data of high dimension space by kernel function, $g(x) = \sum_{SV} a_i y_i K(x, x_i) + b\ 0 \leq a_i \leq C$, a_i is the Lagrange factor. The decision output is that: $d(x) = \mathrm{sgn}[g(x)]$.

Through 1-on-1 to promote the SVM to multi-class classification: N Construction on the number of separator $N \cdot (N-1)/2$. Discrimination, the new test sample x can be obtained $N \cdot (N-1)/2$ discrimination results and vote. x belong to the highest classification. Token the category subscript class if appeared flat votes.

94.2.2 Fusion Method Based on the Output Sub-Module Decision-Making

Training of large-scale data is not only time-consuming and memory demanding on the hardware, there would be insufficient memory space training. Were solved using this small module based on SVM information fusion technology will be the number of large-scale data decomposition, the ultimate fusion. Assume that decomposition of the overall problem into K sub-module, each module containing the N type of data, including information fusion method based on SVM (Hu et al. 2005; Platt 1999; Hsu and Lin 2002): (1) decision-making output of the sub-module integration; (2) sub-module in N the decision function value on the class integration; integration of the weighted value of the decision function (3) sub-module in the class N; (4) sub-module the number of votes in the class N fusion.

This article taken the first category, the decision-making output of the sub-module integration:

$$d(x) = \arg\max\{V_1, V_2, \ldots V_k\}, V_j = \sum_{i=1}^{k} \delta_{ij,}\delta_{ij,}$$
$$= \begin{cases} 1, d_i(x) = j \\ 0, d_i(x) \neq j \end{cases}, (i = 1, 2, \ldots K; j = 1, 2, \ldots N)$$

such as the number of votes are p, discrimination in accordance with $d(x) = \arg\max\left\{\sum_{i=1}^{p} \left|f_{ij}(x)\right|\right\}$.

94.3 Diesel Engine Sensor Fault Diagnosis Application

According to characteristics of diesel engines, commonly used cylinder head vibration acceleration sensor, the instantaneous speed sensor, cylinder pressure sensor three types of sensors to collect the required information, the amount of feature extraction, and in accordance with the integration of decision-making output of the above sub-module fusion. Prone to the actual running of each cylinder power imbalance in the type of fault, for example. The failure of the cylinder power imbalance is a common fault. Cylinder head vibration sensors, in theory, the cylinder pressure sensor, instantaneous speed sensor fusion of the three diagnoses can get the best results. But in the actual diagnostic process, the high temperature and high pressure cylinder environmental damage the performance and life of the pressure sensor, greatly increasing the difficulty of the measurement of cylinder pressure. And by calculating the conversion speed is obtained by the instantaneous cylinder pressure, the conversion formula (Kennedy and Eberhart 1995; Coello and Lechuga 2002):

$$\left\{J + m_1R^2 \sum_{k=1}^{N} [f(\theta - \phi_k)]^2\right\}\ddot{\theta} + \left\{m_1R^2 \sum_{k=1}^{N} [f(\theta - \phi_k)g(\theta - \phi_k)]\right\}\dot{\theta}$$
$$= A_pR \sum_{k=1}^{N} [f_p^{(k)}(\theta)f(\theta - \phi_k)] - T$$

The test measured in normal and pipeline oil spill two states under the cylinder head vibration 5 signal for each, is calculated to extract diagnostic indicators such as Table 94.1.

Recourse to Table 94.1 data to establish a diagnostic model. Assume that the indicators in the state vector X = [X1, X2, X3] T in accordance with and other

Table 94.1 Sample data

Sample number	Detonation pressure of normal state 8.367 MPa			Detonation pressure of oil spill state 7.608 MPa		
	P_{1-1}	P_{1-2}	P_{1-3}	P_{1-1}	P_{1-2}	P_{1-3}
1	63.1677	8.2508	12.4569	51.3794	7.5608	10.9037
2	60.1160	8.9492	13.0616	50.6096	7.3252	10.6371
3	61.5950	7.8080	11.9880	50.6898	7.6953	11.1545
4	64.2261	8.8686	12.9638	52.4091	7.9606	11.7211
5	62.6066	9.9479	15.1454	52.5400	7.9170	11.5639

covariance matrix normal distribution, denoted as $X \sim N(\mu(\theta), \sum)$. Sample mean to estimate the μ (θ):

$$\mu(\theta = 8.365) = \begin{bmatrix} 62.342 \\ 8.7649 \\ 13.1231 \end{bmatrix} \quad \mu(\theta = 7.607) = \begin{bmatrix} 51.5256 \\ 7.6918 \\ 11.1961 \end{bmatrix}$$

To estimate the sample covariance matrices in the $\sum$:

$$\sum = \frac{1}{n-k-1}\sum_{l=1}^{k}\sum_{i=1}^{n_i}(X_1^l - \bar{X}_l)(X_1^l - \bar{X}_i) = \begin{bmatrix} 1.8874 & & \\ 0.1707 & 0.3926 & \\ 0.1595 & 0.5986 & 0.9834 \end{bmatrix}$$

94.4 Comparison with Other Traditional Diesel Engine Fault Diagnosis Results

The current methods commonly used in diesel engine fault diagnosis, including wavelet analysis, artificial neural network diagnosis, extended rough set theory, and so on. Each method has the characteristics for diesel engine operation of the law and prone to failure characteristics, compare the pros and cons of various methods in dealing with the diesel engine fault diagnosis is the key to promote the further development of diesel engine fault diagnosis technology.

Fault data processing capabilities of several methods for comparing the above, in the experiments from the actual testing of the diesel engine, select the total number of features for 1820, the normal signal, the total number of features for the 714's imbalance signal, the total number of features for the 1148 collision friction signal. From randomly selected 70 % of the characteristics of data for network training, the remaining 30 % for network testing. Therefore, training in normal working condition the signal characteristics for 1274, the imbalance in the number of signal characteristics for 497, collision friction signal characteristics 812. Signal characteristics of normal conditions in the test were 546, the number of features of the unbalanced signal 217, and collision characteristics of friction signal for 336. The experimental results of the training set and test set, respectively, as shown in Table 94.2.

Table 94.2 Test set classification comparison

Test set classification comparison		Normal	Unbalanced	Friction and collision
The total characteristic numbers		546	217	336
Artificial neural networks	Correct classification number	525	207	279
	Correct classification rate	96.15 %	95.39 %	83.04 %
Generalized rough sets theory	Correct classification number	539	217	294
	Correct classification rate	98.72 %	100 %	87.5 %
Wavelet analysis	Correct classification number	532	210	273
	Correct classification rate	97.44 %	96.77 %	81.25 %
SVM-based multi-sensor information fusion technology	Correct classification number	536	215	304
	Correct classification rate	98.17 %	99.08 %	90.48 %

From the experimental results can be seen, for diesel engine fault diagnosis, artificial neural network methods require a large amount of data is not dominant. The wavelet analysis method in the training set for the high recognition rate of the normal signal, but performance degradation is more obvious in the test set. And for the failure of the diesel engine, we put more weight on the test set under diesel imbalance signal and friction collision signal to identify the correct rate. The imbalance signal recognition, SVM-based multi-sensor information fusion technology and generalized rough set theory is almost equal, there are certain advantages in the identification of friction collision signal.

94.5 Conclusion

In this paper, we use the SVM-based multi-sensor information fusion technology for diagnosis of diesel engine failure. And with the example of the multi-cylinder power imbalance failure, acquisition failure diesel real vehicle data, using a variety of diagnostic methods for the comparison test. The results show that SVM-based multi-sensor fusion technology can effectively identify diesel engine operating status and faults category. And more focused subsequent posterior distribution compared to single sensor, compared with methods such as artificial neural network, the same confidence level confidence interval is smaller, higher accuracy.

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Chapter 95
The Purchase House Choice Research Based on the Analytic Hierarchy Process (AHP)

Zhi-hong Sun, Lu Pan, Yan-yan Wang and Da-hu Zhang

Abstract Analytic Hierarchy Process (AHP) is a powerful tool to analyze multiobjective and multicriteria complex system, which is a systematic and hierarchical analytical method with the combination of qualitative and quantitative analysis. By using AHP method to quantitatively analyze a variety of consideration factors in house purchasing decision-making, and then using the results to help people to make a scientific and rational decision-making in purchasing a house process.

Keywords Ahp · Multiobjective decision-making · The consistency test · The indicators of purchasing house · Weight

95.1 Introduction

Buying a satisfied house is the dream of many people, however, today, with the fluctuant development of real estate industry, to realize this dream is not so simple. In the actual purchasing process, buyers' requirements for houses are not limited to residential and other simple functions but require more humane, more comfortable. Therefore, the respects that buyers concern about are increasingly broad, and the requirements tend to fine, including real estate lots, product price, design style,

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E. Qi et al. (eds.), *The 19th International Conference on Industrial Engineering and Engineering Management*, DOI: 10.1007/978-3-642-38391-5_95,

landscape supporting, property services, district supporting, the quality of housing, the developers' credibility and traffic conditions, etc. Although what buyers concerned about are more and fine, but every respect to achieve the wish of home buyers is unlikely. How to buy a most satisfactory house relatively from many houses? When the indicators conflict, what should be as home buyers' primary standards? These are the problems that buyers pay close attention to very much.

95.2 Analytic Hierarchy Process

Analytic Hierarchy Process (AHP) was proposed by Operational Research Expert Professor Saaty in the 1970s, which is a systematic and hierarchical analytical method with the combination of qualitative and quantitative analysis (Hu and Guo 2007). It is an effective method to transform the semi-qualitative and semi-quantitative problems into quantitative problems, and is also a powerful tool of analyzing multiobjective and multicriteria complex system. Its core is to decompose a complex problem into a number of different factors, then in accordance with the relationship between the factors to establish a hierarchical structure model, with forming target layer, rule layer and scheme layer, and then with pairwise comparison method to construct judgment matrix. AHP has been widely used in various fields, such as economic planning and management, energy distribution, the military command, etc. (Chen et al. 2007, 2011; Zhao 2007; Jin et al. 2011; Qi 2008; Li et al. 2012). The main steps of AHP are as follows:

(1) To establish a hierarchical structure model.
(2) To construct the judgment matrix.
(3) To calculate the relative weights and consistency test.
(4) To calculate the total ranking of levels and consistency test.

The formula of judgment matrix consistency index CI is:

$$CI = \frac{\lambda_{\max} - n}{n - 1} \quad (95.1)$$

where, n is the order of Matrix, $\lambda_{\max}$ is the largest eigenvalue of judgment matrix.

The formula of judgment matrix random consistency ratio CR is:

$$CR = \frac{CI}{RI} \quad (95.2)$$

where, the value of RI refers to the experimental results of Saaty (Hu and Guo 2007), seen in Table 95.1.

Table 95.1 Values of the random consistency index RI

n	3	4	5	6	7	8	9	10	11
RI	0.58	0.9	1.12	1.24	1.32	1.41	1.45	1.49	1.51

According to Saaty's rule of thumb, when $CR < 0.1$ that the judgment matrix has a satisfactory consistency, now, the normalized eigenvector, corresponding to the largest eigenvalue $\lambda_{\max}$, as the weight vector of the judgment matrix.

95.3 Applying AHP to Make a Purchasing House Choice

95.3.1 Establishing a Hierarchical Structure Model

Here we build a three-tier hierarchy structure, as follows:

The first layer is the target layer (O), namely to select the appropriate region to buy a house. The second layer is the criteria layer (C), that is, the indicators of purchasing house, including nine aspects, such as real estate lots, product price, design style, landscape supporting, property services, district supporting, the quality of housing, the developers' credibility and traffic conditions, each aspects in turn to be recorded as $C_k(k = 1, 2, \ldots, 9)$. And the third layer is the program layer (P), here taking four houses of one city as the program layer, from which a buyer wants to buy a house, and be denoted by $P_n(n = 1, 2, \ldots, 4)$. As a result, the structure chart of hierarchical model is builded in Fig. 95.1 (Yuan 2012; Mo 2007; Huang et al. 2006; Yang et al. 2004; Pan et al. 2010).

95.3.2 Determining the Weights W^1 of the Criteria Layer (C) to the Target Layer (O)

A large survey network has done a large-scale survey to the people who want to buy houses, and according to the large amounts of data, it has obtained the houses buyers' concern degree to all aspects in the purchasing house process, shown in Table 95.2.

Based on Table 95.2, we can obtain the degrees of influence of the purchasing indicators when people buy a house. Then according to Saaty's comparison

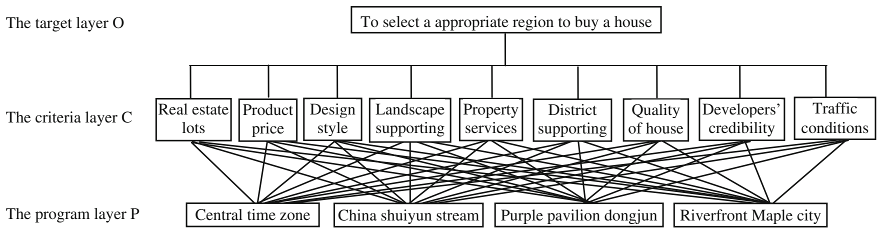

Fig. 95.1 The structure chart of the hierarchical mode

Table 95.2 The concern degrees to indicators of purchasing house

Indicators of purchasing house	Concern degrees (%)
Real estate lots C_1	48.08
Product price C_2	34.35
Design style C_3	49.13
Landscape supporting C_4	23.43
Property services C_5	32.17
District supporting C_6	27.62
Quality of housing C_7	47.23
Developers' credibility C_8	27.43
Traffic conditions C_9	45.97

criterion (Hu and Guo 2007), through the pairwise comparisons of the 9 aspects in the criteria layer, we can establish the judgment matrix A, as follows:

$$A = \begin{pmatrix} 1 & 4 & 1/2 & 6 & 4 & 5 & 2 & 5 & 3 \\ 1/4 & 1 & 1/4 & 4 & 2 & 3 & 1/4 & 3 & 1/4 \\ 2 & 4 & 1 & 6 & 4 & 5 & 3 & 5 & 3 \\ 1/6 & 1/4 & 1/6 & 1 & 1/4 & 1/3 & 1/5 & 1/2 & 1/5 \\ 1/4 & 1/2 & 1/4 & 4 & 1 & 3 & 1/4 & 3 & 1/4 \\ 1/5 & 1/3 & 1/5 & 3 & 1/2 & 1 & 1/5 & 2 & 1/5 \\ 1/2 & 4 & 1/3 & 5 & 4 & 5 & 1 & 5 & 2 \\ 1/5 & 1/3 & 1/5 & 2 & 1/3 & 1/2 & 1/5 & 1 & 1/5 \\ 1/3 & 4 & 1/3 & 5 & 4 & 5 & 1/2 & 5 & 1 \end{pmatrix}$$

By calculating, we can get the largest eigenvalue of the judgment matrix A, that is $\lambda_{\max} = 9.7920$, and the corresponding normalized eigenvector is

$$w^1 = (0.2126, 0.0694, 0.2653, 0.0229, 0.0599, 0.0385, 0.1637, 0.0301, 0.1375)^T$$

Using (95.1), $CI^1 = 0.0990$, and the corresponding random consistency index is $RI_9 = 1.45$ (n = 9), so using (95.2), we can get

$$CR^1 = \frac{CI^1}{RI_9} = \frac{0.0990}{1.45} = 0.0683 < 0.1.$$

The above result indicates that it passed the consistency test. So w^1 is the weight vector of the criterion layer C to the target layer O.

95.3.3 *Determining the Weights W^2 of the Program Layer (P) to the Criteria Layer (C)*

According to the assessment of experts on the various indicators of the four regions, we establish the judgment matrices of C_k-P, and conduct consistency test, with the results in Table 95.3.

Table 95.3 the judgement matrices of C_k-P and the results of consistency test

Layer P	Layer C								
	C_1 w_1^2	C_2 w_2^2	C_3 w_3^2	C_4 w_4^2	C_5 w_5^2	C_6 w_6^2	C_7 w_7^2	C_8 w_8^2	C_9 w_9^2
P_1	0.4675	0.4554	0.0955	0.0919	0.4675	0.4733	0.4718	0.4675	0.4718
P_2	0.2771	0.2628	0.16	0.3016	0.2771	0.2842	0.1643	0.2771	0.1643
P_3	0.16	0.1409	0.2771	0.1537	0.16	0.1696	0.2562	0.16	0.2562
P_4	0.0955	0.1409	0.4675	0.4528	0.0955	0.0729	0.1078	0.0955	0.1078
λ_j	4.031	4.0104	4.031	4.1658	4.031	4.0511	4.0458	4.031	4.0458
CI_j^2	0.0103	0.0035	0.0103	0.0553	0.0103	0.017	0.0153	0.0103	0.0153
CR_j^2	0.0114	0.0039	0.0114	0.0614	0.0114	0.0189	0.017	0.0114	0.017

From Table 95.3, we can see that the consistency ratio CR of the various indicators are all less than 0.1, that is, all passed the consistency test. Then the weight of layer P to layer C is:

$$w^2 = (w_1^2, w_2^2, \cdots, w_9^2)_{4\times 9}$$

95.3.4 Determining the Combined Weights W of the Program Layer (P) to the Target Layer (O)

According to the C–O weights w^1 and the P–C weights w^2, we can obtain the P–O weights:

$$\begin{aligned} w = w^2 \cdot w^1 &= (w_1^2, w_2^2, \ldots, w_9^2) \cdot w^1 \\ &= (0.3608, 0.2119, 0.2189, 0.2083)^T, \end{aligned}$$

and the consistency ratio of the combination is:

$$CR = \frac{\sum_{j=1}^{9} a_j CI_j^2}{\sum_{j=1}^{9} a_j RI_4} = 0.014 < 0.1$$

where a_j ($j = 1, 2, \ldots, 9$) corresponds to the various weights of w^1. Therefore, the combined weights w can be the basis for objective decision-making.

95.3.5 Comprehensive Ranking

According to the combined weights w, we can finally obtain the ranking of the four intentive regions, that is, Central time zone region is better than Purple pavilion dongjun region, Purple pavilion dongjun region is better than China shuiyun stream region, and China shuiyun stream region is better than Riverfront Maple city region. Therefore, funds permitting, buying a house in Central time zone region could better meet the demand on all aspects.

95.4 Conclusion

AHP method is practical, and its calculation is simple and easy to be operated. Using AHP method to analyze a variety of consideration factors in house purchasing decision-making, it can guide consumers to buy houses scientifically and rationally. This method is also applied in the purchasing decision-making of other consumer goods, such as car buying, insurance buying, etc. (Song and Wang 2012; Zhang and Lin 2012; Kang and Zhu 2012). In summary, AHP method has certain guiding significance in solving similar multiobjective problems.

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Chapter 96
The Relations Tracking Method of Establishing Reachable Matrix in ISM

Xue-feng He and Yue-wu Jing

Abstract Interpretative Structural Modeling (ISM) is a common Structure modeling technology. For this technology, the establishment of reachable matrix is a quite important step. By analyzing the relations among many factors in a system, the relations tracking method for reachable matrix is presented in this paper. Through a comparative analysis of several methods, the relations tracking method is proved to be rapid and effective for establishment of reachable matrix meanwhile avoiding complex matrix operations, and can be used to enhance the applicability of ISM.

Keywords Adjacency matrix · Directed graph · Interpretative structural modeling · Reachable matrix

96.1 Introduction

The Interpretative Structural Modeling (ISM) is a common structure modeling technology and widely used in many fields (Li 2011; Thakkar et al. 2004, 2007; Singh 2007; Kanungo and Bhatnagar 2002; Bolaños et al. 2005). In terms of the workflow of ISM, when directed graph is obtained, the establishment of reachable matrix is a quite important step (Wang 1998). Usually, the main methods for establishing reachable matrix are formula method (Wang 2000), experience

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E. Qi et al. (eds.), *The 19th International Conference on Industrial Engineering and Engineering Management*, DOI: 10.1007/978-3-642-38391-5_96,

dialogue method (Zhenkui 1998) and Warshall algorithm (Lipschutz and Lipson 2002; Wang and Ge 1996) and so on. In this paper, the relations tracking method for reachable matrix is presented, compared with the other methods, this method can avoid complex matrix operations.

96.2 Relations Tracking Method

96.2.1 Definition

Relations tracking method, just as its name implies, the relationships among many factors in a system should be tracked firstly and then the reachable matrix may be established. In this paper we use Fig. 96.1 as an example to illustrate.

96.2.2 Steps

The first step is to find out the direct reachable set of each node.

Direct reachable set is the element set that a node can reach directly not including the node itself, expressed with D<i>. For example, for Fig. 96.1, the direct reachable set of node S_2 is D<2> = {3, 4}. Similarly, D<4> = Ø. All the direct reachable sets are shown in Table 96.1.

The second step is to find out the tracking reachable set of each node.

Tracking reachable set is the element set that each node can reach, whether directly or indirectly, which includes the node itself, expressed with R<i>. For reachable matrix, this step is quite important.

The core idea of relations tracking method is as follows. Each node can be viewed as a source node and the direct reachable set of the node will be obtained, then each node in the direct reachable set can be viewed as a branch node which can be used as the next level branch node, thus the tree branch of each node can be obtained and all the nodes of tree branch constitute the tracking reachable set of

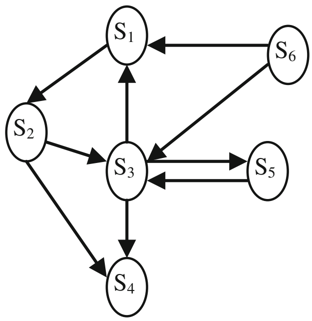

Fig. 96.1 Directed connection diagram

Table 96.1 The direct reachable sets

S_i	S_1	S_2	S_3	S_4	S_5	S_6
D < i>	2	3,4	1, 4, 5	Ø	3	1,3

each node. If a direct reachable set is an empty set, then the tracking reachable set is the node itself. For example, in Table 96.1, the direct reachable set of S_4 is empty, then R<4> = {4}.

The important principles: in the process of branching, if a node is repeated, then the node should be omitted, that is the node is no longer continue to branch.

For example, for the tracking reachable set of S_1, the tree branch obtained is shown in Fig. 96.2.

Thus, $R < 1> = \{1, 2, 3, 4, 5\}$, similarly, $R < 2> = \{1, 2, 3, 4, 5\}$, $R < 3> = \{1, 2, 3, 4, 5\}$, $R < 5> = \{1, 2, 3, 4, 5\}$, $R < 6> = \{1, 2, 3, 4, 5, 6\}$, the tree branches of S_2, S_3, S_5 and S_6 are shown in Fig. 96.3.

The third step is to write out the reachable matrix.

The reachable matrix M is shown below.

$$M = \begin{bmatrix} 1 & 1 & 1 & 1 & 1 & 0 \\ 1 & 1 & 1 & 1 & 1 & 0 \\ 1 & 1 & 1 & 1 & 1 & 0 \\ 0 & 0 & 0 & 1 & 0 & 0 \\ 1 & 1 & 1 & 1 & 1 & 0 \\ 1 & 1 & 1 & 1 & 1 & 1 \end{bmatrix}$$

This method can avoid fundamentally complex matrix operations, and it just needs to track the relations among nodes.

96.2.3 The Explanation of Relations Tracking Method

The relations tracking method reflects the essence of reachable matrix. In terms of this method, the tracking reachable set can be obtained directly based on the directed graph, so the reachable matrix obtained from relations tracking method is just requested. From reachable matrix M it can be known that the elements in row 1, 2, 3 and 5 are same, which suggest that S_1, S_2, S_3, S_5 may form loops.

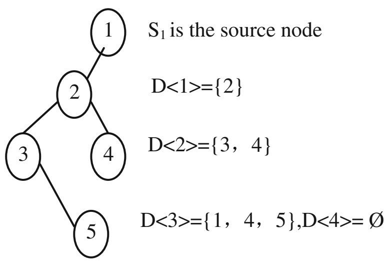

Fig. 96.2 The tree branch of S_1

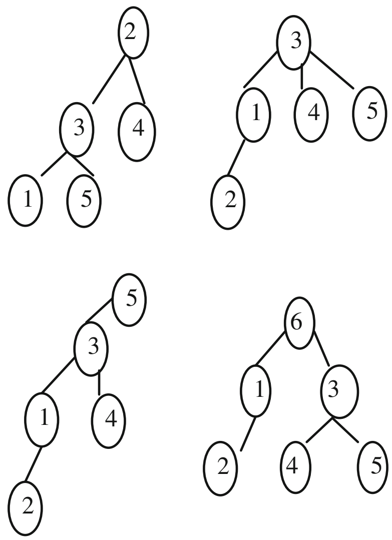

Fig. 96.3 The tree branches of S_2, S_3, S_5, S_6

The relations tracking method can avoid the repeated searching because a repeated node will be no longer continue to branch. Breadth First Search is a method looking for the shortest path between two nodes in a directed graph (Wang et al. 1994; Lu and Feng 2006; Yuan and Wang 2011), although the repeated searching can be avoided, it requires that a clear hierarchical relation be established firstly. However, in the ISM process, the hierarchical relationship is just obtained after reachable matrix.

96.3 Comparative Analysis of Several Methods

96.3.1 Formula Method

With formula method, the reachable matrix is obtained in terms of (A + I)r = (A + I)r−1 = M. A is adjacency matrix, I is unit matrix, M is reachable matrix. A can be obtained based on directed graph.

Usually, in terms of the formula, after the sequential operation, A_i can be obtained, that is $A_1 \neq A_2 \neq \ldots \neq A_{r-1} = A_r = A_{r+1}$, $A_r = (A + I)^r$, $r \leq n-1$, n is order number. Because $M = (A + I)^r$, then $M = A_r =$ Ar−1. Also taken Fig. 96.1 as an example, the operation process is shown below.

$$A = \begin{bmatrix} 0 & 1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 1 & 0 & 0 \\ 1 & 0 & 0 & 1 & 1 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 \\ 1 & 0 & 1 & 0 & 1 & 0 \end{bmatrix}$$

$$A_1 = A + I = \begin{bmatrix} 1 & 1 & 0 & 0 & 0 & 0 \\ 0 & 1 & 1 & 1 & 0 & 0 \\ 1 & 0 & 1 & 1 & 1 & 0 \\ 0 & 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 & 1 & 0 \\ 1 & 0 & 1 & 0 & 1 & 1 \end{bmatrix}$$

$$A_2 = (A + I)^2 = A_1^2 = \begin{bmatrix} 1 & 1 & 1 & 1 & 0 & 0 \\ 1 & 1 & 1 & 1 & 1 & 0 \\ 1 & 1 & 1 & 1 & 1 & 0 \\ 0 & 0 & 0 & 1 & 0 & 0 \\ 1 & 0 & 1 & 1 & 1 & 0 \\ 1 & 1 & 1 & 1 & 1 & 1 \end{bmatrix}$$

$$A_3 = (A + I)^3 = A_2.A_1 = \begin{bmatrix} 1 & 1 & 1 & 1 & 1 & 0 \\ 1 & 1 & 1 & 1 & 1 & 0 \\ 1 & 1 & 1 & 1 & 1 & 0 \\ 0 & 0 & 0 & 1 & 0 & 0 \\ 1 & 1 & 1 & 1 & 1 & 0 \\ 1 & 1 & 1 & 1 & 1 & 1 \end{bmatrix}$$

$$A_4 = (A + I)^4 = A_3.A_1 = A_3 = M = \begin{bmatrix} 1 & 1 & 1 & 1 & 1 & 0 \\ 1 & 1 & 1 & 1 & 1 & 0 \\ 1 & 1 & 1 & 1 & 1 & 0 \\ 0 & 0 & 0 & 1 & 0 & 0 \\ 1 & 1 & 1 & 1 & 1 & 0 \\ 1 & 1 & 1 & 1 & 1 & 1 \end{bmatrix}$$

Formula method is a traditional method and used widely, but the biggest drawback of this method is the complicated matrixes calculation which is only acceptable when elements are quite few. Actually a system is often large with many elements, and the relationships among elements are quite complicated. Therefore complicated matrix calculation decreases the practicality of this method (Tian and Wang 2003).

96.3.2 Warshall Algorithm

The steps of this algorithm are shown below. ①P ← A. ②k ← 1. ③i ← 1. ④if $p_{ik} = 1$, then $p_{ij} \leftarrow p_{ij} \vee p_{kj}$, $j = 1,2,\ldots,n$. ⑤i ← i+1. If $i \le n$, then turn to step ④. ⑥k ← k+1. If $k \le n$, then turn to step ③, otherwise stop. A is adjacency matrix, P is reachable matrix.

Among these steps, the step ④ is crucial. For Fig. 96.1, the operation process is shown as follows.

$$\text{①}P \leftarrow A \qquad P = \begin{bmatrix} 0 & 1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 1 & 0 & 0 \\ 1 & 0 & 0 & 1 & 1 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 \\ 1 & 0 & 1 & 0 & 1 & 0 \end{bmatrix}$$

$$\text{②}\underline{k \leftarrow 1} \qquad i \leftarrow 1 \; p_{11} = 0, \quad i \leftarrow 2 \; p_{21} = 0$$

$$i \leftarrow 3 \; p_{31} = 1 \quad P = \begin{bmatrix} 0 & 1 & 0 & 0 & 0 & 0 \\ \hdashline 0 & 0 & 1 & 1 & 0 & 0 \\ 1 & \underline{1} & 0 & 1 & 1 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 \\ 1 & 0 & 1 & 0 & 1 & 0 \end{bmatrix}$$

$$i \leftarrow 4 \; p_{41} = 0, \quad i \leftarrow 5 \; p_{51} = 0$$

$$i \leftarrow 6 \; p_{61} = 1 \quad P = \begin{bmatrix} 0 & 1 & 0 & 0 & 0 & 0 \\ \hdashline 0 & 0 & 1 & 1 & 0 & 0 \\ 1 & 1 & 0 & 1 & 1 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 \\ 1 & \underline{1} & 1 & 0 & 1 & 0 \end{bmatrix}$$

$\underline{k \leftarrow 2}$

$$i \leftarrow 1\, p_{12} = 1 \quad P = \left[\begin{array}{cccccc} 0 & 1 & \underline{1} & \underline{1} & 0 & 0 \\ 0 & 0 & 1 & 1 & 0 & 0 \\ \hdashline 1 & 1 & 0 & 1 & 1 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 \\ 1 & 1 & 1 & 0 & 1 & 0 \end{array}\right]$$

$i \leftarrow 2\ p_{22} = 0,$

$$i \leftarrow 3\, p_{32} = 1 \quad P = \left[\begin{array}{cccccc} 0 & 1 & 1 & 1 & 0 & 0 \\ 0 & 0 & 1 & 1 & 0 & 0 \\ \hdashline 1 & 1 & \underline{1} & 1 & 1 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 \\ 1 & 1 & 1 & 0 & 1 & 0 \end{array}\right]$$

$i \leftarrow 4\ p_{42} = 0, \quad i \leftarrow 5\ p_{52} = 0$

$$i \leftarrow 6\, p_{62} = 1 \quad P = \left[\begin{array}{cccccc} 0 & 1 & 1 & 1 & 0 & 0 \\ 0 & 0 & 1 & 1 & 0 & 0 \\ \hdashline 1 & 1 & 1 & 1 & 1 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 \\ 1 & 1 & 1 & \underline{1} & 1 & 0 \end{array}\right]$$

$\underline{k \leftarrow 3}$

$$i \leftarrow 1\, p_{13} = 1 \quad P = \left[\begin{array}{cccccc} \underline{1} & 1 & 1 & 1 & \underline{1} & 0 \\ 0 & 0 & 1 & 1 & 0 & 0 \\ 1 & 1 & 1 & 1 & 1 & 0 \\ \hdashline 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 \\ 1 & 1 & 1 & 1 & 1 & 0 \end{array}\right]$$

$$i \leftarrow 2\ p_{23} = 1 \quad P = \begin{bmatrix} 1 & 1 & 1 & 1 & 1 & 0 \\ \underline{1} & \underline{1} & 1 & 1 & \underline{1} & 0 \\ 1 & 1 & 1 & 1 & 1 & 0 \\ \hdashline 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 \\ 1 & 1 & 1 & 1 & 1 & 0 \end{bmatrix}$$

$$i \leftarrow 3\ p_{33} = 1 \quad P = \begin{bmatrix} 1 & 1 & 1 & 1 & 1 & 0 \\ 1 & 1 & 1 & 1 & 1 & 0 \\ \underline{1} & \underline{1} & \underline{1} & \underline{1} & \underline{1} & 0 \\ \hdashline 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 \\ 1 & 1 & 1 & 1 & 1 & 0 \end{bmatrix}$$

$$i \leftarrow 4\ p_{43} = 0$$

$$i \leftarrow 5\ p_{53} = 1 \quad P = \begin{bmatrix} 1 & 1 & 1 & 1 & 1 & 0 \\ 1 & 1 & 1 & 1 & 1 & 0 \\ 1 & 1 & 1 & 1 & 1 & 0 \\ \hdashline 0 & 0 & 0 & 0 & 0 & 0 \\ \underline{1} & \underline{1} & 1 & \underline{1} & \underline{1} & 0 \\ 1 & 1 & 1 & 1 & 1 & 0 \end{bmatrix}$$

$$i \leftarrow 6\ p_{63} = 1 \quad P = \begin{bmatrix} 1 & 1 & 1 & 1 & 1 & 0 \\ 1 & 1 & 1 & 1 & 1 & 0 \\ 1 & 1 & 1 & 1 & 1 & 0 \\ \hdashline 0 & 0 & 0 & 0 & 0 & 0 \\ 1 & 1 & 1 & 1 & 1 & 0 \\ \underline{1} & \underline{1} & \underline{1} & \underline{1} & \underline{1} & 0 \end{bmatrix}$$

Because the calculation process is quite tedious, so the partial steps (k = 4 and 5) are omitted.

When k = 6, the comparing result is as follows.

$$\begin{aligned} k \leftarrow 6 \quad & i \leftarrow 1\ p_{16} = 0 \\ & i \leftarrow 2\ p_{26} = 0 \\ & i \leftarrow 3\ p_{36} = 0 \\ & i \leftarrow 4\ p_{46} = 0 \\ & i \leftarrow 5\ p_{56} = 0 \\ & i \leftarrow 6\ p_{66} = 0 \end{aligned}$$

The essence of Warshall algorithm is matrix comparing and matrix updating based on the comparisons, at last the reachable matrix can be obtained. The comparing scope of formula method is between matrix and matrix, while the comparing scope of Warshall algorithm is limited in a matrix. However, Warshall algorithm also involves a large number of repeated comparing. From the operations above it can be known that when $k = 3$, $i = 5$, matrix P do not change, but according to this algorithm, the comparing of remainder must go on.

Another problem of Warshall algorithm is, reachable matrix obtained from Warshall algorithm cannot reflect the circumstance that a node gets to itself. However, the reachable matrix obtained from formula method can reflect the circumstance that each node gets to itself. The reason is that the operation of formula method is made after the adjacency matrix and unit matrix added together. This paper argues that when reachable matrix obtained from Warshall algorithm plus unit matrix, the problem can be solved effectively.

Compared with formula method and Warshall algorithm, relations tracking method take the form of tree branch to track the reachable set, thus the complicated operations can be avoided. Of course, with computer programming the establishment of reachable matrix may be more efficient.

96.4 Conclusion

When establishing ISM, the calculation of reachable matrix is always quite crucial and tedious, in order to solve this problem, the relations tracking method for reachable matrix is presented, compared with the other methods, this method can avoid complex matrix operations and consequently enhance the practical operability of ISM.

Acknowledgments This research is supported by the Sichuan Province Cyclic Economy Research Center (XHJJ-1222).

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Chapter 97
The Selection of the Regional Center City Under the Policy of Expanding Domestic Demand

Jian-wei Cheng and Juan Shang

Abstract From the perspective of region economics, this paper makes the comparison on regional advantages and the selection of the regional center city between sixteen provincial capital cities in the Central, Northwest and Southwest Region in China, by exploiting AHP and constructing the index system with twelve secondary indexes on the five factors of geography location, traffic facilities, economics, population and human capital. The following research conclusions are drawn. First, in Central Region, Wuhan, having the highest composite score, should be selected as the regional center city. Second, although it is not located the geographical center in the Northwest Region, Xi'an has the highest composite score and each secondary index is highest, which should be selected as the regional center city. Third, in Southwest Region, Chongqing should be selected as the regional center city.

Keywords City · Region center · Expand domestic demand · AHP

97.1 Introduction

With the development of the Chinese economy, Chinese government has been transforming the mode of economic growth and expanding domestic demand. In the twelfth five-year guideline for national economic and social development of the People's Republic of China, it is stated clearly to improve the pattern of regional development and expand inland development. For example, "Build long-term mechanism to expand domestic demand, rely on consumption, investment and exports, and promote economic growth." "Take the expansion of consumer

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E. Qi et al. (eds.), *The 19th International Conference on Industrial Engineering and Engineering Management*, DOI: 10.1007/978-3-642-38391-5_97,

demand as a strategic focus to expand domestic demand, further release the consumption potential of urban and rural residents, and gradually realize the domestic market scale to be one of the largest sizes of in the world" (The twelfth five-year guideline for national economic and social development of the People's Republic of China). Under this macroscopic environment, inland region having the resources, labor and other advantages will actively undertake international and coastal industrial transfer. In recent years, the domestic consumption level has risen greatly. Per capita consumption expenditure of urban residents has increased from 4998 yuan in 2000 to 13471 yuan in 2010, while that of rural residents has increased from 1670 yuan in 2000 to 4382 yuan in 2010. Under the policy of expanding domestic demand, consumer demand in China will be greatly improved. The inland cities have more advantages of geography location over coastal cities such as shorter transportation distance and lower logistics cost so that they can better meet the increasing consumer demand after expanding domestic demand. Moreover, Chinese government has accelerated the development of Central and Western regions, which put forward the strategy of "The Rise of Central China" and "China Western Development". The regions of central and western will have more policy support. Therefore, in the new economic situation, the cities in the regions of central and western will have great development.

97.2 Research Situations and Problems

Many scholars have made a lot of researches on the development of the cities and regions. Linneker and Spence (1996) concluded the positive relationship of transport infrastructure with regional economic development. Lawson (1999) researched the competence theory of the region. Siegfried (2002) presented that it has closer economic associations in adjacent regions.

The comparative researches between the cities are made mainly from the perspective of urban competitiveness. Hao and Ni (1998) researched empirically seven cities' competitiveness of Beijing, Tianjin, Shanghai, Dalian, Guangzhou, Xiamen, and Shenzhen from the 21 subdivision indexes by using principal components analysis method. Ning and Tang (2001) designed a city competitiveness model, based Michael E. Porter and IMD national competitiveness model. Li and Yu (2005) presented that city competitiveness is the sustainable development capacity of a city to attract, acquire, control and convert resources, and then create value and wealth and improve the living standard of the presidents. Wei-zhong Su, Lei Ding, Peng-peng Jiang and Qi-yan Wang made the empirical study for the tourism competitiveness between different cities (Ding et al. 2006; Su et al. 2003; Jiang and Wang 2008; Wang and Wang 2009). Cheng-lin Qin and Jun-cheng made the researches on the polycentric urban-regional structure (Qin and Li 2012; Zhu et al. 2012). However, the studies are mostly made from the city's current situation. There are few studies from the perspective of Regional Economics, from the basic potential factors, such as geographical location, transport and radiation.

According to the “Growth pole theory” by Francois Perroux, regional economic development depends mainly on the minority regions or industries with better conditions, which should be fostered to the growth pole of region economic. The surrounding areas or related industries will be affected and promoted through the polarization and diffusion effect of the growth pole (Luan 2008). Therefore, under the present circumstances, to obtain the rapid development of the central and western region, China should put limited funds into the cities with the regional advantages in the central and western region to realize polarization and diffusion effects so as to promote the development of the whole region. However, the central and western regions have vast territory, in which there are so many different cities. It is an urgent problem which city has more geography location advantages so as to have faster development, and has the role of regional centers to radiate surrounding areas. This paper tries to solve this problem. From the perspective of region economics, this paper makes the selection research on the regional center city for three regions, based on the empirical data of the central, northwest and southwest region in china.

In Central, Northwest and Southwest Region, their provincial capital cities are selected as the research object in this paper since they are the largest city of their provinces with the greatest policy advantage and economic advantage. According to the national statistical standards, the provincial capital cities in Central Region are Taiyuan (Shanxi), Zhengzhou (Henan), Wuhan (Hubei), Changsha (Hunan), Hefei (Anhui), Nanchang (Jiangxi). The provincial capital cities in Northwest Region are Xi’an (Shaanxi), Lanzhou (Ganshu), Xining (Qinghai), Yinchuan (Ningxia), Urumqi (Xinjiang). The provincial capital cities in Southwest Region are Chongqing, Chengdu (Sichuan), Guiyang (Guizhou), Kunming (Yunnan), Lhasa (Tibet).

97.3 Index selection

According to the regional economics theory, such as “agricultural location theory” by J.H.Thünen, “industrial location theory” by Alfred Weber, “transport location theory” by Edgar M. Hoover, Market Location theory by August Losch, “Central Place Theory” by Walter Christaller and “growth pole theory” by Francois Perroux, a regional center must consider the geographical location, population, capital, labor cost, transportation, marketing and other factors. Through comprehensive analysis, this paper presents that a regional central city should have the following factors. First, it is located in the geographical center. Second, it has convenient transportation and logistics facilities, which can form great polarization and diffusion effect. Third, it has good economic base, which not only reflects a region economic strength, competitiveness and consumption ability, but also a regional market environment and commercial atmosphere. Fourth, it has certain population. The place with numerous populations can provide a large number of labor forces as well as potential consumers. Fifth, it has the advantage of human

Table 97.1 Influence index of the selection of regional center city

First index	Secondary index	Symbols
Geography location	Distance sum between the city and other cities	X_1
Traffic facilities	Railway mileage per ten thousands square kilometers in the province	X_2
	Highway mileage per ten thousands square kilometers in the province	X_3
Economics	City GDP	X_4
	Total retail sales of consumer goods	X_5
	Per capita disposable income of urban residents	X_6
	Per capita net income of rural residents	X_7
Population	Total population number of the province	X_8
	Employment number of the province	X_9
Human capital	Total number of college student in the province	X_{10}
	Average number of people having the higher education per ten thousands persons	X_{11}
	Average number of the college student per ten thousands persons	X_{12}

capital. In the knowledge economy era, human capital is the main factor reflecting competition ability. In this paper, considering the above five factors and the data collection, twelve secondary indexes are selected, shown in Table 97.1.

As shown in Table 97.1, Geography location is compared by calculating the distance sum between the city and other cities. The city with the smallest distance sum is located relatively in the center, which can bring the polarization and diffusion effects. The city area is small.

Railroad and highway is distributed in a mesh structure in the surrounding area. The railway and highway conditions within the city can not reflect a city traffic convenience. Moreover, the population and human capital have mobility. The quantity within city can not reflect the city's regional competitive advantage. Therefore, the traffic facilities, the population and the human capital select the province data as the index. In order to eliminate the influence of provincial area, the railway mileage and the highway mileage per ten thousands square kilometers are selected as the index reflecting a city traffic convenience. The total population number and the employment number of the province are selected as the population index. Relatively, the total number of college student in the province is selected to reflect the total situation of human capital. The average number of people having the higher education per ten thousands persons is selected to reflect the average situation of human capital, as well as the average number of the college student per ten thousands persons. The GDP, total retail sales of consumer goods, per capita disposable income of urban residents and per capita net income of rural residents of that city are selected as the index of economics.

97.4 Model Selection and Data Comprehensive Processing

97.4.1 Index Weight

Weight is the coefficient of index importance. Calculating the weights of the indexes commonly uses these methods, such as the subjective weighting method, the objective weighting method and the Analytic Hierarchy Process. Analytic Hierarchy Process (AHP) is proposed in the mid 1970s by TL Saaty, a professor of the University of Pittsburgh. It decomposes the complex question into several component factors, which is divided further into the target layer, rule layer and index layer so as to form a model with multi-objective and multi-level and ordered hierarchical structure. The comparison of each factor is made to determine the relative importance of the factors. The steps are the establishment of the hierarchical structure, constructing judgment matrix, hierarchical ranking and consistency check (Peng et al. 2004).

AHP is used to determine the index weigh in the paper. The index comparison values of judgment matrix are determined after comprehensive consideration of the theoretical analysis, statistics data and expert score. Target layer A, rule layer B and index layer P are made as shown in Table 97.2. In order to facilitate comparison and reduce the occupied space, the analysis result after calculating is attached to the last two columns in Table 97.2.

According to AHP, the largest eigenvalue $\lambda_{\max}$ and the corresponding eigenvector ω can be calculated by constructing the judgment matrix. For the judgment matrix A-B, shown in Table 97.3, we can conclude that $\lambda_{\max}$=5.0304, $\omega = (0.375, 0.215,\ \ 0.215, 0.121, 0.074)^T$, $CI = \frac{\lambda_{\max} - n}{n-1} = 0.0076$. And the judgment coefficient $CR = \mathrm{CI/RI} = 0.0068 < 0.10$, which means that the consistence of judgment matrix is satisfied. Therefore, we get that the weight value of B_1, B_2, B_3, B_4, and B_5 for A are 0.375, 0.215, 0.215, 0.121, 0.074, in which $B_{1,}$ geographical location index, is the greatest. Similarly, we can construct the judgment matrix B_3-P (Table 97.4) in which the judgment coefficient $CR = 0.0045 < 0.10$ and the consistence of judgment matrix is satisfied. The weight value of B_{31}, B_{32}, B_{33} and B_{34} for B_3 are 0.423, 0.227, 0.227, 0.123. The judgment matrix $B_5 - P$ (Table 97.5) can be constructed, in which the judgment coefficient $CR = 0.0083 < 0.10$ and the consistence of judgment matrix is satisfied. The weight value of B_{51}, B_{52} and B_{53} for B_5 are 0.539, 0.297 and 0.164.

B_2 and B_4 have only two secondary indexes, which are given that the weight values are both 0.5. So $CI = RI = 0$ .We make a consistence test for the total hierarchy, which is the weight value of the lowest index for the overall target. The judgment coefficient $CR = \sum_{i=1}^{n} \alpha_i CI_i / \sum_{i=1}^{n} \alpha_i RI_i = 0.0052 < 0.10$, in which $\alpha_i$is the weight value of B_i for A and CI_i is the consistence coefficient of B_{ik} for B_i, so the consistence of judgment matrix is satisfied. The final result is shown as Table 97.2, of which the last column is the weight value of each index for A.

Table 97.2 Index weight value by AHP

Target layer A	Rule layer B	Weight value of B for A	Index layer P	Weight value of P for B	Weight value of P for A
Composite score A	Geography location B_1	0.375	B_{11} for distance sum X_1	1.000	0.375
	Traffic facilities B_2	0.215	B_{21} for railway mileage X_2	0.500	0.108
			B_{22} for highway mileage X_3	0.500	0.107
	Economics B_3	0.215	B_{31} for city GDP X_4	0.423	0.091
			B_{32} for total retail sales X_5	0.227	0.049
			B_{33} for disposable income X_6	0.227	0.049
			B_{34} for net income X_7	0.123	0.026
	Population B_4	0.121	B_{41} for total population X_8	0.500	0.061
			B_{42} for employment number X_9	0.500	0.061
	Human capital B_5	0.074	B_{51} for total number of college student X_{10}	0.539	0.040
			B_{52} for average number of people having the higher education X_{11}	0.297	0.022
			B_{53} for average number of the college student X_{12}	0.164	0.012

Table 97.3 Judgment matrix A-B

A	B_1	B_2	B_3	B_4	B_5	ω
B_1	1	2	2	3	4	0.375
B_2	1/2	1	1	2	3	0.215
B_3	1/2	1	1	2	3	0.215
B_4	1/3	½	1/2	1	2	0.121
B_5	1/4	1/3	1/3	1/2	1	0.074

$\lambda_{\max} = 5.0304,\ CI = 0.0076,\ RI = 1.12,\ CR = 0.0068 < 0.10$

Table 97.4 Judgment matrix B_3-P

B_3	B_{31}	B_{32}	B_{33}	B_{34}	ω
B_{31}	1	2	2	3	0.423
B_{32}	1/2	1	1	2	0.227
B_{33}	1/2	1	1	2	0.227
B_{33}	1/3	½	1/2	1	0.123

$\lambda_{\max} = 4.0123,\ CI = 0.0041,\ RI = 0.9,\ CR = 0.0045 < 0.10$

Table 97.5 Judgment matrix B_5-P

B_5	B_{51}	B_{52}	B_{53}	ω
B_{51}	1	2	3	0.539
B_{52}	1/2	1	2	0.297
B_{53}	1/3	1/2	1	0.164

$\lambda_{\max} = 3.0096,\ CI = 0.0048,\ RI = 0.58,\ CR = 0.0083 < 0.10$

97.4.2 Data Dimensionless Processing

Because each index has different units and dimensions, dimensionless processing for these indexes must be done in order to compare and summarize. The normal methods of index standardization are range transformation method, linear proportional method, normalized method, standard sample transformation method, vector normalization method and taking reciprocal. In the paper, linear proportional method is used on the standardization and summation of these indexes.

In the decision matrix $X = \left(x_{ij}\right)_{m \times n}$,

For the positive index, given $x_j^* = \max_{1 \le i \le m} x_{ij} \ne 0$, then

$$y_{ij} = \frac{x_{ij}}{x_j^*},\ (1 \le i \le m,\ 1 \le j \le n) \tag{97.1}$$

For the reverse index, given $x_j^* = \min_{1 \le i \le m} x_{ij} \ne 0$, then

$$y_{ij} = \frac{x_j^*}{x_{ij}}, (1 \le i \le m, 1 \le j \le n) \tag{97.2}$$

$Y = \left(y_{ij}\right)_{m \times n}$ is called as the linear proportional standard matrix.

In the twelve indexes, the distance sum is the reverse index, which means the higher the distance sum is, the lower the transform score is. So the index of distance sum should be standardized by the Eq. (97.2). The other eleven indexes are the positive index, which should be standardized by the Eq. (97.1). It must be noted that the maximum and minimum values are the respective region value within central, southwest and northwest regions, not the total value.

97.4.3 Evaluation Model

Linear weighting method is used as the evaluation model of.

$$Y_j = \sum_{i=1}^{12} \beta_i \times X_{ij} \qquad (i = 1, 2, \ldots 12;\ j = 1, 2, \ldots 16)$$

In which Y_j is "j" city's composite score, β_i is the weight value of "i" index, X_{ij} is the dimensionless value of "i" index of "j" city. According to the weight value in the Table 97.2, the final formula is:

$$\begin{aligned} Y =& 0.375X_1 + 0.108X_2 + 0.107X_3 + 0.091X_4 + 0.049X_5 + 0.049X_6 \\ &+ 0.026X_7 + 0.061X_8 + 0.061X_9 + 0.040X_{10} + 0.022X_{11} + 0.012X_{12} \end{aligned}$$

97.4.4 Calculation Results and Description

Considering the data consistency, all the data are in 2010. The data of X_1, X_2, X_7, X_8, X_9, X_{10} and X_{12} are from the "2011 China Statistical Yearbook". The data of X_3, X_4, X_5, and X_6 are from Statistical Communiqué on the 2010 National Economic and Social Development on these 16 cities. The original data are not listed for saving the space. By calculating, the final result is shown on the Table 97.6, in which the Y column is the final composite score.

As shown in Table 97.6, by considering and calculating comprehensively the twelve secondary indexes, it is concluded that the composite score rank of the six cities in Central Region are Wuhan (87.52), Zhengzhou (85.75), Changsha (74.83), Hefei (73), Nanchang (64.03) and Taiyuan (54.38), which means Wuhan, the highest score city, has the greatest advantages to become the regional center city in Central Region. But the gap between Zhengzhou and Wuhan is very small, only 1.77. After analysis of various secondary indexes, Both of Wuhan and Zhengzhou have five indexes being the highest score (100). By comparing the secondary respectively, Wuhan has the advantages of better geography location and economics, while Zhengzhou has the advantages of better traffic and more population and labor force. Zhengzhou is predominant on the total number of human capital.

Table 97.6 The composite scores of sixteen cities

Region	City	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}	X_{11}	X_{12}	Y
Central region	Taiyuan	52.3	93.4	57.2	32.2	32.7	75.6	71.5	38.0	27.6	38.6	91.5	73.4	54.38
	Zhengzhou	79.1	100.0	100.0	72.5	66.5	82.8	86.7	100.0	100.0	100.0	67.1	63.3	85.75
	Wuhan	100.0	70.5	75.6	100.0	100.0	91.2	78.0	60.9	51.6	89.0	100.0	100.0	87.52
	Changsha	72.9	68.0	73.3	82.4	71.8	100.0	100.0	69.9	66.3	71.9	79.7	70.6	74.83
	Hefei	85.5	79.6	72.9	49.0	33.3	83.5	66.9	63.3	63.7	64.5	70.3	63.4	73.00
	Nanchang	80.0	66.2	57.4	40.0	30.3	80.1	67.6	47.4	38.2	56.0	71.8	74.4	64.03
Northwest region	Xi'an	69.3	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	99.3	100.0	88.58
	Lanzhou	100.0	28.9	39.0	33.9	33.8	63.2	59.2	68.5	73.4	41.1	70.7	58.7	66.74
	Xining	95.9	13.0	12.0	19.4	14.4	63.3	71.2	15.1	15.1	4.8	81.0	34.9	50.33
	Yinchuan	89.6	94.9	47.3	23.5	14.0	76.8	79.5	16.9	16.7	8.6	86.1	58.2	62.54
	Urumqi	39.0	12.8	12.8	40.4	35.0	64.7	96.3	58.5	43.7	27.1	100.0	45.7	38.50
Southwest region	Chongqing	99.4	100.0	100.0	100.0	100.0	91.1	64.3	35.9	38.3	48.1	100.0	100.0	88.77
	Chengdu	100.0	43.2	38.7	70.3	84.0	100.0	100.0	100.0	100.0	100.0	77.2	74.2	83.11
	Guiyang	95.6	67.1	60.6	14.2	16.8	79.7	72.8	43.2	48.1	29.8	61.2	46.0	66.17
	Kunming	90.5	37.1	37.4	26.9	36.8	90.6	70.8	57.2	56.3	40.4	66.9	57.7	63.18
	Lhasa	48.6	2.6	3.6	2.3	3.1	79.6	61.0	3.7	3.5	2.9	63.7	56.9	27.35

Wuhan is predominant on the average situation of human capital. Compared comprehensively the six cities in Central Region, it can be concluded that the scores was hierarchy distribution and the overall development of the Central Region is relatively balanced.

The composite score rank of the five cities in Northwest Region are Xi'an (88.58), Lanzhou (66.74), Yinchuan (62.54), Xining (50.33), Urumqi (38.50). Xi'an is not located on the center of the Northwest Region, but its composite score is far higher than the second city, Lanzhou, and it has ten indexes to be the highest score (100). Xi'an has the greatest advantages to become the regional center city in Northwest Region. Similarly, compared comprehensively the five cities in Northwest Region, it can be concluded that the scores was of great difference. The development gap between the cities of the Central Region was very large.

The composite score rank of the five cities in Southwest Region are Chongqing (88.77), Chengdu (83.11), Guizhou (66.17), Kunming (63.18), Lhasa (27.35), which means Chongqing has the greatest advantages to become the regional center city in Southwest Region. But the gap between Chengdu and Chongqing is small, only 5.66. From each secondary index, Chongqing and Chengdu have both six indexed being the highest score. Chongqing has the great advantage of traffic facilities. Correspondingly, Chengdu has the advantage of population and labor force. Similarly, compared comprehensively the five cities in Southwest Region, it can be concluded that the scores was also of great difference. The overall development of the Southwest Region is obvious uneven.

97.5 Conclusion and Suggestion

Under this macroscopic environment of expanding domestic demand, the cities in Central and West Region are facing tremendous development opportunity. From the perspective of region economics, this paper makes the comparison on regional advantages and selection of the regional center city between sixteen provincial capital cities in the Central, Northwest and Southwest Region in china, by constructing the index system with twelve secondary indexes on the five factors of geographical location, traffic facilities, economics, population and human capital and exploiting AHP. The following conclusions are drawn.

Wuhan, Xi'an, Chongqing have the more regional advantages to meet increasing consumer demand. Chinese government should position Wuhan as the regional center city in Central Region, Xi'an as the regional center city in Northwest Region, and Chongqing as the regional center city in Southwest Region, giving the three cities more policy and funds support. The three cities should be built to be the regional growth pole so as to enlarge the polarization and diffusion effect and drive the three regional developments.

At the same time, Wuhan should take full advantages of its economic and human capital, and concentrate on capital industry and science and technology industry. Xi'an has long distance with the other cities in the Northwest Region.

The traffic of the Northwest Region and the regional gap is worst in the three regions, which means the polarization and diffusion effect of Xi'an for Northwest Region is weaker. Xi'an should strengthen the connection so as to build the Northwest growth pole in Asia-Europe continental bridge and drive the development of Northwest Region. The composite scores of Chongqing and Chengdu are both on the top in the southwestern region, much greater than other provincial capital cities in the Southwest Region. Furthermore, the two cities are much close on the geographical location, Chongqing and Chengdu should reinforce the cooperation and become the regional growth dual pole so as to drive the development of Southwest Region.

Acknowledgments Based on empirical data of the Central, Northwest and Southwest Region in China

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Chapter 98
A Research on Mine Pressure Monitoring Data Analysis and Forecast Expert System of Fully Mechanized Coal Face

Hong-bing Qiao, Hai-long Xu, Ao-shuang Pang, Chang-dong Zhou and Yi-lun Wang

Abstract Based on the research of mine pressure monitoring system of fully mechanized coal face, we have designed a set of software, whose perfect function is mine pressure monitoring data analysis. The data from mine pressure monitoring system could be collected and analyzed scientifically and effectively. We have accomplished the establishment of four databases combined with safety production condition of working face and the result of data analysis. Besides, we have designed a mine pressure forecast model and forecast expert system with the four established databases. It is of practical significance for safety production of working face.

Keywords Data analysis · Database · Forecast expert system · Mine pressure monitoring

98.1 Introduction

In coal industry, the roof accident has been the major security hidden danger for coal mine workers for many years (Qian and Shi 2003). According to statistics, the coal roof accidents make up 42 % of various accidents. The roof accidents are threatening the life of coal mine workers seriously. One of the main reasons, which cause all kinds of mine disasters, is mine pressure appearance (Cen 1998). Therefore, it is particularly important to carry out pressure monitoring for hydraulic support which is the roof support equipment. In recent years, with the development of science and technology, the constant improvement of mining technology and strengthening the requirement of safety production in coal mine,

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E. Qi et al. (eds.), *The 19th International Conference on Industrial Engineering and Engineering Management*, DOI: 10.1007/978-3-642-38391-5_98,

mine pressure monitoring has been carried out extensively to some extent (Sun et al. 2006). We have designed a set of software, which owns perfect function, for mine pressure monitoring data analysis of fully mechanized coal face. It plays a positive role in the research on appearance regularity of mine pressure and the prevention of coal mine roof accidents. Based on date analysis we have also designed mine (Zhang 2004).

98.2 Selection of Data Analysis Software Development Environment on Mine Pressure Monitoring

98.2.1 Design of the Software Interface

Software interface is designed by using Configuration King which owns the features of strong adaptability, extensive application, easy extension, low cost and short development cycle. Besides, it owns rich graphics library and all kinds of communication interface. It is compatible with other programming languages, and it could be extended using Visual Basic 6.0 and Visual C++. It has the alarm window. Meanwhile, it could generate all kinds of reports and real-time trend curve expediently.

98.2.2 Design of Data Processing and Analysis

Data processing and analysis are designed based on Matlab which is a business mathematics software developed by MathWorks company of American. Matlab is the senior calculation language used for algorithm development, data analysis and numerical calculation. Besides, this software, with kind working platform and programming environment, has enhanced functionality of data analysis and graphics processing.

98.2.3 Design of Databases

Database is established using SQL database tool which is an operation command set specially designed for the establishment of database. SQL is a kind of database language with all ready function. When using it, users only need to send out the command of “what to do”, without considering “how to do”. It has become the basis of the database operation with features of powerful function, easy learning and convenient using.

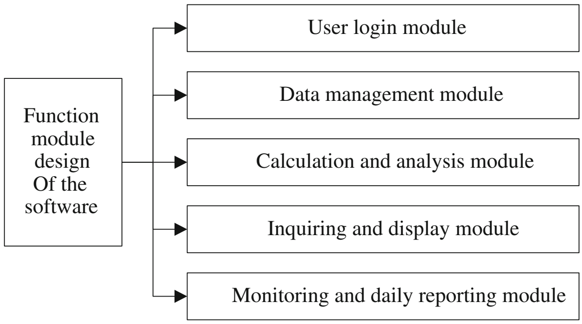


Fig. 98.1 Main function modules of analysis software

98.3 Function Module Design of Data Analysis Software on Mine Pressure Monitoring

Main function modules of data analysis software on mine pressure monitoring are shown in Fig. 98.1: Main function modules of data analysis software on mine pressure monitoring are shown in Fig. 98.1 (Gong and Wang 2011):

98.3.1 User Login Module Design

Different users have different operating authority, which is also the key to guarantee the normal operation of the system. User login module is the necessary channel through which users enter the main application program. Here users need to complete the information authentication. We need to understand the process of user information. The flow diagram is shown in Fig. 98.2.

98.3.2 Data Management Module Design

See Fig. 98.3

98.3.3 Calculation and Analysis Module Design

According to the observation, we complete the conventional calculation work, such as pillar load, under remove and the closer quantity between top and bottom floor.

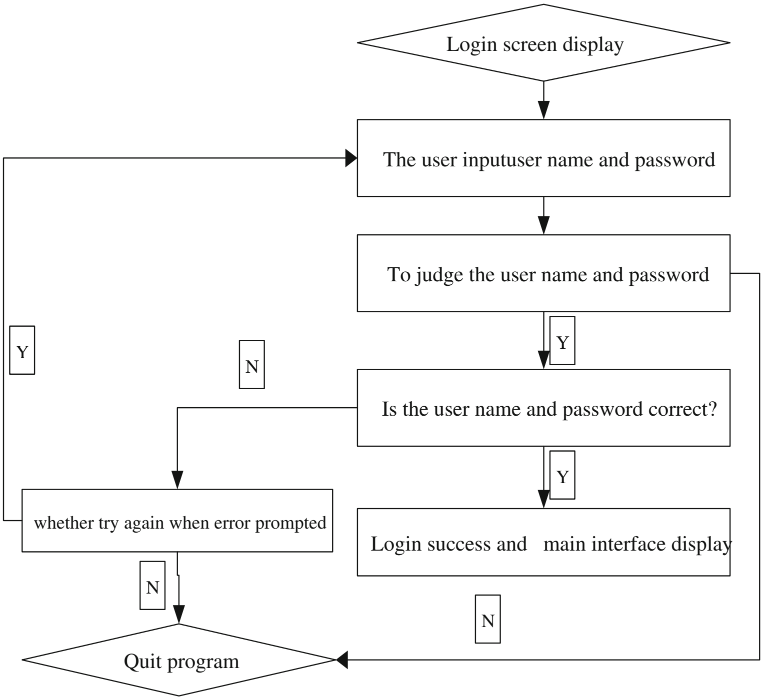
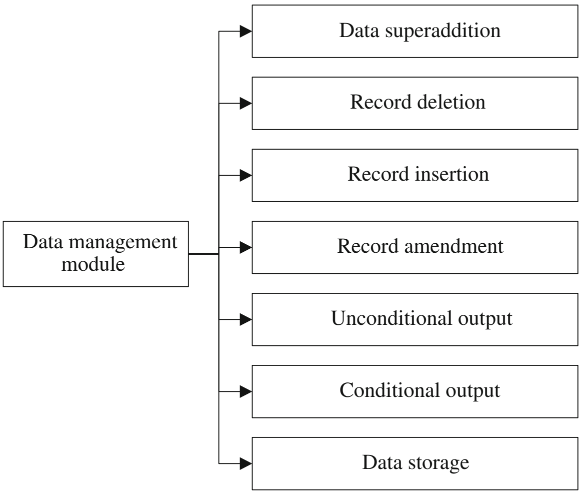


Fig. 98.2 Data management module design

Fig. 98.3 Data management module design



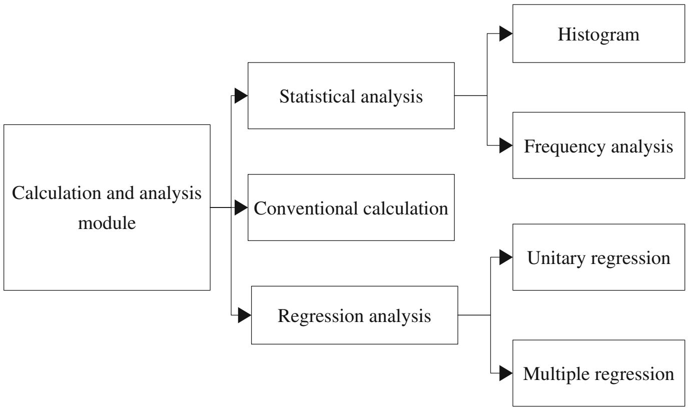


Fig. 98.4 Calculation and analysis module design

According to the process, every interval percent can be calculated when the extreme value and the number of intervals given. On the basis of it, the probability distribution examination and the characteristic value calculation could be carried out.

Unitary linear or nonlinear and multivariate linear or nonlinear regression analysis could be taken on the basis of shared database. It also adds the multivariate stepwise regression. The program can automatically screen factors to ensure the effectiveness of the regression equation. Besides, the program could carry on weight analysis of influence factors (Mu et al. 2012).

Calculation and analysis method of module is shown in Fig. 98.4.

98.3.4 Inquiring and Display Module Design

Any database could be queried in this module. In a single query condition, people can find out the maximum, the minimum and the average. The record number and percentage which meet certain condition could be found out. Search results can then be displayed and printed according to user requirements. This module contains content as shown in Fig. 98.5.

98.3.5 Monitoring and Daily Reporting Module Design

It needs strict scientificalness and clear pertinence in monitoring and daily reporting module. People could make bold discussion about newfound problems and expound their own and academic points of view. The so-called scientificalness means processing all the observation data using theory of probability and

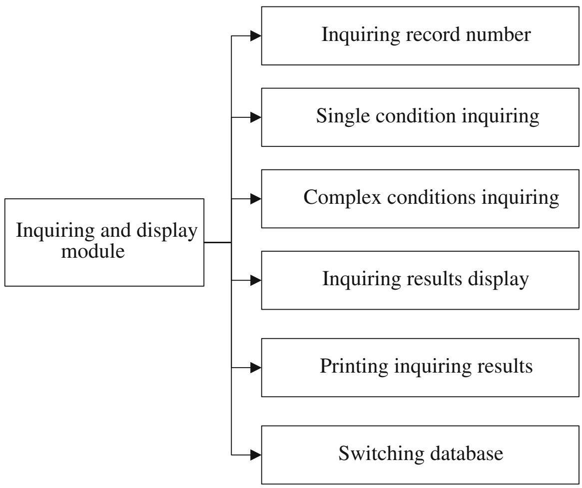


Fig. 98.5 Inquiring and display module design

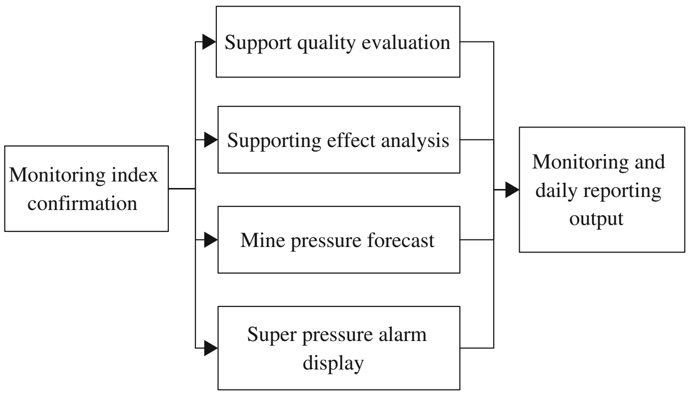


Fig. 98.6 Monitoring and daily reporting module design

mathematical statistics method, but not choosing optionally or analyzing using the wrong method. The so-called pertinence means summarizing the achievements practically and realistically according to concrete contents, purpose and the used instruments of this observation, then obtaining the mine pressure characteristics, the roof control method and the improvement way of this working face or tunnel (Cao 2011). This module contains several contents as shown in Fig. 98.6.

98.4 The Establishment of Database

The database establishment not only includes all of the observed contents and the relevant information of working face production, but also meets convenient data processing (Li et al. 2002). Four original databases are established (Zhao et al. 2011; Tan 2000).

98.4.1 Observation Line Database

We record every observation line which is set every ten hydraulic supports. Observation contents include the support working state and roof bolting effects.

98.4.2 Daily Observation Database

The record, which is made for every day or every shift, includes the position of winning machine, the setting load of stanchion and the end resistance.

98.4.3 Stanchion Resistance Database

This database, taking mining face cycle for a record, could carry out various calculations of the stanchion resistance.

98.4.4 Basic Parameters Database of Working Face

This section contains the basic parameters, such as the length of the working face, the slope angle, the coal thickness, the coal hardness and the surrounding of working face.

98.5 The Establishment of Forecast Expert System

It is an indispensable security technology to take mining pressure prediction. Realizing automation and intellectualization is the urgent task which would turn the technology into high-tech products (Zhou et al. 2011).

According to the results of data analysis and coal mine safety production experience for many years, this system explores with mine pressure prediction mechanism deeply. Mine pressure prediction expert system is on the basis of mine pressure data analysis, prediction model, reasoning strategy, monitoring method and the data processing method. The core of the system is the knowledge base and reasoning machine. The knowledge base is the set of mine domain knowledge that mine pressure prediction needs, including basic facts, rules and other relevant information (Huang et al. 2008). The knowledge representation is various, including framework, rules, semantic networks and so on. The knowledge, deriving from field experts, is the key to expert system capacity, namely the quality standard of the expert system depends on the quality and quantity of the knowledge. As the knowledge base and the expert system are independent of each other, user can change and perfect knowledge contents to improve the performance of the system. While reasoning machine, which is actually proceeded to explain the knowledge, is the executive core part of problem solving. According to the semanteme of knowledge, it conducts interpretive execution for the knowledge found through certain strategy and records the results in the appropriate space of the dynamic base.

Mine pressure forecast expert system model is shown in Fig. 98.7.

The establishment of the system should include the following three factors:

- It should possess the knowledge of experts who are in the mine pressure forecast field.
- It can simulate specialistic thought.
- It also possesses expert-level problem-solving.

The process of establishing mine pressure forecast expert system could be called “the knowledge engineering”. In other words, the software engineering thought is applied to design system based on the knowledge. It includes several aspects below (Jiang et al. 1995):

- Knowledge acquisition.
- The selection of appropriate knowledge representation.
- Software design.
- The engineering accomplishment with the right computer programming language.

The system, which sets up a bridge between automatic forecast and forecast mechanism, is able to predict mine pressure rule and display overpressure alarm. It plays a significant role in safety production, roof management, reasonable selection of hydraulic support and optimized support design.

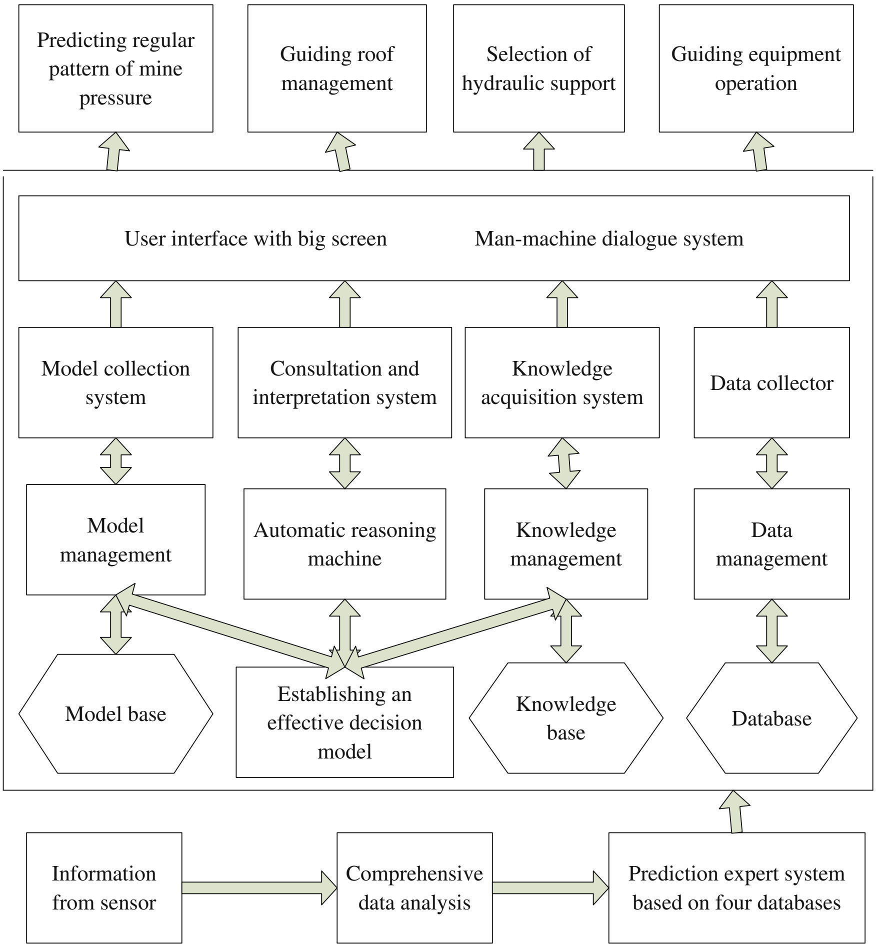


Fig. 98.7 Mine pressure forecast experts system diagram

98.6 Conclusion

a. User Login Module Design (1) Through the mine pressure monitoring data analysis of the fully mechanized mining face, people could grasp mine pressure distribution, working resistance of hydraulic support, pressure cycle, caving span, first pressure span and so on. It has theoretical significance in safety production.
b. The result of data analysis could provide important basis for the correct selection of hydraulic support and occupy a significant role in giving full play to the performance of mining equipment.

c. Mine pressure forecast expert system could predict roof accident effectively. People would move support before the peak value comes and find hidden danger of the support, such as tilt, roof exposure, sealing performance and so on. The application of mine pressure monitoring system is an important measure to avoid blindness and empiricism of roof management. And it could also provide reliable basis for working out mining regulations of similar coal seam.

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Chapter 99
The U-Shaped Relationship Between Corporate Social Disclosure and Corporate Performance: Evidence from Taiwan's Electronics Industry

Chin-Shien Lin, Ruei-Yuan Chang and Van Thac Dang

Abstract This study investigates the corporate social disclosure (CSD) of the electronics industry in Taiwan and examines the relationship between corporate social responsibility disclosure and corporate economic performance. The annual reports of 600 out of 929 companies on the Taiwan Market Observation Post System and in the Taiwan Economic Journal database in 2009 were hand-collected. The results reveal the practice of corporate social responsibility disclosure in Taiwan's electronics industry. More specifically, this paper finds that the relationship between corporate social responsibility disclosure and corporate economic value-added is best illustrated by the U-shaped curve. On the one hand, the findings of this study help to build knowledge of corporate social responsibility in Taiwan's business companies. On the other hand, the results of this study somewhat explain the inconsistent findings of the relationship between corporate social responsibility disclosure and corporate performance in the previous literature. This study provides important implications for both academics and practitioners.

Keywords Corporate social disclosure · Economic value-added · U-shaped · Content analysis

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E. Qi et al. (eds.), *The 19th International Conference on Industrial Engineering and Engineering Management*, DOI: 10.1007/978-3-642-38391-5_99,

99.1 Introduction

In a modern society, business firms have been viewed as open systems that interact with and are integral parts of their environment. Business firms not only obtain material, financial, and human resources from the outside environment, but also gain support and legitimacy from their stakeholders and the whole society (Ott et al. 2010). Business firms are now facing increasing pressure from stakeholders, regulators and society as the latter demands more comprehensive and transparent information regarding the former's financial soundness, employee policies, environmental policies, social responsibility involvement, etc. As a result, an increasing number of business firms are now disclosing their corporate social responsibility activities (Bebbington et al. 2007). Although corporate social responsibility disclosures (CSD) has been the subject of substantial academic research for the last two decades, CSD has so far remained mainly a phenomenon of developed countries in Western Europe, the USA, and Australia (Bebbington et al. 2007; Patten 2002). In fact, very few papers have discussed this issue in the context of developing countries, and the few ones that have focused on Hong Kong, Korea, Malaysia, Singapore, and some South African countries (Bebbington et al. 2007; Choi 1998; Tsang 1998). In Taiwan, to our knowledge, only some limited empirical studies have concentrated on this issue. Because of this gap in the empirical studies, it is very difficult to know the practices of CSD in Taiwan. For this reason, our first purpose is to examine the CSD practices of companies in Taiwan.

In addition, the relationship between CSD and firm performance remains inconsistent in the previous literature (Garay and Gonzalez 2010). One view is that increased disclosure will produce costs of equity capital and negatively impact firm performance (Dhaliwal et al. 2009). A contradictory view holds that by increasing their social and environmental disclosures, firms will enhance their reputations (Armitage and Marston 2008), which in turn helps them to gain support and legitimacy from stakeholders and society. Therefore, the undefined relationship between CSD and firm performance in previous research is one of the most important issues for future research (Richardson and Welker 2001).

Recently, a study by Wang et al. (2008) find that the relationship between corporate philanthropy and firm financial performance follows an inverted U-shape. Their findings provide an important reference for our arguments in this study. Additionally, based on the private costs theory and the agency theory, when firms disclose more social and environmental information to the public, they will incur substantial direct and indirect costs (Barnett and Salomon 2006). These costs would suggest a negative relationship between CSD and firm performance. However, according to the stakeholder theory, the increased disclosure of firms will reduce information asymmetry, thus lowering the estimation risk of the distribution of returns, which consequently enables firms to gain the trust of investors and stakeholders. As a result, the firms will obtain resources controlled by these stakeholders, such as human capital, financial capital, social capital, etc.

(Donaldson and Preston 1995). As a result of these benefits, we can expect a positive relationship between CSD and firm performance. The costs and benefits of both of these effects result in a rough, non-linear relationship between CSD and firm performance. This paper contributes to the literature by testing empirically the existence of a U-shaped relationship between CSD and firm performance. To address the aforementioned gap in previous empirical studies, a sample of annual reports of 600 out of 929 electronics companies was hand-collected on the Taiwan Market Observation Post System and in the Taiwan Economic Journal database in 2009 so as to examine the practice of CSD in Taiwan and to test the relationship between CSD and firm performance. The findings of this study provide a better understanding of the practices of CSD in Taiwan. More specifically, the finding of a U-shaped relationship between CSD and economic value-added somewhat helps to explain the inconsistent results in the previous literature.

99.2 Literature Review and Hypothesis Development

Over the past two decades, CSD has been one of the most commonly discussed issues in many developed economies (Bebbington et al. 2007). However, previous findings on the relationship between CSD and firm performance have been inconsistent (Garay and Gonzalez 2010). According to Gray et al. (1993), it is unnecessary to report social and environmental disclosures because of the absence of any demand for such information and the absence of any legal requirement for CSD. If firms disclose their CSR in such circumstances, the costs would outweigh the benefits (Solomon and Lewis 2002). It would also be irrational for firms to disclose any information harmful to themselves. Consequently, a burden cost will have a negative impact on firm performance (Dhaliwal et al. 2009).

However, a number of scholars have suggested that by making social and environmental disclosures in their annual reports, firms enjoy multiple benefits (Armitage and Marston 2008; Godfrey 2005), such as enhanced firm reputation (Armitage and Marston 2008), effective response to pressure and prediction of future environmental regulations (Blair 2000), reduction in information asymmetry and boost in investor interest (Gray et al. 1995), as well as establishment and maintenance of good stakeholder relationships, which are conducive to gaining support and legitimacy from stakeholders and society (Milne and Patten 2002).

Yet still, some other researchers claim that there is no significant relationship between CSD and firm performance (Freedman and Wasley 1990). According to their findings, it is likely that the relationship between CSD and firm performance is more complex, and not simply a direct one as proposed by previous studies (Wang et al. 2008). For this reason, it is necessary to take a further step to clarify the relationship between CSD and firm performance.

To understand the relationship between these two variables, it is essential to consider simultaneously the costs and benefits of CSD activities. Based on the private costs theory, CSD is a costly endeavor, leading to direct expenses that have a negative impact on corporate performance (Haley 1991). Similarly, from the viewpoint of agency theory, managers tend to engage in opportunistic behavior to further their own gain. When managers pursue any purpose other than corporate performance through CSD activities, CSD incurs burden costs. Nevertheless, the benefits of CSD must be taken into account simultaneously. CSD is often viewed as a communication tool between firms and their stakeholders. By making CSD, firms disseminate information about operating conditions and other dimensions of the business, such as financial situations, environmental policies, employee policies, customer relationship management, community relations, and so on. Such information will give stakeholders a better understanding of the firms and build a strong relationship and trust between firms and their stakeholders. In this case, CSD activities invariably generate various benefits. For example, stakeholders and investors will be more willing to invest money and resources (Donaldson and Preston 1995), regulators and communities will appreciate firms with a high reputation and lend more support to them (Milne and Patten 2002), and the firms will respond effectively to pressure and predict future environmental regulations (Blair 2000). However, the impact of CSD on firm performance will depend on the trade-off between these costs and benefits of CSD. If the level of CSD is too low, it is not sufficient for stakeholders and investors to know the firm well. In this case, information asymmetry and uncertainty will make stakeholders and investors hesitant when making investment strategies. At the same time, due to non-transparent information, managers may engage in opportunistic behavior through CSD for their own advantage. Hence, for a low level of CSD, the costs outweigh the benefits, leading to a negative impact on firm performance. On the other hand, if adequate CSD is made above a given threshold and meet the expectations of the stakeholders, firms can obtain many benefits from those stakeholders and investors as well as society, such as tangible resources (money and resources invested by stakeholders and investors) and intangible resources (public images, trust, legitimacy, human resource capital, etc.), and reduced opportunistic behavior due to information transparency. As a result, the benefits generated will surpass costs, leading to a positive effect of CSD on firm performance. Therefore, by considering these costs and benefits of CSD simultaneously, a U-shaped relationship emerges between CSD and firm performance. With this, the following hypothesis is posited:

Corporate social responsibility disclosure and corporate performance have a U-shaped curvilinear relationship.

99.3 Methodology

(1) Sample and data collection

The electronics industry is one of the core industries with great contribution to the development of Taiwan's economy. According to Taiwan's Ministry of Economic Affairs, electronic product exports account for nearly 30 % of the total exports in 2009. In order to maintain sustainable competitiveness of the Taiwanese electronics industry, many companies are emphasizing their concern with environmental and green products. Because the electronics industry contributes greatly in both quantity and quality to the development of Taiwan's economy, this study uses it as the subject for investigation. A sample of annual reports of 929 companies was collected on the Taiwan Market Observation Post System and in the Taiwan Economic Journal database in 2009. After discarding incomplete data and missing variables, the final complete sample consists of 600 corporate annual reports.

(2) Corporate social responsibility disclosure

Consistent with previous research, in this study, CSD is measured according to the method of content analysis (Gray et al. 1995; Naser et al. 2006). Content analysis is a methodology used to measure objectively, systematically, and qualitatively the content of communication (Naser et al. 2006). Also, it is a method of collecting data that forms codifying quantitative information and categories to obtain scales of different levels of complexity (Gray et al. 1995; Naser et al. 2006). Additionally, using the number of sentences is more easily distinguishable and prevents the problems of allocations and standardizing the number of words (Haniffa and Cooke 2005). For these reasons, the number of CSD dimensions and the length of CSD items expressed in terms of number of words and sentences were used to capture CSD in this study. Drawing from previous studies (Patten 2002; Haniffa and Cooke 2005; Newson and Deegan 2002), this study integrates seven dimensions of CSD, including environment, energy, human resources, community involvement, fair business practices, products and services, and customers.

(3) Firm performance: Economic value-added

The measurement of firm performance in previous studies can be divided into non-financial and financial measurements. Non-financial measurements such as customer satisfaction, process efficiency, etc. lack consistency in standardized quantity of indicators and easily cause errors (Shane and Spicer 1983). Financial measurements such as Tobin's Q, return on assets (ROA), and return on equity (ROE) are widely used in previous research (Garay and González 2010). Then there are scholars who use economic value-added (EVA) to measure firm performance (Palliam 2006). The advantage of using economic value-added is that it can precisely evaluate a firm's true value, capture simultaneously the firm's internal financial situation and market dynamics, and consider the firm's long-term development (Brewer et al. 1999). Because EVA integrates the advantages of accounting-based measurements (ROA and ROE) and market-based measurements (Tobin's Q), this study uses EVA as a proxy for firm performance.

(4) Control variables

To control other variables that may have a significant impact on firm performance, this study selects systematic risk, capital expenditure, ratio of net value to market value, and sales growth rate as control variables (O'Byrne 1996).

99.4 Empirical Results

(1) Descriptive statistics

Table 99.1 shows the means, standard deviations, and correlation coefficients for variables in this study. It is shown that CSD in terms of words and CSD in terms of sentences are not significantly related to firm economic value-added. However, the square of CSD in terms of words is significantly positively related to economic value-added ($r = 0.13$, $p < 0.01$), and the square of CSD in terms of sentences is also significantly positively related to economic value-added ($r = 0.11$, $p < 0.01$). These results indicate that CSD may not linearly relate to economic value-added.

(2) Results of the curve regression analysis

The results of the curve regression analysis are presented in Table 99.2. In order to determine the relationship between CSD and economic value-added, this study examines simultaneously the CSD in terms of words and sentences. As shown in Table 99.2, for CSD in terms of words, the adjusted R square is 0.04, the F value is statistically significant (F = 10.89, $p < 0.01$), and the relationship between CSD and economic value-added follows a U-shaped curve (CSD in terms of words: $\beta = -0.14$, $p < 0.05$; square of CSD in terms of words: $\beta = 0.21$, $p < 0.01$). Similarly, for CSD in terms of sentences, the adjusted R square is 0.04,

Table 99.1 Means, standard deviations, and correlation coefficients

	1	2	3	4	5	6	7	8	9
1. EVA	1.00								
2. β	−0.16**	1.00							
3. N/M_Ratio	0.07	−0.16**	1.00						
4. Sale_GR	−0.07	0.05	−0.19**	1.00					
5. Cap_Ex	0.12**	−0.05	−0.14**	0.05	1.00				
6. CSD_Words	0.05	0.09*	−0.07	−0.04	0.05	1.00			
7. CSD_Sentences	0.00	0.16**	−0.09*	−0.04	−0.04	0.80**	1.00		
8. CSD_Words square	0.13**	0.02	−0.03	−0.01	0.16**	0.82**	0.47**	1.00	
9. CSD_Sentences square	0.11**	0.02	−0.01	−0.00	0.08*	0.74**	0.71**	0.73**	1.00
Mean	0.01	−0.00	0.00	−0.00	0.01	−0.04	−0.01	0.47	0.93
Standard deviation	0.98	1.00	1.00	1.00	0.98	0.68	0.97	3.16	2.77

[a] n = 600 *** <0.001 ** < 0.01 * < 0.05

Notes EVA is economic value-added, β is beta value represents systematic risk, N/M_Ratio is the ratio of net value to market value, Sale_GR is sales growth rate, Cap_Ex is capital expenditure, CSD_Words is corporate social responsibility disclosure in terms of number of words, CSD_Sentences is corporate social responsibility disclosure in terms of number of sentences, CSD_Words square is the square of CSD_Words, and CSD_Lines square is the square of CSD_Lines

Table 99.2 Results of regression analysis on the relationship between CSD and economic value-added[a]

	CSD_ Sentences		CSD_Words	
	Model 1		Model 2	
	β	VIF	β	VIF
Control variables				
β	-0.13^{**}	1.05	-0.12^{**}	1.07
N/M_Ratio	0.05	1.10	0.05	1.11
Sale_GR	−0.05	1.04	−0.06	1.04
Cap_Ex	0.00	1.09	0.01	1.07
Independent varialbes				
CSD_ Sentences/Words	-0.16^{*}	3.61	-0.14^{*}	2.52
CSD_ Sentences/Words square	0.26^{**}	3.67	0.21^{**}	2.47
R^2	0.05		0.05	
Adjusted R^2	0.04		0.04	
F	11.65^{**}		10.89^{**}	

[a] n = 600 *** < 0.001 ** < 0.01 * < 0.05

the F value is statistically significant ($F = 11.65$, $p < 0.01$), and the relationship between CSD and economic value-added also follows a U-shaped curve (CSD in terms of sentences: $\beta = -0.16$, $p < 0.05$; square of CSD in terms of sentences: $\beta = 0.26$, $p < 0.01$). The results of CSD in terms of number of words and sentences offer evidence to support the U-shaped relationship between CSD and economic value-added, thus providing support for the hypothesis of this study. In addition, among the four control variables, only systematic risk is significantly negatively related to economic value-added; other control variables, including the ratio of net value to market value, sales growth rate, and capital expenditure, are not significantly related to economic value-added.

99.5 Discussion and Conclusion

Social and environmental disclosures are widely discussed in recent years; however, the discussions are limited to developed countries in Western Europe. Due to cultural and national differences among developed and developing countries, the results of previous studies on these developed countries cannot be generalized to other developing countries (Bebbington et al. 2007; Choi 1998; Tsang 1998). This study examines the relationship between CSD and firm performance. For the measurement of CSD, this study adopts content analysis of CSD in terms of number of words and sentences, which is consistent with the methods employed by previous research. In terms of firm performance measurement, this study uses economic value-added to capture each firm's internal financial situation and market dynamics. The finding of a U-shaped relationship between CSD and economic value-added bears important implications for both researchers and business firms. From a theoretical point of view, the results of this study help to explain the inconsistent findings of the relationship between CSD and firm performance in previous literature, because previous studies consider costs and benefits as two separate parts of CSD and only examine the linear relationship between CSD and performance. This study analyzes simultaneously the trade-off between the costs and benefits of CSD and discovers a U-shaped curve between CSD and economic value-added, which may be a reasonable explanation of the relationship between CSD and firm performance. On a practical level, the findings of this study imply that firms should use CSD as a tool for obtaining their goals. Firms making social and environmental disclosures are likely to incur burden costs at the beginning because the lower level of CSD is not sufficient to gain recognition from stakeholders and investors. In this case, reporting CSD is an unprofitable activity. However, as the level of CSD exceeds a certain threshold, reporting CSD will help firms reduce information asymmetry between them and their stakeholders, obtain recognition from investors and communities, and thus build good reputation and attain social capital, relational capital, and resources controlled by those stakeholders and investors. Subsequently, the more CSD firms report, the less costs they will incur and the more benefits they will obtain.

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Chapter 100
Empirical Study on the Five-Dimensional Influencing Factors of Entrepreneurial Performance

Xin Lan

Abstract Entrepreneurial is the current hot issues, but the entrepreneurial success rates are not high. Entrepreneurial performance relates to survival or extinction of the enterprises, researching the factors that influence entrepreneurial performance is the key points to capture success. In this study, we make use of theoretical analysis and empirical research to explore five-dimensional factors that affect entrepreneurial performance, which consists of capital dimension, innovative dimension, team dimension, market dimension and environmental dimension. Then through regression analysis, we sorted out the stepwise regression model coefficients and test values, to establish the regression equation. We analyzed the influence of five-dimensional factors to entrepreneurial performance. The study is conducive to entrepreneurial activities to overcome difficulties and to entrepreneurial success.

Keywords Entrepreneurial · Entrepreneurial performance · Five-dimensional factors · Empirical research

100.1 Introduction

Entrepreneurship can not only cultivate the national innovative capability, but also to improve national productivity and employment rates and speed up the construction pace of knowledge-based economy strategy. It is a favorable way to alleviate the current difficult of employment. In this context, our many business support policies were introduced, in particular, to encourage and support college students entrepreneurial. However, the participation and success rates of college student start remain

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E. Qi et al. (eds.), *The 19th International Conference on Industrial Engineering and Engineering Management*, DOI: 10.1007/978-3-642-38391-5_100,

low. As a result, to improve the business performance of our college business should be a subject worthy of attention in entrepreneurial management discipline study. The starting point of this study is to explore the real key dimensions of factors impact on business performance, but the ultimate goal is to improve business performance and the rate of business success.

So, what are the key factors currently affecting business performance, how to make business out of the woods effectively. In this study, we have searched much literatures, we found many literatures only remained in the relatively study on macro education and the management level to put forward some frameworks and models, few articles from the entrepreneur's perspective to analysis the reality of current entrepreneurial difficulties, use quantitative analysis to reflect the impact dimensions of the entrepreneurial performance, and make use of the relevant strategies to promote entrepreneurship success (Lan and Yang 2010).

100.2 Theoretical Basis and Research Hypothesis

Definition of entrepreneurship through a different interpretation, Shane illustrates how entrepreneurs identify and exploit entrepreneurial opportunities in new ventures based on their prior, and then produce a variety of results (Shane and Venkataraman 2000). Yu Yi-hong found that entrepreneurship is a complex process that discovering and capturing opportunities and creating new products and services, and realize their potential value process. Bemadin believed that performance should be defined as the results of work, which reflected the achievement and results gained by people in their work (Schumpeter 1982). Nowadays, operating profit created by young entrepreneurs is mainly reflected in their profit or loss. The study on the achievement of these companies was based on their performance in recent 2 years.

100.2.1 Capital Dimension and Entrepreneurship Performance

The three elements of Timmons Model tell us that, business opportunity, entrepreneurial team and entrepreneurial resource can promote the development of entrepreneurship during their consistently matching and balancing with each other. These elements drive each other in different development stages of the company while changing their relation from imbalance to balance. The capital factor in entrepreneurship is the most important dimension in resource elements of Timmons Model; it appears that difficulties faced in entrepreneurship are often the problem of capital. Capital deficiency will make it very difficult to transform innovation into real productivity or to carry out business operation (Yang and Lan 2011b).

Some youths really have very good entrepreneurial plans, but they have not starting money, as a result, their plans cannot be put into practice; or even they start their entrepreneurial activities, the capital problem will also impact operating profit. At present, all levels of governments are widely introducing various kinds of supporting policies, such as patent application grant, innovation fund for medium or small-sized enterprises, industry-specific subsidies, business subsidies to college graduates, entrepreneurship competition prize. Therefore, we proposed the following assumptions:

H1: Lacking of starting money is the first difficulty in developing entrepreneurial activities; the more starting money is the better entrepreneurship performance will be.

H2: In the operation of the venture company, good capital chain will promote the company to develop in a healthy manner; the circulating fund has a significant impact on entrepreneurship performance.

H3: Smooth financing channel will speed up the development of the venture company, and promote the company to achieve better entrepreneurship performance.

H4: Government's support toward entrepreneurial activities through offering innovation fund, business subsidies, etc. will help improve entrepreneurship performance, thus government support has a positive impact on entrepreneurship performance.

100.2.2 Innovation Dimension and Entrepreneurship Performance

Schumpeter pointed out in his Theory of Economic Development, the economic development was obtained from innovation, while the subject of innovation is entrepreneurs (Schumpeter 1991). Drucker thought that innovation was a special tool featuring entrepreneurship, which gave resources a new capacity to make fortune. Drucker even thought that one person could not be called an entrepreneur if he did not have a venture company (Drucker 2005). From the above, we draw a conclusion that there is a close relation between innovation and entrepreneurship.

Samuelson found that in the annual growth rate per capita of 1.8 %, about 1.5 % was from technology innovation after studying on the economic growth in the USA from 1990 to 1996 (Samuelson and William 1992). What is worthy to be mentioned is: innovation not only refers to invention, it also means real development of invention which is called entrepreneurship. Compared with entrepreneurship, invention is relatively simple and easy to do, and difficulties often appear in real development of invention. Technology innovation will influence the research and development and production of new products, while only good quality products have market potential, which may further influence the entrepreneurship performance. Therefore, we put forward the following assumptions:

H5: Technology innovation can promote the research and development and production of new products, which will further significantly influence entrepreneurship performance.

Cheng (2010) thought that, development difficulties of venture companies in our country were closely related to the insufficient of innovative motivation, unreasonable internal and external incentive systems. Zhou (2009) pointed out that the key to solve the difficult situation in transformation from technology imitation to independent innovation was to strengthen the research and development and supply of generic technology. The abovementioned studies were done from the point of view of how to improve innovation, and all of them placed much emphasis on independent innovation, but, nowadays, college graduates or young entrepreneurs are facing the difficulty of transforming technology into real productivity, although they have some technology innovations, they fail to put these technology innovations into real operation, which as a result leads to the low pioneering success rate. According to the above analysis, we proposed several assumptions for testing:

H6: Successful transformation of innovation into real operation has a positive impact on entrepreneurship performance.

Business model is a substantial factor including positioning and channels for a company to provide its products and services to the customers and the company's operation structure which enable the company to achieve its business goals. The first innovation of a company is the innovation of its business model, which is the foundation of development and profit. Therefore, I put forward the following assumption that:

H7: The innovative business model has a significant impact on entrepreneurship performance.

100.2.3 Cooperation Team Member Dimension and Entrepreneurship Performance

Factors such as the quality, experience and expertise of the entrepreneur and his team members will influence the success of entrepreneurship. According to our investigation and survey, entrepreneurial team members' experience in business management as well as their relevant management knowledge impact greatly on entrepreneurship performance. Therefore, in this paper, we proposed the following assumptions:

H8: Practical experience in business operation has a positive impact on entrepreneurship performance.

H9: Expertise has a positive impact on entrepreneurship performance.

H10: Cooperation of team members has a positive impact on entrepreneurship performance.

100.2.4 Market Dimension and Entrepreneurship Performance

The supply-and-demand difficulty existing in the entrepreneur market seriously restricts the combination between entrepreneurs and technology innovation capital, and weakens the function of entrepreneurs' innovation and innovative vigor of their companies. Market structure and competition situation the entrepreneurs faced with are important factors which impact the success of entrepreneurship. Entrepreneurs must adopt proper competition strategies in such market structure, if fail to conduct market positioning correctly or adopt the wrong marketing mix strategies, their companies may stop developing or even become unable to exist. We proposed assumptions for testing as follows:

H11: Wrong or unclear target market strategy will be a disadvantage to the success of entrepreneurship, correct target market strategy has a positive impact on entrepreneurship performance.

H12: Products/services meeting market demands significantly have a positive impact on entrepreneurship performance.

H13: Competitive price has a positive impact on entrepreneurship performance.

H14: Reasonable marketing strategies have a positive impact on entrepreneurship performance.

100.2.5 Environment Dimension and Entrepreneurship Performance

Entrepreneurial environment refers to the aggregate of a series of concepts which significantly promote the success of entrepreneurship. Gu et al. (2008) conducted a comprehensive analysis on the current situation of Chinese supporting policies on entrepreneurship and their weaknesses based on the investigation to the theory framework of the relative policies in other countries, and proposed a system to improve such polices in China from five aspects respectively entrepreneurship financing, entrepreneurship services, entrepreneurship cluster, entrepreneurship education and entrepreneurship culture. Here we proposed two assumptions for testing as follows:

H15: The effective support from the government and social organization will have a significantly positive impact on entrepreneurship performance.

H16: Support from colleges and families have a significant impact on entrepreneurship performance.

100.3 Research Devising

100.3.1 Definition and Measurement of Variable

The scope of this analysis is mainly those entrepreneurial activities of entrepreneurs who developed their entrepreneurial activities at their first time independently, such kind of entrepreneurial activities do not have their initial capital accumulation, and their capital resources are mainly from self-raised funds or from financing activities. The explained variable in this analysis is the entrepreneurship performance, which is mainly reflected in the profit or loss situation of venture companies, the situation of companies we investigated and surveyed in this research all reflects their performance of the last 2 years.

In this research, we used Likert Scales in the measurement of the influencing factors of entrepreneurship performance viewing from the angle of entrepreneurs. We designed a 7-grade scale (1 = completely don't agree, 4 = remain neutral, 7 = fully agree), and the entrepreneurs investigated should score carefully according to their degree of acceptance to the questions.

100.3.2 Sample Selection and Data Collection of the Formal Questionnaire

After retrieving, consulting and studying related literature, in order to make the results of the study more general, we took various entrepreneurial projects into consideration in our questionnaire to make it suited to the Pioneer Park for Chinese college students (Chengdu) and the Liaison student entrepreneurial base of the institutions including Youth (College Student) Pioneer Park of Chengdu Hi-Tech Zone, Technology Park of University of Electronic Science and Technology of China, Sichuan Normal University Chengdu College, Chengdu University of Information Technology, Sichuan University Jincheng College, University of Electronic Science and Technology of China Chengdu College, Chengdu Vocational & Technical College, Sichuan Top Vocational Institute of Information Technology College, and the 376 enterprises and project teams in the Chengdu Hi-Tech Zone Innovation Center. The targets of this investigation are all business or project leaders who are developing entrepreneurial activities, and all of them are able to answer the questions in the questionnaire. In this investigation, we distributed 900 questionnaires in total, among which 756 were taken back, that is, the recovery rate of it is 84 %; and 698 were valid questionnaires, the validity rate is 92 %. The questionnaires were distributed reasonably in those companies, and the industries selected are also representative industries, which including 5 ones, for example, information technology, where college graduates are more willing to do business in these fields.

100.4 Result of the Study

100.4.1 Reliability Test of Samples

In this study, we made descriptive statistics, and reliability and validity tests of the collected sample data. And the result of reliability analysis shows that the "Cro-banch a" value of capital dimension, market dimension, innovation dimension, environment dimension and cooperation team member dimension are 0.931, 0.969, 0.943, 0.952 and 0.674, respectively. According to the suggestion of Churchilli, the coefficient of the items is more reliable when the value of "Cro-banch a" is greater than 0.7.

100.4.2 Exploratory Factor Analysis

In this study, in order to test the validity of the assumption of the five influencing factors of the achievement of entrepreneurial activities, we made an exploratory factor analysis on the 16 questions in the questionnaire. In the factor analysis, we adopted a principle component analysis method, and varimax in rotation. We also used SPSS17.0 in Bartlett sphericity test and KMO measurement, the observation of the statistic product of Bartlett test of sphericity is 1633.350, and the corresponding probability is close to 0. When significance level "a" is 0.05, due to the probability "p" is less than the significance level "a", as a result, the null hypothesis of Bartlett test of sphericity is rejected, and it can be considered that there is a significant difference between correlation matrix and unit matrix. Then let us observe the KMO value, if it is greater than 0.7, it can be said that this project has passed factor analysis and it conforms to the standard of KMO measurement which is often used in factor analysis as proposed by Kaiser, therefore, we can explore the key influencing factors of entrepreneurship success by using factor analysis method.

Questions in the questionnaire are systematically subordinate to several factors at the same time, the factor analysis indicates that capital dimension questions are four-factor structure, and the factor loading of them are between 0.735 and 0.915; the innovation dimension questions are three-factor structure, the factor loading of them are between 0.816 and 0.917; the cooperation team member dimension questions are three-factor structure, the market dimension questions are four-factor structure, the factor loading of them are between 0.661 and 0.891; the environment dimension questions are two-factor structure, the factor loading of them are between 0.722 and 0.746, the factor loading of them are between 0.729 and 0.877. As there is no cross loading, see from the loading coefficient of each factor in the corresponding dimension, all the loading are very large, which shows that the factors have a good convergence, and the questions are reasonable, and the dimensions established based on assumption also conform to the study.

100.4.3 Multiple Regression Analysis

The study also tested the abovementioned assumptions by using regression analysis model, made an analysis on the impact of capital dimension, innovation dimension, cooperation team member dimension, market dimension and environment dimension on the entrepreneurship performance, and then formed Table 100.1 as follows of Model 1, Model 2, Model 3, Model 4 and Model 5.

In Model 1, the accessibility of initial capital ($\beta = 0.489$, $P < 0.01$), financing channel ($\beta = 0.943$, $P < 0.01$), circulating fund ($\beta = 0.840$, $P < 0.05$) have a significant impact on entrepreneurship performance, which conforms to assumptions H1–H3. However, assumption H4 of whether received government funding has no significant correlation with entrepreneurship performance and it is not verified, which shows that the direct funding of government did not help to improve the entrepreneurship performance.

In Model 2, the assumption H6 of conversion of entrepreneurship achievement ($\beta = 6.099$, $P < 0.01$) will impact the entrepreneurship performance, assumption H7 of having innovative business model ($\beta = -1.518$, $P < 0.01$) will also impact the profitability of the companies, and it is verified. But assumption H5 of technology innovation and product research and development has no significant correlation with entrepreneurship performance, which shows the pressure of technology research and development of these companies are very big.

In Model 3, having experience in business operation ($\beta = 3.058$, $P < 0.01$) has a significant impact on entrepreneurship performance, then the assumption H8 is verified. But surprisingly, the relation between expertise and entrepreneurship performance is relatively weak, and the cooperation of team members has no significant correlation with entrepreneurship performance, that is, the assumptions H9 and H10 are not verified.

In Model 4, the degree of clearance of target market position ($\beta = -0.096$, $P < 0.01$) promotes the venture companies to develop in a healthy manner, if they don't have a clear idea about the target market they may fall into difficulties, thus the assumption H11 is verified. The degree of the products/services meeting the market demand has a significant impact on entrepreneurship performance, which shows that the assumption H12 is verified. Competitive price and efficient sales promotion strategies have a significant impact on entrepreneurship performance; therefore, assumptions H13 and H14 are verified (Yang and Lan 2011a).

In Model 5, if receiving efficient support from the government and social organization ($\beta = -0.341$, $P < 0.01$), then the entrepreneurship performance of the company will improve significantly, thus the assumption H15 is verified. The efficient support from colleges and families ($\beta = -1.187$, $P < 0.01$) has a significant impact on entrepreneurship performance, and the assumption H16 is verified.

Table 100.1 Verification results on the five-dimension supporting system model of entrepreneurship performance

Variables	Model 1	Model 2	Model 3	Model 4	Model 5
H1: Enough capital has been raised	0.489***	0.989***	1.405***		
H2: Smooth financing channel	0.943***	0.701***	0.237***		
H3: Sufficient circulating fund	0.840**	4.475***	5.543***		
H4: Received support from the government funding	−0.420	−3.979***	−4.873		
H5: Technology innovation and product research and development		−.183	−.653		
H6: Conversion of entrepreneurship achievement		6.099***	4.476***		
H7: Innovative business model		−1.518***	−1.792***		
H8: Have experience in business operation			3.058***		
H9: Have expertise			0.444		
H10: Cooperation of team members			0.102		
H11: Degree of clearance of target market position				0.096***	
H12: Degree of the products meeting the market demand				1.086***	
H13: Competitive price				0.026***	
H14: Degree of using sales promotion strategies				0.014**	
H15: Degree of support from the government and social organizations					1.187***
H16: Degree of support from colleges and families					0.341***
F	81.196	142.009	119.599	63379.427	246.445
R_2	0.391	0.661	0.702	0.998	0.489

Note * means P < 0.1, ** means P < 0.05, *** means P < 0.01 (two-tailed)

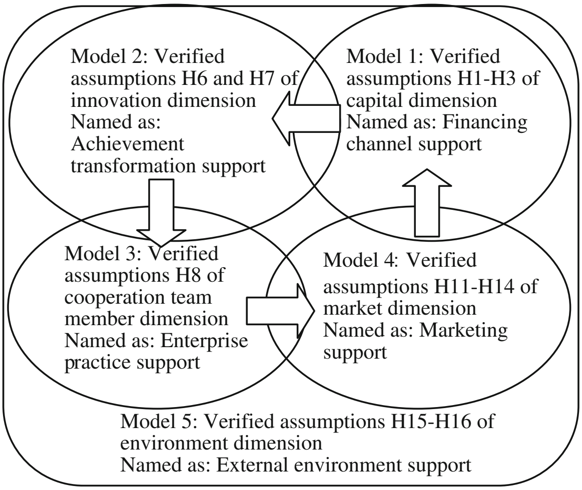

Fig. 100.1 The key factors from the five-dimension model of entrepreneurship performance

100.5 Conclusion

This study is made from the angle of entrepreneurs, starting from the influencing factors of entrepreneurship performance, and based on the features of real difficulties appear in the entrepreneurial activities, with combination with results of extensive research literature. It conducted an empirical research on the structure of the five dimensions which influence the entrepreneurship performance, through five-dimension supporting system model building, exploratory factor analysis and regression analysis, we concluded that five-dimension influencing factors consisting of capital dimension, innovation dimension, cooperation team member dimension, market dimension and environment dimension. All the abovementioned five dimensions have factors successfully verified, in this analysis; we named all the verified factors in each dimension and obtained a supporting system model of entrepreneurship performance and its key factors, as shown in Fig. 100.1.

In a word, five-dimension supporting system model of entrepreneurship performance from perspective of entrepreneurs is a mirror, by using such model to analyze the influencing factors of entrepreneurship performance during certain period and in a certain place, we can conclude the structure of government support system during that period and in that place. The key factors costing much effort play an instructive role on enhancing pioneering success rate.

Acknowledgments Project: It is a financial support project of China West Normal University "empirical research on marketing plight and strategies of the new ventures" (No. 11A016).

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Chapter 101
A Multistart Local Search Heuristic for Knapsack Problem

Geng Lin

Abstract Knapsack problem is one of classical combinatorial optimization problems, and has a lot of applications. It is known to be NP-hard. In this paper we propose a multistart local search heuristic for solving the knapsack problem. Firstly, knapsack problem is converted into an unconstrained integer programming by penalty method. Then an iterative local search method is presented to solve the resulting unconstrained integer programming. The computational results on three benchmarks show that the proposed algorithm can find high quality solutions in an effective manner.

Keywords Knapsack problem · Local search · Heuristic

101.1 Introduction

Given n items to pack in a knapsack of capacity c. Each item i is associated with a weight w_i and a profit p_i. The objective of the knapsack problem is to maximize the profit sum without having the weight sum to exceed c. The problem can be mathematically formulated as follows (Martello et al. 2000; Pisinger 1995):

$$(KP)\begin{cases} \max \quad f(x) = \sum_{i=1}^{n} p_i x_i \\ s.t. \quad \sum_{i=1}^{n} w_i x_i \le c \\ \qquad x \in S, \end{cases}$$

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E. Qi et al. (eds.), *The 19th International Conference on Industrial Engineering and Engineering Management*, DOI: 10.1007/978-3-642-38391-5_101,

where $S = \{0,1\}^n$ and x_i takes a value of 1 if item i is to be included in the knapsack, and 0 otherwise. Without loss of generality, we assume that $w_i \le c$, for $i = 1, \ldots, n$ to ensure that each item considered fits into the knapsack, and that $\sum_{i=1}^{n} w_i > c$ to avoid trivial solutions.

KP is one of the classical optimization problems in combinatorial optimization, and has a lot of applications (Gorman and Ahire 2006) in production, logistics, material cutting and financial problems. In solving large combinatorial optimization problems, KP is also regarded as a sub-problem to deal with. It has been widely studied in the last few decades due to its theoretical interest and its wide applicability, see Kellerer et al. (2004) and references therein. KP is known to be NP-hard, so the exact algorithms with polynomial complexity can only exist in the case $P = NP$. It can be solved in pseudo polynomial time by dynamic programming (Papadimitriou 1981). A lot of heuristic algorithms have been considered for approximately solving the knapsack problem, such as tabu search (Hanafi and Freville 1998), genetic algorithm (Zhao et al. 2011; Tian and Chao 2011; Shan and Wu 2010), artificial fish school algorithm (Li et al. 2009), ant colony algorithm (Liao et al. 2011).

Local search algorithms are widely applied to numerous hard optimization problems, including problems from mathematics, operations research, and engineering. A local search algorithm starts from an initial solution and iteratively moves to a neighbor solution. Every solution has more than one neighbor solutions, the choice of which one to move to is taken using only information about the neighborhood of the current one. When no improving configurations are present in the neighborhood, local search is trap in a local optima.

In this paper, a new local search method is proposed for knapsack problem. When local search is stuck at a locally optimal solution, we restart the local search procedure from a new initial solution.

The remainder of the paper is arranged as follows: In Sect. 101.2, some definitions and local search methods which have been used in the literature are introduced. Section 101.3 presents a new multistart local search method for the knapsack problem. Experiments were done on some benchmarks, computational results and comparisons are presented in Sect. 101.4, and concluding remarks are put in Sect. 101.5.

101.2 Methodology

Local search is a well-known approach for solving a lot of combinatorial optimization problems. When using a local search procedure to a given instance of an optimization problem, we need to define a "neighborhood", which is a subset of the solution set, for each solution. Local search algorithm begins with an initial solution and searches its neighborhood, then moves from solution to solution in the neighborhood by applying local changes, until the current solution is better than its neighbors.

There are two neighborhood structures have been considered for the knapsack problem: the 1-flip and 1-flip-exchange neighborhoods. If two solutions differ exactly on one assignment, they are 1-flip neighbor.

Definition 1 For any $x \in S$, the 1-flip neighborhood $N_f(x)$ of x is defined by $N_f(x) = \{y \in S| \ \|x - y\|_1 \le 1\}$. The 1-flip neighborhood $N_f(x)$ can be reached by adding or removing one item from x. Hence, $|N_f(x)| = n + 1$.

If two solutions are 1-flip-exchange neighbors if one can be obtained from the other by exchanging two items. It is an extension of 1-flip neighborhood.

A lot of algorithms for knapsack problem used above two neighborhood structures. They start from an initial solution and iteratively move to the best solution of the neighbor, until the current solution is better than its neighbors. These local search methods are belonging to greedy algorithm, and trap in a local optima easily.

101.3 The Proposed Local Search Method

In this section, firstly, we convert knapsack problem equivalently into unconstrained integer programming. Then a new local search method for the resulting unconstrained integer programming is proposed.

101.3.1 Equivalent Unconstrained Integer Programming

We use penalty method to transform knapsack problem to unconstrained integer programming. Constructing the following unconstrained integer programming:

$$(NKP)\begin{cases} \max \quad g(x) = \sum_{i=1}^{n} p_i x_i - kh(x) \\ s.t. \qquad x \in S \end{cases}$$

where $k > 0$ is a penalty parameter, and $h(x) = \max\{\sum_{i=1}^{n} w_i x_i - c, 0\}$.

Lemma 1 *If $k > p_{\max}$, where $p_{\max} = \max\{p_1, \ldots, p_n\}$, problems KP and NKP have the same optimal solution and optimal value.*

101.3.2 Local Search Method

A lot of local search methods used in the existing algorithms for knapsack problem based on greedy method. It trap into a local optima easily. We present an iterative local search method for knapsack problem. The main idea of the algorithm is to flip a bit at a time in an attempt to maximize the profit sum without having the weight sum to exceed c. Define the $gain(i, x)$ of item i as the objective value of the problem (NKP) would increase if the i bit is flipped, which is as follows:

$$gain(i, x) = g(x_1, \ldots, x_{i-1}, 1 - x_i, x_{i+1}, \ldots, x_n) - g(x).$$

Note that an item's gain may be negative. For each item i, the local search algorithm computes the $gain(i, x)$. It starts with a randomly solution in the solution space S and changes the solution by a sequence of 1-flip operations, which are organized as passes. At the beginning of a pass, each item is free, meaning that it is free to be flipped; after a bit is flipped, it become unfree, i.e., the bit is not allowed to be flipped again during that pass. The algorithm iterative selects a free item to flip. When a item is flipped, it becomes unfree and the gain of free items are updated. After each flip operation, the algorithm records the objective value of (NKP) achieved at this point. When there are no more free item, a pass of the algorithm stops. Then it checks the recorded objective values, and selects the point where the maximum objective value was achieved. All items that were flipped after that point are flipped. Another pass is then executed using this solution as its starting solution. The local search algorithm terminates when a pass fails to find a solution with better value of the objective value of (NKP).

When the local search algorithm traps in a local optima, we restarts the local search algorithm from a randomly solution.

Let V be a set of items which are free to flip in a pass. The multistart local search algorithm can be stated as follows:

Step 0. Choose a positive number max *iter* as the tolerance parameter for terminating the algorithm. Set $N = 0$, $x^{global} = 0$.
Step 1. Generate a solution $x = \{x_1, \ldots, x_n\}$ randomly.
Step 2. Set $V = \{1, \ldots, n\}$, $t = 1$, $x^0 = x$. Calculate $gain(i, x)$, for $i \in V$.
Step 3. Let $gain(j, x) = \max\{gain(i, x), i \in V\}$. Set $x^t = (x_1, \ldots, 1 - x_j, \ldots, x_n)$, and $V = V \backslash \{j\}$, $x = x^t$, $t = t + 1$.
Step 4. If $V \neq \emptyset$, calculate $gain(i, x)$ for $i \in V$, go to Step 3. Else go to Step 5.
Step 5. Let $x^{\max} = \max\{x^t, t = 1, \ldots, n\}$. If $g(x^{\max}) > g(x^0)$, set $x = x^{\max}$, go to Step 2. Else, if $g(x^{global}) > g(x^{\max})$, let $x^{global} = x^{\max}$. Go to Step 6.
Step 6. If $N < \max$ *iter*, let $N = N + 1$, go to Step 1. Else output x^{global}.

101.4 Numerical Experiment

In this section, we test the proposed multistart local search algorithm. The experiments were performed on a personal computer with a 2.11 GHz processor and 1.0 GB of RAM. For our experiments we employ the following three benchmark instances, which are also used to test the genetic algorithm for knapsack problem in (Shan and Wu 2010).

Problem 1. $(w_1, \ldots, w_{20})$ = (92, 4, 43, 83, 84, 68, 92, 82, 6, 44, 32, 18, 56, 83, 25, 96, 70, 48, 14, 58), $(p_1, \ldots, p_{20})$ = (44, 46, 90, 72, 91, 40, 75, 35, 8, 54, 78, 40, 77, 15, 61, 17, 75, 29, 75, 63), $c = 878$.

Problem 2. $(w_1, \ldots, w_{50})$ = (220, 208, 198, 192, 180, 180, 165, 162, 160, 158, 155, 130, 125, 122, 120, 118, 115, 110, 105, 101, 100, 100, 98, 96, 95, 90, 88, 82, 80, 77, 75, 73, 70, 69, 66, 65, 63, 60, 58, 56, 50, 30, 20, 15, 10, 8, 5, 3, 1, 1), $(p_1, \ldots, p_{50})$ = (80, 82, 85, 70, 72, 70, 66, 50, 55, 25, 50, 55, 40, 48, 50, 32, 22, 60, 30, 32, 40, 38, 35, 32, 25, 28, 30, 22, 50, 30, 45, 30, 60, 50, 20, 65, 20, 25, 30, 10, 20, 25, 15, 10, 10, 10, 4, 4, 2, 1), $c = 1000$.

Problem 3. $(w_1, \ldots, w_{100})$ = (54, 183, 106, 82, 30, 58, 71, 166, 117, 190, 90, 191, 205, 128, 110, 89, 63, 6, 140, 86, 30, 91, 156, 31, 70, 199, 142, 98, 178, 16, 140, 31, 24, 197, 101, 73, 169, 73, 92, 159, 71, 102, 144, 151, 27, 131, 209, 164, 177, 177, 129, 146, 17, 53, 164, 146, 43, 170, 180, 171, 130, 183, 5, 113, 207, 57, 13, 163, 20, 63, 12, 24, 9, 42, 6, 109, 170, 108, 46, 69, 43, 175, 81, 5, 34, 146, 148, 114, 160, 174, 156, 82, 47, 126, 102, 83, 58, 34, 21, 14), $(p_1, \ldots, p_{100})$ = (597, 596, 593, 586, 581, 568, 567, 560, 549, 548, 547, 529, 529, 527, 520, 491, 482, 478, 475, 475, 466, 462, 459, 458, 454, 451, 449, 443, 442, 421, 410, 409, 395, 394, 390, 377, 375, 366, 361, 347, 334, 322, 315, 313, 311, 309, 296, 295, 294, 289, 285, 279, 277, 276, 272, 248, 246, 245, 238, 237, 232, 231, 230, 225, 192, 184, 183, 176, 174, 171, 169, 165, 165, 154, 153, 150, 149, 147, 143, 140, 138, 134, 132, 127, 124, 123, 114, 111, 104, 89, 74, 63, 62, 58, 55, 48, 27, 22, 12,6), $c = 6718$.

The proposed algorithm uses a parameter maxiter as a termination parameter. In the experiment, we set maxiter = 30. We run the proposed algorithm 10 times to above three benchmarks. The test results are given in Table 101.1. In order to compare with genetic algorithm proposed in (Shan and Wu 2010), the results of greedy algorithm, basic genetic algorithm, hybrid genetic algorithm (Shan and Wu 2010) are also listed in Table 101.1, and the results quote from (Shan and Wu 2010) directly. Table 101.1 gives the best solutions found by greedy algorithm, basic genetic algorithm, hybrid genetic algorithm. P and W denotes the sum of the profit, and the sum of weight, respectively. g means algorithm found the best solution within g generations.

The following observations can be made based on the experimental results in Table 101.1.

(1) The proposed algorithm found the solution better than those of greedy algorithm and basic genetic algorithm found.
(2) The proposed algorithm and hybrid genetic algorithm found the same best objective value.
(3) Note that our proposed used only 30 initial solutions. It shows that the proposed can reduce the chance that local search process becomes trapped at local optima.

Table 101.1 Experiment results

Problem	Greedy algorithm (Shan and Wu 2010)	Basic genetic algorithm (Shan and Wu 2010)	Hybrid genetic algorithm (Shan and Wu 2010)	The proposed algorithm
	P/W	$P/W/g$	$P/W/g$	P/W
1	1023/825	1024/878/29	1024/878/12	1024/878
2	3095/996	3077/1000/192	3103/1000/50	3103/1000
3	26380/6591	25848/6716/319	26559/6717/147	26559/6717

101.5 Conclusion

A multistart local search algorithm is proposed to find approximate solutions for knapsack problems. Penalty method is used to transform knapsack problem to unconstrained integer programming. An iterative local search method is presented to solve the resulting unconstrained integer programming. It can reduce the chance of trapping at local optima. Experiments were done on three benchmarks from literature. Compare with some existing algorithms, it shows the proposed algorithm is effective.

Acknowledgments This research is supported by the Science and Technology Project of the Education Bureau of Fujian, China, under Grant JA11201.

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Chapter 102
Heterogeneity of Institutional Investors and Investment Effects: Empirical Evidence from Chinese Securities Market

Ying Jin

Abstract With social security funds and securities investment funds as research objects, this paper makes an empirical study on cross-sectional data in the period 2008–2010 of listed companies of which the stocks are heavily held by institutional investors. Using property rights theory and agency theory, this paper verifies the following hypothesis: securities investment funds and social security funds face different political and social pressure, and have different payment mechanisms for managers, thus the fund owners may have conflict or convergence of interests with companies' administration, which may affect contrarily the investment value of companies. This paper contributes by demonstrating the influence on companies' investment effects of heterogeneity of Chinese institutional investors, which provides new evidence for judging, in the era of diversified institutional investors, the different roles of different institutional investors in corporate governance and performance, and offers supporting evidence for China to formulate development strategy for institutional investors.

Keywords Corporate governance · Investment value · Securities investment fund · Social security fund

102.1 Introduction

In mature capital markets, the supervision of institutional investors tends to exert important influence on the corporate governance, and it is a reliable mechanism for addressing corporate governance issues. As super-conventional development of Chinese institutional investors leads to a diversified structure, people are

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E. Qi et al. (eds.), *The 19th International Conference on Industrial Engineering and Engineering Management*, DOI: 10.1007/978-3-642-38391-5_102,

concerned whether it is possible to effectively supervise the company's administration and alleviate the problem of internal control to accrue the value of the company, and whether different institutional investors have different effects on corporate governance as well as investment value. Diversified institutional investors mean that except securities investment funds, institutional investors have held a certain amount of stocks, and may have significant impact on the capital market. This article will study difference between securities investment funds and social security funds in aspects such as the political and social pressure they face and the incentives, and make an empirical research on the different effects caused when these two kinds of funds hold stocks.

102.2 Literature Review

At present, a lot of domestic and foreign research has been made on institutional investors' participation in corporate governance. On whether institutional investors are involved in corporate governance, there are different types of opinions among foreign scholars. Scholars who believe in "shareholder activism" think that institutional investors have favorable conditions for supervision, for example, they are professional investors and hold a large amount of stocks, and therefore they obtain information superiority. In addition, heavily held stocks make them susceptible to liquidity losses when they withdraw from the market, and they have to bear a strict fiduciary responsibility. This means investors can benefit from supervision. The above factors indicate that "free rider" problem can be avoided (David and Kochhar 1996; Grossman and Hart 1980; Smith 1996). Scholars who believe in "shareholder passivism" presume that because of reasons like legal restrictions, difficulty of supervision, high cost and liquidity, institutional investors are not proactively involved in supervision of the companies; their stock holding has no significant impact on the value of the companies (Agrawal and Knoeber 1996; Bhide 1994; Coffee 1991). Those who hold the eclectic opinion believe that due to different funding sources, amount of shareholdings, and whether the institutional investors have conflict of interest with the companies, investors' roles in corporate governance differ (Cornett et al. 2007).

Previously, Chinese researchers think that due to their own conditions and external environmental constraints, institutional investors (mainly those of securities investment funds) have very limited roles in corporate governance. For instance, Huang (2006) considered that Chinese institutional investors were highly dependent on the government, and that the government intervened in operations of institutional investors with resource control or political control. However, huge disparity existed between government targets and business goals, therefore institutional investors were not qualified to supervise the businesses. Over time, a growing number of scholars believe that Chinese institutional investors do resort their oversight capacity to govern. For example, Wang et al. (2008) presumed that as transformation of our government's functions and reform of split share structure went on, the government was being phased out as a manager and a supervisor. Since the types of institutional investors augmented and their share proportions increased, it was possible for them to become qualified company oversight bodies.

According to associated preliminary findings in China, these studies mainly focused on securities investment funds, or they regarded all institutional investors as homogeneous funds. The findings simply presumed that institutional shareholders had either no significant impact or positive effect on firm value. However, they ignored that differences between institutional managers' business objectives might affect adversely the firm value.

102.3 Research Hypotheses

Many foreign scholars believe that unlike banks and insurance companies which have business ties with the invested companies, public pension funds are relatively independent institutional investors (Cornett et al. 2007) as well as long-term funds, they are suitable to be the overseers of enterprises. Woidtke (2002) divided pension funds into two types: public pension funds and private pension funds. By comparing effects on industry's adjustment Tobin's Q of companies when these two types of funds hold stocks in companies, Woidtke found that shareholdings of public pension funds are negatively related with industry's adjustment Tobin's Q, while the shareholdings of private pension funds are positively related with industry's adjustment Tobin's Q. She suggested that the remarkable differences were resulted from the fact that public pension funds faced greater political pressure than private pension funds and their incentives were decoupled from performance. Domestic scholars, such as Zhang and Sun (2006), believed that the social security funds had long-term goals, and were suitable to be institutional investors who could participate in corporate governance and stabilize market. However, they ignored the inconsistency between objectives of social security fund managers and those of corporate. Wang (2008) proposed that one particular problem of agency during management of public pension reserve funds was the intervention of political factors in the funds' operations. Based on the above analysis, we propose Hypothesis 1.

H_1: The shareholding proportions of social security funds are negatively correlated with investment value of companies.

The minority shareholders have the rights to transfer fund shares, which is the rights provided by the redemption mechanism (for open-end funds), or the rights of transfer in capital markets (for closed-end funds), and can pose strong constraints on fund managers. In addition, an essential part of incomes of the fund companies is the management fees charged in accordance with the size of the trust fund. The rights to transfer of minority shareholders provide incentives for fund managers to monitor management of the companies; this can maximize the interests of minority shareholders, and can also make the goals of the fund managers less susceptible to administrative intervention. From the perspective of incentives of the funds, at the beginning of each year, fund managers and fund companies sign a performance contract, in which both parties agree on certain performance targets. The targets are usually about how high the annual cumulative rate of return of the fund administered by a fund manager must rank among the same type of funds. The ranking is directly linked with the performance bonus that fund manager can obtain. This performance-sensitive payment system urges fund managers to strive to safeguard the interests of minority shareholders, and strengthen supervision as the shareholdings of funds expand. Such supervision can ease the company's problem of agency, reduce agency costs, and increase the value of the companies as well as that of the funds. Moreover, Chinese fund companies have strict trust and agency relationship with minority shareholders. This means fund managers are under dual supervision of the trustees and the general assembly of fund holders, and they are responsible, on behalf of the minority shareholders, to oversee the companies and to protect and increase the interests of minority shareholders. Therefore, fund managers and the firms have the same goal: maximization of investment value. Based on the above analysis, we propose Hypothesis 2.

H_2: The shareholding proportions of securities investment funds are positively correlated with the investment value.

Because securities investment funds account for a majority of institutional investors, this paper proposes Hypothesis 3.

H_3: The shareholding proportions of institutional investors as a whole (including securities investment funds, social security funds and insurance companies) are positively correlated with the investment value.

102.4 Study Design

102.4.1 Sample Source and Selection

We have chosen the period 2008–2010 as the sample interval. Since value indicators lag by 1 year, we verified how the shareholding proportions of securities investment funds, social security funds and institutions as a whole in the period 2008–2009 affected corporate investment value of 2009–2010. We selected 817 samples of 2008, and 1178 samples of 2009. The data used in this paper comes from the CSMAR database.

102.4.2 Variable Setting and Model Design

As for indicators of investment value, in addition to earnings per share and net assets yield that represent companies' accounting performance, Tobin's Q used to study relationship between corporate governance and the value was also chosen.

Tobin's Q, which is a market indicator, equals to the ratio of the company's market value to replacement value of the company's assets, and can reflect the company's future development potential. What's more, Tobin's Q can reflect not only the public shareholder activism, but also the value effects of nonpublic shareholder activism, for example private negotiations (Woidtke 2002; Sun and Huang 1999).

To fully reflect the investment effect, capital expenditure, which is the company's most important investment decision, was also considered. Many scholars believe that capital expenditure is likely to become an important tool for the controlling shareholders or administrators of the company to secure personal interests and damage the interests of minority shareholders (Hu et al. 2006). Under the institutional context in which companies are controlled by the largest shareholders, investigating the impact of active shareholder behavior of institutional investors, which is an emerging governing mechanism, on investor protection from the perspective of capital expenditure will help understand the effect of the supervision of the institutional investors, and provide backing evidence for Chinese authorities' vigorous decisions on supporting institutional investors.

We selected capital expenditure as the proxy indicator of investor protection, and used "cash for building the fixed assets, intangible assets and other long-term assets" on the cash flow statement as the proxy variable of total capital expenditure (Zhang 2010). Referring to the article of Hua and Liu (2009), we used the following variables as control variables. First, we used GROW to represent the company's growth. Capital expenditures differ as companies' growth differs. More developed companies have more potential investment opportunities and thus will spend more capital. Operating revenue growth rate is frequently used as indicators for measuring growth. Second, we used CASH to represent net cash flow generated from operations. The above mentioned net cash flow is an important factor affecting the company's capital expenditure level.

In terms of indicators for institutional shareholding (INS), this paper used shareholding proportions of securities investment funds, shareholding proportions of the social security funds and those of institutional investors as a whole. In terms of control variables, we used the ownership structure variables to represent internal mechanism of corporate governance (Bai and Liu 2005). We selected the shareholding proportions of the largest shareholders (TOP_1) and those of the second to the tenth largest shareholders (TOP_{2-10}). TOP_1 reflects corporate holding structure with Chinese characteristics; TOP_{2-10} reflects the roles of the second to the tenth largest shareholders in balancing internal control of the largest shareholders. Company size and financial leverage (asset-liability ratio) were used to represent the other control variables that affect the corporate investment value.

We took into consideration that institutional investors might expand their shareholding proportions the same time when investment value increased. That is to say, institutional investors may invest in the company due to recent growth in investment value, rather than company stocks in order to improve companies' increase investment value. For example, institutional investors supervise company's administration after holding more their shareholdings of the company after finding that corporate performance is better. At this point, institutional investors' ownership and investment value are also positively correlated. Therefore, we measured indicator variables of investment value in the following year, to ensure investment improvement derived from the influence of institutional investors' shareholdings increase on the company's administration decisions. Due to the hysteretic nature of accounting statements, the ownership structural variables, indicators of financial leverage and firm size have also been brought forward a year. The regression equation is as follows:

$$TBQ = \alpha + \beta INS + \sum \beta i\, Controli + \varepsilon \tag{102.1}$$

$$EPS = \alpha + \beta INS + \sum \beta i\, Controli + \varepsilon \tag{102.2}$$

$$ROE = \alpha + \beta INS + \sum \beta i\, Controli + \varepsilon \tag{102.3}$$

$$CAP = \alpha + \beta INS + \sum \beta i\, Controli + \varepsilon \tag{102.4}$$

The variables used in this paper are showed in Table 102.1.

102.5 Empirical Results and Analysis

In this paper, we used cross-sectional data to make least-square linear regression of the above variables, and analyzed the impact of year by year change in the macroeconomic environment on the institutional investors' shareholdings with annual dummy variable YEAR (for data of shareholdings in 2008, YEAR = 0; for data of shareholdings in 2009, YEAR = 1).

From statistical characteristics of variables, we can learn that in the period 2009–2010, average Tobin' Q of stocks heavily held by institutional investors is 2.84, average earnings per share is 0.45, average return of net assets is 12.04, average rate of capital expenditures is 6.24 %. In the period 2008–2009, average shareholding proportion of securities investment funds is 4.54 %, average shareholding proportion of social security funds is 0.29 % and that of institutional investors as a whole is 12.04 %. In listed companies of which the stocks are heavily held by institutional investors, the average shareholding proportion of the largest shareholders is 38.55 %, while that of the second to the tenth largest shareholders is 19.69, the average asset-liability ratio is 49.7 %.

According to the results of multiple linear regressions(results table omitted), we can see that VIF values of the regression equations are much less than 10, indicating that the regression model is not affected by the multicollinearity. The Durbin-Watson stat is also close to 2, which demonstrates that the auto-correlation between the variables is low. The regression results show that the negative correlation between shareholding proportions of social security funds and TBQ, EPS, ROE, CAP is significant, which validates H_1. The remuneration of managers in social security funds is not linked to performance. Under political social pressure,

Table 102.1 Definition of variables

	Classification of variables	Names of variables	Descriptions of variables
Dependent variables	Indicators of market value	TBQ	Tobin's Q of the company
	Indicators of earning capacity	EPS	Earnings per share
		ROE	Return on net assets
	Protection indicators of interests of minority shareholders	CAP	Capital expenditure rate = Cash paid to build fixed assets, intangible assets and other long-term assets/total assets
Independent variables	Institutional ownership variables (of the top ten shareholders)	INSSE	Shareholding proportions of securities investment funds
		INSSO	Shareholding proportions of social security funds
		INS	Shareholding proportions of institutional investors as a whole
Control variables	Characteristics of ownership structure	TOP_1	Shareholding proportions of the largest shareholders
		TOP_{2-10}	Shareholding proportions of the second to the tenth largest shareholders
	Other variables	LOGSIZE	Log of total assets (company size)
		LEV	Financial leverage (debt ratio)
		CASH	Net cash flow generated from operations/ total assets
		GROW	Operating revenue growth rate

social security funds have different goals with the listed companies, and they will exercise a negative impact on the companies' investment value. The positive correlation between shareholding proportions of securities investment funds, shareholding proportions of institutional investors as a whole and TBQ, EPS, ROE, CAP is significant, which validates H_2 and H_3. With expanding of shareholding proportions of securities investment funds, securities investment funds and institutional investors as a whole can overcome "free rider" problem of minority shareholders. They are motivated and capable to oversee the company's administration, and can play imperative roles in promoting the company's investment value. In addition, we can conclude the following from the empirical results: (1) the ownership structural variables have no significant impact on the investment value, indicating that the largest shareholders used their advantages of control to violate company assets and undermine the interests of outside investors. Other large shareholders, because they have different targets, do not manage to form effective balance with the largest shareholders. This also demonstrates that institutional investors as a whole can inhibit large shareholders from infringing the interests of minority shareholders, protect their interests, and mitigate the problem of agency; (2) the negative correlation between investment value of companies and company size as well as asset-liability ratio is significant. The investment value of companies is negatively correlated with company size; this conforms to the fact that investment value of larger companies is prone to be underestimated while the investment value of smaller companies is prone to be overestimated. High debt ratio will increase creditors' constraints on the companies, and diminish the necessity of oversight and institutional investors' interest in investment, thereby reducing investment value of companies; (3) the positive correlation between the net cash flow generated from operations and capital expenditure rate is significant, indicating that investment spending is influenced by the scale of internal financing. However, the negative correlation between the company's growth and capital expenditure level is insignificant and does not pass statistical test. That is to say, companies' investment spending decreases with the improvement of investment opportunities, therefore reflecting a possible shortage of investment in Chinese listed companies.

102.5.1 Conclusions and Recommendations

The results of empirical tests show that although the social security funds are relatively long-term funds and have conditions for supervising administration of listed companies, they, under the political and social pressure, have different operating objectives with listed companies and will pose a negative impact on their market value. The securities investment funds' incentives are highly related with performance, making them less vulnerable to the political and social pressure. To increase in funds' shareholdings will urge the funds to supervise more closely listed companies, thereby accruing the investment value. Moreover, it is verified that the overall shareholdings of institutional investors have a positive impact on the investment value of listed companies.

This paper demonstrates that heterogeneity exists in institutional investors, due to differences between incentives and conflicts of interests, different institutions have different impacts on corporate governance and value of listed companies, which provides new evidence for judging roles of different institutions in corporate governance in the era of diversified Chinese institutional investors. Given the ineffective supervision of Board of Directors and roles of institutional investors as a whole in promoting the value of companies, supervision of institutional investors has become a reliable mechanism for overseeing listed companies. Chinese authorities should continue to vigorously support institutional investors. But given that social security funds have negative influence on the investment value of listed companies, Chinese government, when supporting diversified institutional investors, should reduce the political and social pressure on institutional investors and set up payment systems that are closely linked to performance, in order to enable the funds to be independent market participants and create a harmonious governance structure.

Acknowledgments *Fund*: This paper explains the preliminary results of the philosophy and social science project (2010SJD630048) of Education Department of Jiangsu Province.

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Chapter 103
Integer Linear Programming Model and Greedy Algorithm for Camping Along the Big Long River Problem

Zhen-ping Li and Xiao-dong Huang

Abstract In this paper, we investigate the problem of camping along the Big Long River: How to schedule the X trips in a rafting season of the Big Long River so that the total meets of any boats are minimal? By introducing the proper variables, the problem is formulated into an integer linear programming model. For small size problem, this integer linear programming can be solved by Lingo software; for large size problem, we design a greedy algorithm to arrange the schedule of the given X boats. Finally, we do some simulations of the above model and algorithm and obtain the optimal solution.

Keywords Camping along the river · Integer linear programming model · Greedy algorithm · Simulation · The optimal solution

103.1 Introduction

Visitors to the Big Long River (225 miles) can enjoy scenic views and exciting white water rapids. The river is inaccessible to hikers, so the only way to enjoy it is to take a river trip that requires several days of camping. River trips all start at First Launch and exit the river at Final Exit, 225 miles downstream. Passengers take either oar-powered rubber rafts, which travel on average 4 mph or motorized boats, which travel on average 8 mph. The trips range from 6 to 18 nights of camping along the river. Currently, X trips travel down the Big Long River each year during a six month period (the rest of the year is too cold for river trips). There are Y camp sites on the Big Long River, distributed fairly uniformly

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E. Qi et al. (eds.), *The 19th International Conference on Industrial Engineering and Engineering Management*, DOI: 10.1007/978-3-642-38391-5_103,

throughout the river corridor. In order to make sure the passengers enjoy a wilderness experience and also for the sake of their safety (http://wenku.baidu.com/view/19fab121192e45361066f5e4.html), we should try to avoid the meet of two groups of boats on the river. Besides, due to the capacity constraints, no two sets of campers can occupy the same site at the same time.

Every year, before the rafting season, the park managers must arrange the schedule of these X trips that will raft along the Big Long River in the rafting season. The key problem is how to schedule these X trips so that the total meets among all boats in the river is minimum. In this paper, we will solve this problem. This paper is organized as follows: in Sect. 103.2, we make some assumptions (Fu 2008; Xiang and Xu 2011) and introduce several variables (Gan et al. 2005), and then we formulate the problem into an integer linear model. Then we will design a greedy algorithm in Sects. 103.3 and 103.4 are the simulation results. The conclusion is given in Sect. 103.5.

103.2 The Integer Linear Programming Model

103.2.1 Assumptions and Variables

103.2.1.1 Assumptions

- Once people choose one of the propulsion (oar- powered rubber rafts or motorized boats) at first, they can not change again on the way;
- The duration of each trip ranges from 6 to 18 nights on the river;
- There are X trips, each trip has a given duration;
- There are Y camps distributed fairly uniformly throughout the river corridor;
- There is so enough fuel and power for each boat that no breakdown might occur on the whole river trip;
- Each boat, controlled by the specialized staff, will run exactly on schedule;
- There are 180 days in the Big Long River's rafting season;
- There are 8 h open for the river trip at daytime;
- Each rafting boat must stay in one camping site at night.

103.2.1.2 Variables

X: the total number of available trip boats;
Y: the total number of camping sites;
r_{ik}: the time when boat i arrives at camping site k;
d_{ik}: the time when boat i leaves from camping site k;

$$x_{ik} = \begin{cases} 1, & \text{boat } i \text{ occupys camping site } k \\ 0, & \text{otherwise} \end{cases}$$

$$c_{ij}^{k} = \begin{cases} 1, & \text{boat } i \text{ and } j \text{ meet at river between camping site } k \text{ and } k+1 \\ 0, & \text{otherwise} \end{cases}$$

$$c_{ij}^{k1} = \begin{cases} 0, & \text{if } d_{ik} > d_{jk} \quad \text{and} \quad r_{ik+1} > r_{jk+1} \\ 1, & \text{otherwise} \end{cases}$$

$$c_{ij}^{k2} = \begin{cases} 0, & \text{if } d_{ik} < d_{jk} \quad \text{and} \quad r_{ik+1} < r_{jk+1} \\ 1, & \text{otherwise} \end{cases}$$

T_i: the total trip duration of boat i (measured in nights on the river);
P_i: from which day boat i start off (P_i is an integer) at the First Launch;
$v_{i,\ min}$: the minimal speed of boat i;
$v_{i,\ max}$: the maximum speed of boat i.

103.2.2 The Integer Linear Programming Model

The problem of camping along the Big Long River can be formulated into an Integer Linear Programming Model (Liu et al. 2009; Wang 2010; Li and Wang 2009), in which the schedule time table of all given X boats (the total number of available trip boats) can be obtained with the total meets among all boats in the river be minimal.

103.2.2.1 One Essential Definition

Firstly, we define the open time for river trip. According to the given information, we could define that the river trip is only allowed at daytime from 08:00 to 16:00 clock; for the other time, passengers have to stay at the camping site.

103.2.2.2 The Integer Linear Programming Model

As analyzed above, the objective function is constructed to minimize the total meets between any pair of boats on the river. The constraints including: (1) the river trip can only be allowed at daytime from 08:00 to 16:00; (2) the river trip duration of each boat is an integer, ranging from 6 to18 nights; (3) no two sets of campers can occupy the same site at the same time; (4) the season for river trip only lasts 6 months (180 days). Based on the descriptions above, we formulate the integer linear programming mode as follows:

$$\min nbsp; z = \sum_{i}^{X}\sum_{j}^{X}\sum_{k}^{Y} C_{ij}^{k} \tag{103.1}$$

s.t

$$0 \le r_{ik} \le d_{ik}\ ,\ i = 1, 2, \ldots, X;\ k = 1, 2, \ldots, Y \tag{103.2}$$

$$\frac{w}{v_{i\,max}} \le r_{ik} - d_{i(k-1)} \le \frac{w}{v_{i\,min}}, w = \frac{225}{Y+1} \tag{103.3}$$

$$24P_i + 8 \le d_{io} \le 24P_i + 16 \tag{103.4}$$

$$24\left(P_i + \sum_{s=1}^{k} x_{is}\right) + 8 \le d_{ik} \le 24\left(P_i + \sum_{s=1}^{k} x_{is}\right) + 16 \tag{103.5}$$

$$24\left(P_i + \sum_{s=1}^{k} x_{is}\right) + 8 \le r_{ik} \le 24\left(P_i + \sum_{s=1}^{k-1} x_{is}\right) + 8 \tag{103.6}$$

$$\sum_{s=1}^{Y} x_{is} = T_i \tag{103.7}$$

$$x_{ik} \le d_{ik} - r_{ik} \le Mx_{ik} \tag{103.8}$$

$$6 \le P_i + \sum_{s=1}^{Y} x_{is} \le 180 \tag{103.9}$$

$$\begin{cases} d_{ik} \ge d_{jk} - Mc_{ij}^{k1} \\ r_{i(k+1)} \ge r_{j(k+1)} - Mc_{ij}^{k1} \\ d_{ik} \le d_{jk} + Mc_{ij}^{k2} \\ r_{i(k+1)} \le r_{j(k+1)} + Mc_{ij}^{k2} \\ c_{ij}^{k} \ge c_{ij}^{k1} + c_{ij}^{k2} - 1 \end{cases} \tag{103.10}$$

$$|r_{ik} - r_{jk}| \ge 16 - M(2 - x_{ik} - x_{jk}) \tag{103.11}$$

$$\begin{cases} r_{ik} \ge 0 \\ x_{ik} = 0, 1 \\ c_{ij}^{k} = 0, 1 \\ P_i \ge 0 \quad \text{(integer)} \\ T_i \ge 0 \\ i, j = 1, 2, \ldots, X \\ k = 1, 2, \ldots, Y \end{cases} \tag{103.12}$$

The objective function (103.1) is to minimum the total meets between any pair of boats on the river.

Constraint (103.2) means the time when boat i leaves site k is later than that when boat i arrives at site k.

Constraint (103.3) guarantees the time for boat i to travel from site $k-1$ to site k is between the lower and upper bound.

Constraint (103.4) means that boat i will begin its trip in the P_ith day at the open time, where $P_i = 1, 2, \ldots, 174$.

Constraint (103.5) guarantees that boat i leaves camping site k at the open time.

Constraint (103.6) guarantees that boat i arrives at camping site k at the open time.

Constraint (103.7) means the duration of boat i is T_i, where T_i is an integer ranging from 6 to 18.

Constraint (103.8) describes the condition whether boat i occupies the camping site k.

Constraint (103.9) guarantees all the boats will finish their river trips in six months.

Constraint (103.10) describes the condition whether boat i and boat j meets on the river.

Constraint (103.11) guarantees no two sets of campers can occupy the same camping site at the same time.

Constraint (103.12) describes the value range of variables.

103.3 Greedy Algorithm

As a matter of fact, we could use Lingo software to solve this problem; however, the problem scale is so large that the time consuming will be too long. So it's not wise enough to use Lingo software in this situation. Here we design a greedy algorithm (Chen et al. 2008; Chen and Xu 2011; Su and Zhang 2011; Liang et al. 2005; Wang and Li 2008) to solve this problem.

103.3.1 Several Essential Supposes

According to our model, we will write a procedural by using the MATLAB software, but before this we give some essential supposes again:

- To avoid the meet between any pair of boats on the river, the boats have to start off by some gap time, and we define the gap time as follows: Gap time $= 225/(Y+1)/v$, where v is the speed of boat.
- The boat will run at the same speed during the whole trip.
- The actual time of river trip for each boat every day is not more than 5 h.
- Passengers who want to have a river trip need to make a booking in advance, and then we will divide the six months' rafting season into several cycles

according to the passengers' booking. During one cycle time, we will arrange the boats by their duration like this: boat of 6 nights first, and then it will be 7, 8,… in turn, boats of 18 nights will be the last to be arranged.

- The number of boats (represented with Q) arranged every day will depend on its duration and could be calculated by $Q = [Y/T_{\text{dur}}]$. For example, for boats whose duration is 6, the maximum number of this type boats we can arrange every day is $[Y/6]$; for boats whose duration is 7, the maximum number we can arrange every day is $[Y/7]$. Why? We can explain this by the following graph (see Fig. 103 1).

Suppose $Y = 24$, then for boats whose duration is 6, the maximum number of boats we can arrange every day is 4:

In Fig. 103.1, the bold horizontal line denotes the riverbank while the thin vertical line represents the camping site and the arrow symbolizes the boat. At the first day we arrange 4 boats. Then we can see these four boats as a whole and its whole trip process could be described vividly in the above graph. By this method we can guarantee to utilize the camping sites in the best possible way. As to other boats of different duration, we can draw the similar graph like the above.

103.3.2 The Greedy Algorithm

The greedy algorithm can be described as follows.

BEGIN

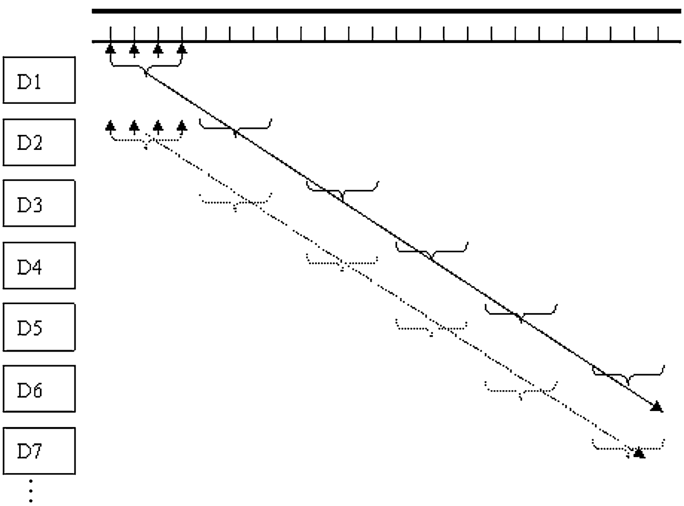

Fig. 103.1 Trip process of boats arranged in the first and the second days

Classes all X boats into 13 groups according to their duration. Denote the number of boats whose duration is i by $X(i), i = 6, 7, \ldots, 18$.

Provided that the maximum river trip time every day is no more than 5 h, calculate the maximum number of boats whose duration is i we can arrange every day, denoted it by m(i), where $m(i) = [Y/i]$.

for $i = 6 : 18$

Arrange the schedule of all boats with duration i.

For all $X(i)$ boats with duration i, arrange them to start off from the First Launch in $X(i)/m(i)$ consecutive days, with the time gap between two successive boats is 225/(Y + 1)/v daytime.

After all $X(i)$ boats with duration i arranged, we can arrange the following $X(i + 1)$ boats with duration $i + 1$ in the following $X(i+1)/m(i+1)$ days…, till all X boats are arranged.

end

END

103.4 Simulation Results

In this section, we will do some simulations of the model and algorithm described above.

Supposing Xi denotes the number of boats whose duration is $i(i = 6, 7, \ldots, 18)$, where

$$X_6 = 5, X_7 = 6, X_8 = 11, X_9 = 12, X_{10} = 10, X_{11} = 8, X_{12} = 6, X_{13} = 15,$$
$$X_{14} = 7, X_{15} = 12, X_{16} = 12, X_{17} = 11, X_{18} = 9.$$

Given $Y = 53$.

We run our procedural coded by MATLAB software, the simulation result are as follows:

D1: 5 boats whose duration is 6 nights and 3 boats whose duration is 7 nights will start off in the first day;

D2: 3 boats whose duration is 7 nights and 4 boats whose duration is 8 nights will start off in the second day;

D3: 6 boats whose duration is 8 nights will start off in the third day;

D4: 1 boat whose duration is 8 nights and 5 boats whose duration is 9 nights will start off in the fourth day;

D5: 5 boats whose duration is 9 nights will start off in the fifth day;

…

D31: 2 boats whose duration is 18 nights will start off in the 31st day;

D32: 2 boats whose duration is 18 nights will start off in the 32nd day;

D33: 1 boat whose duration is 18 nights will start off in the 33rd day.

The detail rafting schedule of all boats can be described in Fig. 103.2.

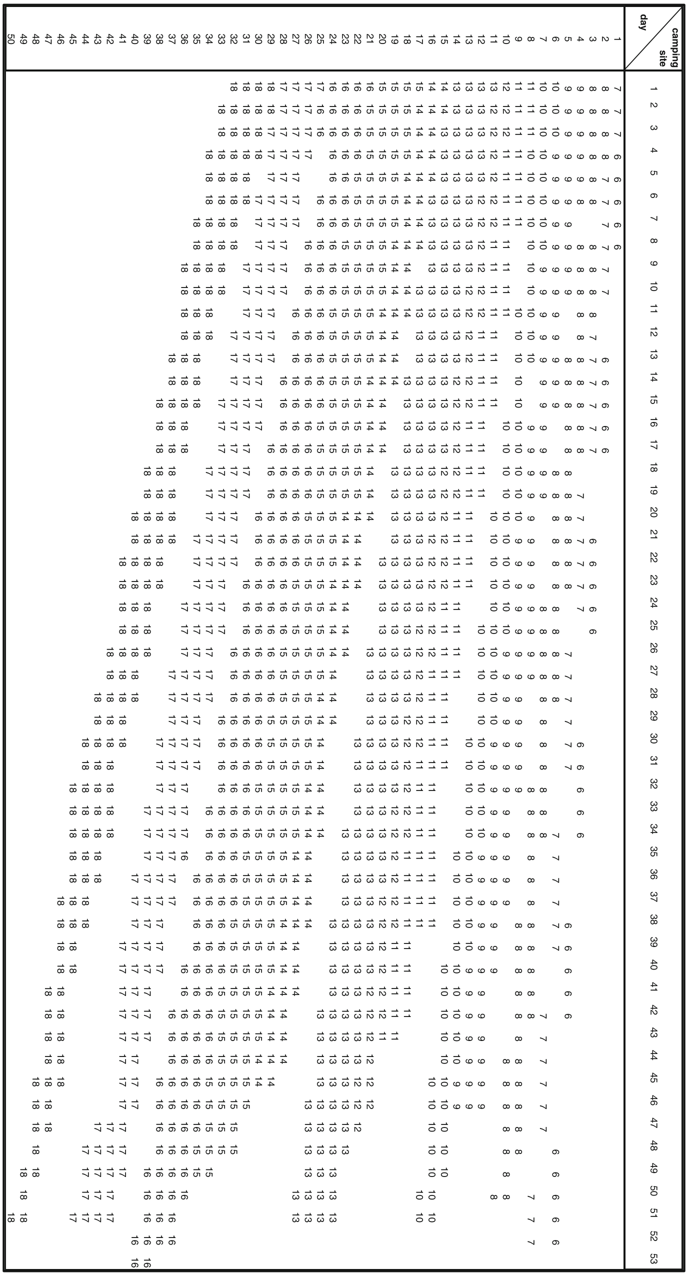

Fig. 103.2 The detail schedule of all boats obtained by greedy algorithm

According to the simulation results, we find that we can arrange the 124 boats in about 50 days. This inspired us that we can divided the rafting season (180 days) into several (for example 3) periods. Arrange X/3 boats in every period respectively according to the greedy algorithm. This can avoid all boats with same duration be arranged in several concentrate days.

Remarks: By using the greedy algorithm, we can give a solution to the problem; however this solution might not be the optimal one. But based on this solution, we can take some measures to improve. By continuous adjusting, we can finally find a satisfied solution.

103.5 Conclusion

The problem of Camping along the Big Long River is very complex and the solution should be of great openness. In this paper, we formulate this problem into an integer linear programming model and design a greedy algorithm to arrange the schedule of boats. Then by doing some simulations with this algorithm, we give a solution to the problem. The results show that this method can obtain the optimal solution by continuous improving. Furthermore; we can estimate the capacity of the river by this greedy algorithm.

Although river trip is quite interesting and exciting, it is also very risky and need some spirit of adventure. Any accident may happen during this process, such as bad weather, passenger's injuries and so on. These potential factors might have a great impact on the supervisor's decision and management. We don't take these factors into account. In the future, we will consider these factors in the model and algorithm.

Acknowledgments This work is supported by National Natural Science Foundation of China under Grant No.11131009 and the Funding Project for Academic Human Resources Development in Institutions of Higher Learning under the Jurisdiction of Beijing Municipality (No.PHR201006217).

The author gratefully acknowledges the valuable discussions and comments that Huang qiuai, Chen Qing, Li Tingting and Wang Shan provide for this paper.

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Chapter 104
Research on End Distribution Path Problem of Dairy Cold Chain

Zhen-ping Li and Shan Wang

Abstract The vehicle routing problem of dairy cold chain end distribution with random demand and time window is investigated in this paper. Considering the characteristics of dairy cold chain end distribution, the chance constrained theory and the penalty function is introduced to establish a mathematical model of this problem. A scanning-insert algorithm to solve the model is proposed. The algorithm can be described as: firstly, according to the capacity of the vehicle and time window restrictions, the customers are divide into several groups by scan algorithm; then find a feasible routing line for each group of customers; finally, using the idea of recent insertion method to adjust the vehicle route and find the final optimal distribution vehicle route.

Keywords Dairy cold chain · Random demand · Mathematical model · Scanning-insert algorithm

104.1 Introduction

Vehicle routing problem with time windows refers to the transportation problem in general under the premise of customer‘s requirements of time window. Solomon and Desrosiers etc. (Solomon 1987; Solomon and Desrosiers 1988) consider joined time window constraint to the general vehicle routing problem in 1987. Desorchers et al. (1988) used to concise summary and summarized various kinds of method solving vehicle routing problem with time windows further in 1988. Sexton and

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E. Qi et al. (eds.), *The 19th International Conference on Industrial Engineering and Engineering Management*, DOI: 10.1007/978-3-642-38391-5_104,

Choi (1986) used the Decomposition method proposed by Bender to solve the single vehicle pick-up and delivery problem with time window restriction.

Chance constrained mechanism use the default value constraint error to return to probability in the essence of vehicles service process, and additional cost caused by service failure is not within planning (Chen 2009). Stewart (Stewart and Golden 1983) and Laporte (Laporte et al. 1989) used respectively chance constrained program change SVRP into equivalent deterministic VRP under some assumptions. Dror (Dror and Trudeau 1986) used Clark-Wright algorithm to solve vehicle routing optimization problem.

This paper's main consideration is regular route for distribution mode under the target of minimizing the cost. It means that the customer or the number of nodes and their position are fixed in every day visit, but each customer's demand is different, and their demands meet Normal Distribution.

104.2 Analysis of the Cost in Cold Chain Logistics Distribution

104.2.1 Fixed Costs

Distribution center has to pay for the fixed costs for the use of each vehicle. These costs include the driver's wages, insurance, lease rental of the vehicle.

$$c_1 = \sum_{k=1}^{m} f^k$$

104.2.2 The Transportation Cost

The transportation cost of a vehicle is the relevant expenses caused by travel, which includes fuel consumption, maintenance, maintenance fee.

$$c_2 = \sum_{i=1}^{n} \sum_{j}^{n} c_{ij}^k d_{ij} x_{ij}^k$$

104.2.3 The Cost of Damage

In the cold chain, the main factors causing fresh products damaged are storage temperature, food of microbes in water activity, PH value, oxygen content (Wang 2008). Assume the damage rate is λ, the unit value of the products is P, and capacity of vehicle k is Q_k.

$$c_3 = P\lambda Q_k$$

104.2.4 The Cost of Energy Consumption

The heat load vehicle refrigeration equipment is mainly due to difference heat transfer between the vehicle body inside and outside. Suppose the temperature difference between inside and outside of the vehicle is fixed in a certain period, then the cost of energy consumption can be expressed as:

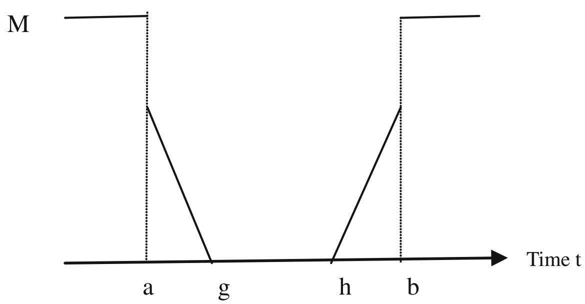
$$c_4 = A\sum_{k=1}^{m}(e^k - s^k)$$

104.2.5 Penalty Cost

Soft time window can allow the distribution vehicle to arrive outside the time window, but outside the appoint time must be punished. Delivery time can be divided into three categories: service in advance, service by time window, service delay (Zhan 2006; Thangiah et al. 1991), which is shown in Fig. 104.1.

(1) Service in advance is that the distribution vehicles arrive in time window [a, g). Immediate delivery may cause customers' inconvenience and complaint, but it can reduce the energy consumption.
(2) Service by time window means that the distribution vehicle arrives in the time window [g, h]. Immediate delivery and the energy costs relate to time is a constant.
(3) Service delay means that the distribution vehicle arrive in time window (h, b]. Immediate delivery and the energy and relevant penalty costs will increase.

Fig. 104.1 Time window



In conclusion, the penalty cost function is:

$$\varphi(t_i^k) = \begin{cases} M, & t_i^k < t_{a_i} \ \ or \ \ t_i^k > t_{b_i} \\ (t_{g_i}^k - t_i^k)\theta, & t_{a_i} \le t_i^k < t_{g_i} \\ 0, & t_{g_i} \le t_i^k \le t_{h_i} \\ (t_i^k - t_{h_i})\eta, & t_{h_i} < t_i^k \le t_{b_i} \end{cases}$$

104.3 Mathematical Model

104.3.1 Related Hypothesis

(1) The model only considers the pure delivery problem.
(2) There are enough delivery vehicles in the distribution center, and each vehicle's capacity is limited.
(3) The stock in the distribution center is enough for all the customers and all customers' time windows are known.
(4) All vehicles start off from the distribution center, and return to the distribution center again after completion.
(5) The position of each customer is given, but quantities demand D_i of each customer i is random, it satisfies a normal distribution $D_i \sim N(\mu_i, \sigma_i^2)$, and they are mutual independent.
(6) The route of each vehicle is determined and will not change in the deliver road.
(7) Products in the transportation process can stay in a fixed transport temperature, and the vehicle's energy consumption is only related to their travel time.

104.3.2 Symbols and Mathematical Model

f^k : Fixed cost of vehicle k;
c_{ij}^k : The unit transportation cost of vehicle k in the travel road from customer i to customer j;
d_{ij} : Distance from customer i to customer j;
A : Unit cost of energy consumption;
e^k : The time when vehicle k return to the distribution center;
s^k : The time when vehicle k start off from the distribution center;
t^k : The time when vehicle k arrives at customer i;
D_i : Demand of customer i;

$$x_{ij}^k = \begin{cases} 1, & \text{If vehicle } k \text{ come to customer } j \text{ from customer } i \\ 0, & \text{otherwise} \end{cases}$$

$$y_i^k = \begin{cases} 1, & \text{If vehicle } k \text{ service for customer } i \\ 0, & \text{otherwise} \end{cases}$$

The mathematical model can be formulated as follows:

$$\min z = \sum_{k=1}^{m} [f^k + P\lambda Q_k + A(e^k - s^k)] + \sum_{k=1}^{m}\sum_{i=1}^{n}\sum_{j=1}^{n} c_{ij}^k d_{ij} x_{ij}^k + \sum_{k=1}^{m}\sum_{i=1}^{n} \varphi(t_i^k) \tag{s.t.}$$

$$\sum_{k=1}^{m} y_i^k = \begin{cases} m, & i = 0 \\ 1, & i = 1,2,\ldots,n \end{cases} \tag{104.1}$$

$$y_j^k = \sum_{i=1}^{n} x_{ij}^k, i \neq j; j = 1,2,\ldots,n \tag{104.2}$$

$$\sum_{i=0}^{n} x_{ip}^k - \sum_{j=0}^{n} x_{pj}^k = 0 \qquad p = 1,2,\ldots,n \tag{104.3}$$

$$t_j^k \geq t_i^k + \frac{d_{ij}}{v} - (1 - x_{ij}^k)M, \quad j = 1,2,\ldots,n; \quad k = 1,2,\ldots,m \tag{104.4}$$

$$t_i^k \geq s^k + \frac{d_{oi}}{v} - (1 - x_{oi}^k)M, \quad i = 1,2,\ldots,n; \quad k = 1,2,\ldots,m \tag{104.5}$$

$$e^k \geq t_j^k + \frac{d_{jo}}{v} - (1 - x_{jo}^k)M, \ j = 1,2,\ldots,n; \ k = 1,2,\ldots,m \tag{104.6}$$

$$t_{a_i} \leq t_i^k \leq t_{b_i}, \ i = 1,2, \ \ldots, \ n; k = 1,2, \ \ldots, \ m \tag{104.7}$$

$$\sum_{i=1}^{n} \mu_i y_i^k + \Phi^{-1}(\beta)\sqrt{\sum_{i=1}^{n} \sigma_i^2 y_i^k} \leq Q^k \tag{104.8}$$

$$y_i^k = 0,1 \quad i = 1,2,\ldots,n; \ k = 1,2,\ldots,m;$$

$$x_{ij}^k = 0,1 \quad i,j = 1,2,\ldots,n; \ i \neq j; \ k = 1,2,\ldots,m;$$

The objective function minimum the total cost.

Constraint (104.1) means that each customer will be serviced by one vehicle, and each vehicle's route start from and ended at the distribution center.

Constraint (104.2) means that if vehicle k arrives at customer j, then it must service for customer j.

Constraint (104.3) means that if vehicle k arrives at customer p, then it must leave from customer p after finishing service.

Constraints (104.4–104.5) are the conditions that the arriving time for vehicle k come to customers i and j must satisfy.

Constraints (104.6–104.7) are the time window restrictions.

Constraint (104.8) means that the probability of each vehicle's capacity is no less than the total demands of all the customers it serviced is great than β.

104.4 Algorithm

The algorithm can be described as follows:

A. Set up the polar coordinates system:
B. Partition the customers into several groups.

  (1) Starting from zero Angle and rotating along counterclockwise direction, pick up the customer into a group one by one until the total demands of all customers in this group exceed a vehicle's capacity limit.
  (2) For each group of customers, ordered them into sequence according to the demand time window and form initial solution route. Then determine whether the solution route satisfies the time window constraints.
  (3) If the solution route satisfies the time window constraints, then a new group is created. Go to (1). Continue to rotate along counterclockwise direction, and the rest of the customers will be added one by one into a new group. Otherwise, if the solution route does not satisfy the time window constraints, we can adjust the order of customers and find another feasible solution route sequence. If no feasible solution route satisfying time window constraints exists, delete a customer who does not satisfy time window constraints from the group, and add it into the next new group as a necessary customer. Go to (1).

C. Repeat step B until all customers are partitioned into groups
D. Optimize the vehicle's route by the recent insertion method in each group

  (1) Select the earliest time requirements customer to form a sub-route with distribution center 0.
  (2) Insert customer point v_k as the next demand point according to time window series. Find an arc (v_i, v_j) in the sub-route, insert customer node v_k between customer nodes v_i and v_j to form a new sub- route such that the new sub-route satisfies time window and the cost increment is minimum.
  (3) Repeat step (2), until all customer nodes are added into a route.

E. Repeat step D, until all groups are optimized.

104.5 Simulation Results

There are 30 customers needed to be serviced. Suppose all vehicles are of the same type. The capacity of each vehicle is 48; fixed costs is 100; the vehicle speed is 30 km/h; Unit of energy consumption cost \$0.5 per minute; unit distance transportation cost is \$5 per kilometer; punishment coefficient θ is 0.4 and η is 0.5; β is 95 %, λ is 0.01, P is 100. The experimental data is random generation through the computer under experimental hypothesis.

A. Set up the polar coordinates system
B. Partition the customers into several groups

(1) Starting from zero Angle and rotating along counterclockwise direction, we can find the first group customers are 2, 3, 5, 6, 7, and 9. The detail information is listed in Table 104.1.

$$Q_1 = 3 + 4 + 9 + 5 + 7 + 11 + 1.65\sqrt{1 + 2 + 3 + 3 + 4 + 5} = 45.4 < 48$$

(2) Find an initial solution sequence 0-2-3-7-5-6-9-0, The initial route is shown in Fig. 104.2.
(3) Continue to rotate counterclockwise to build new group. Repeat the process until all customers are picked into a group.

C. Optimize the initial route of each group by the recent Insertion method

(1) Select customer 2 whose requirement time window is the earliest to form a sub-route with distribution center 0. Insert customer 3 as the next customer point according to its requirement time window. Then customer 3 will be inserted between distribution center 0 and customer 2, forming a new sub-route 0-2-3-0 satisfying time window and with minimal cost increment. See Table 104.2.
(2) Insert customers 7, 5, 6, 9 into the sub-route one by one. We can find the optimal route 0-2-7-9-3-6-5-0. The objective function value is 796.6. The optimal route is shown in Fig. 104.3 and Table 104.3.

Similarly, we can use the same method to find the optimal routes in the other groups. The results are shown in Fig. 104.4.

Table 104.1 Basic information table

Customer	X	Y	Requirements T	Accept time	Demand quantity
2	22	10	5:00–5:30	4:00–6:00	Q ~ N(3,1)
3	12	20	5:50–6:30	5:00–7:00	Q ~ N(4,2)
7	25	30	6:10–6:40	5:10–7:20	Q ~ N(9,3)
5	10	2	6:30–7:20	6:00–7:50	Q ~ N(5,3)
6	8	15	7:10–7:40	6:20–8:00	Q ~ N(7,4)
9	13	35	7:20–7:50	6:20–8:40	Q ~ N(11,5)

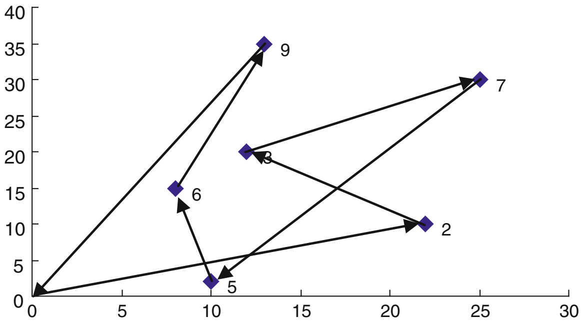


Fig. 104.2 Initial route

Table 104.2 The time table of sub-route

d_{ij}		24		14		23	
Customer	0	–	2	–	3	–	0
Time	4:30		5:18		5:46		6:32
Δt			0		−4		0

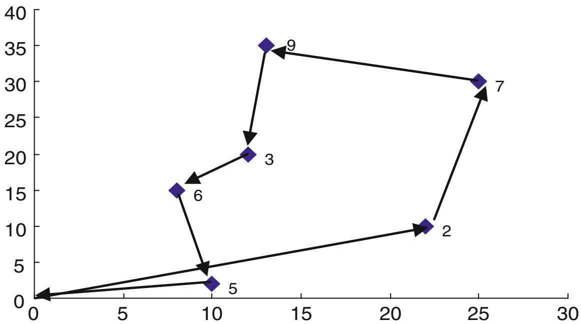


Fig. 104.3 The optimal route

Table 104.3 Time table of the optimal route

d_{ij}		24		20		13		15		6		13		10	
Customer	0	–	2	–	7	–	9	–	3	–	6	–	5	–	0
Time	4:30		5:18		5:58		6:24		6:54		7:06		7:32		7:52
Δt			0		−12		−56		24		0		12		

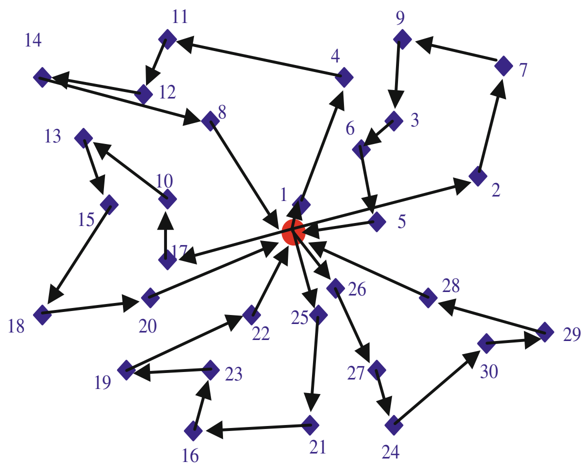


Fig. 104.4 The optimal routes of all groups

104.6 Conclusion

The vehicle routing problem of dairy cold chain end distribution with random demand and time window is investigated in this paper. A mathematical model is constructed, and an algorithm is proposed.

Vehicle routing problem with time windows is a real problem the enterprises facing with at the end of city distribution. It is obvious that to pursuit minimum cost may cause to drop the quality of service and eventually lead to the loss of customers. To establish a suitable mode of long-term sustainable development, the enterprise should find a balance between service quality and cost. As a result, the enterprises could meet customer requirements with the highest level of service and minimum cost. In addition, this paper did not consider the asymmetry of road network and the time handling factors. In the future, we will investigate the problem with these factors.

Acknowledgments This work is supported by National Natural Science Foundation of China under Grant No.11131009 and the Funding Project for Academic Human Resources Development in Institutions of Higher Learning under the Jurisdiction of Beijing Municipality (No.PHR201006217).

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Chapter 105
Improved Evolutionary Strategy Genetic Algorithm for Nonlinear Programming Problems

Hui-xia Zhu, Fu-lin Wang, Wen-tao Zhang and Qian-ting Li

Abstract Genetic algorithms have unique advantages in dealing with optimization problems. In this paper the main focus is on the improvement of a genetic algorithm and its application in nonlinear programming problems. In the evolutionary strategy algorithm, the optimal group preserving method was used and individuals with low fitness values were mutated. The crossover operator uses the crossover method according to the segmented mode of decision variables. This strategy ensured that each decision variable had the opportunity to produce offspring by crossover, thus, speeding up evolution. In optimizing the nonlinear programming problem with constraints, the correction operator method was introduced to improve the feasible degree of infeasible individuals. MATLAB simulation results confirmed the validity of the proposed method. The method can effectively solve nonlinear programming problems with greatly improved solution quality and convergence speed, making it an effective, reliable and convenient method.

Keywords Nonlinear programming · Genetic algorithm · Improved evolutionary strategy · Correction operator method

105.1 Introduction

Nonlinear programming problem (NPP) had become an important branch of operations research, and it was the mathematical programming with the objective function or constraints being nonlinear functions. There were a variety of traditional methods to solve nonlinear programming problems such as center method, gradient projection method, the penalty function method, feasible direction

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E. Qi et al. (eds.), *The 19th International Conference on Industrial Engineering and Engineering Management*, DOI: 10.1007/978-3-642-38391-5_105,

method, the multiplier method. But these methods had their specific scope and limitations, the objective function and constraint conditions generally had continuous and differentiable request. The traditional optimization methods were difficult to adopt as the optimized object being more complicated. Genetic algorithm overcame the shortcomings of traditional algorithm, it only required the optimization problem could be calculated, eliminating the limitations of optimization problems having continuous and differentiable request, which was beyond the traditional method. It used the forms of organization search, with parallel global search capability, high robustness and strong adaptability, and it could obtain higher efficiency of optimization. The basic idea was first made by Professor John Holland. The genetic algorithm had been widely used in combinatorial optimization, controller's structural parameters optimization etc. fields, and had become one of the primary methods of solving nonlinear planning problems (Operations research editorial group 2005; Bazarra and Shetty 1979; Bi et al. 2000; Liang et al. 2009; Holland 1975; Hansen 2004; Saleh and Chelouah 2004; Uidette and Youlal 2000; Lyer et al. 2004).

In this paper, the evolution strategy was improved after analyzing the process of the genetic algorithm and the improved algorithm took full advantages of genetic algorithm to solve unconstrained and constrained nonlinear programming problems. In the MATLAB environment, the numerical example showed that the proposed improved genetic algorithm for solving unconstrained and constrained nonlinear programming was effective, and the experiment proved it was a kind of algorithm with calculation stability and better performance.

105.2 Nonlinear Programming Problems

The nonlinear programming problems could be divided into unconstrained problems and constrained problems (Operations research editorial group 2005; Sui and Jia 2010). We presented the mathematical model here in its general form.

The unconstrained nonlinear programming model:

$$\min f(X) \quad X \in E^n \tag{105.1}$$

where, the independent variable $X = (x_1, x_2, \ldots, x_n)^T$ was an n dimensional vector (point) in Euclidean space. It was the unconstrained minimization problem that was for the minimum point of the objective function $f(X)$ in E^n.

The constrained nonlinear programming model:

$$\begin{array}{lll} & \min f(X) & X \in E^n \\ s.t. & h_i(X) = 0, & i = 1, 2, \ldots, m \\ & g_j(X) \geq 0, & j = 1, 2, \ldots, l \end{array} \tag{105.2}$$

where, "min" stood for "minimizing" and symbol "*s.t*" stood for "subject to". It was the unconstrained minimization problem that was for the minimum point of the objective function $f(X)$ in E^n. Here, $h_i(X) = 0$ and $g_j(X) \geq 0$ were the constrained conditions.

For max $f(X) = -\min[-f(X)]$, only the minimization problem of objective function was needed to take into consideration without loss of generality.

If some constrained conditions were "$\leq$" inequality, they were needed to be multiplied at both ends of the constraints by "-1". So we could only consider the constraint in the form of "$\geq$".

105.3 Analysis and Description of the Improved Genetic Algorithm

Based on the simple genetic algorithm, the following gave the analysis design and description of the algorithm which improved the genetic evolution strategy of genetic algorithm.

105.3.1 Encoding and Decoding

We used the binary encoding and multi-parameter cascade encoding. It meant that we made each parameter encoded by means of the binary method and then connected the binary encoded parameters with each other in a certain order to constitute the final code which represented an individual including all parameters. The bit string length depended on the solving precision of specific problems, the higher precision we required, the longer the bit string.

If the interval of someone parameter was $[A, B]$ and the precision was c digits after decimal point, then the calculation formula for bit string length was:

$$(B - A)\,10^c \leq 2^L \tag{105.3}$$

Here, L took the smallest integer which made the above equation valid.

If the interval of someone parameter was $[A, B]$, the corresponding substring in the individual code was $b_L b_{L-1} b_{L-2} \cdots b_2 b_1$, then its corresponding decoding formula was:

$$X = A + \left(\sum_{i=1}^{L} b_i\, 2^{i-1}\right) \frac{B - A}{2^L - 1} \tag{105.4}$$

105.3.2 Production of the Initial Population

There were two conditions when producing initial population. One was to solve the unconstrained problem; the other was to solve the constrained problem.

Suppose the number of decision variables was n, the population scale was m, a_i and b_i were lower limit and upper limit of a decision variable respectively. For the unconstrained problem, binary encoding was adopted to randomly produce initial individuals of the population.

For constrained problems, the initial population could be selected at random under certain constraint conditions. It also could be produced in the following manner:

First, a known initial feasible individual $X_1^{(0)}$ was given artificially. It met the following conditions:

$$g_j(X_1^{(0)}) = g_j(X_{11}^{(0)}, X_{12}^{(0)}, X_{13}^{(0)}, \ldots, X_{1n}^{(0)}) > 0$$

The other individuals were produced in the following way (Wang et al. 2006):

$$X_2^{(0)} = A + r_2(B - A) \tag{105.5}$$

Here, $A = (a_1,\ a_2,\ a_3,\ldots,a_n)^T$, $B = (b_1,\ b_2,\ b_3,\ldots,b_n)^T$, $r_2 = (r_{21},\ r_{22},\ r_{23},\ldots,\ r_{2n})^T$, random number $r_{ij} \in U(0, 1)$.

Then checking whether $X_2^{(0)}$ satisfied the constraints or not. If the constraints were satisfied, another individual would produce as $X_2^{(0)}$. If the constraints were not satisfied, $X_2^{(0)}$ would be corrected by correction operator.

105.3.3 Correction Operator Method

When genetic algorithm was applied to deal with constrained nonlinear programming problems, the core problem was how to treat constraint conditions. Solving it as unconstrained problems at first, checking whether there were constraint violations in the search process. If there were no violations, it indicated that it was a feasible solution; if not, it meant it was not a feasible solution. The traditional method of dealing with infeasible solutions was to punish those infeasible chromosomes or to discard infeasible chromosome. Its essence was to eliminate infeasible solution to reduce the search space in the evolutionary process (Gao 2010; Wang et al. 2003; Ge et al. 2008; He et al. 2006; Tang et al. 2000; Wang and Cao 2002). The improved evolution strategy genetic algorithm used the correction operator method, which selected certain strategy to fix the infeasible solution. Different from the method of penalty function, the correction operator method only used the transform of objective function as the measure of the adaptability with no additional items, and it always returned feasible solution. It had broken the traditional idea, avoided the problem of low searching efficiency because of refusing infeasible solutions and avoided early convergence due to the introduction of punishment factor, and also avoided some problems such as the result considerably deviating constraint area after mutation operation.

If there were r linear equations of constraints, and the linear equations' rank was $r < n$, all decision variables could be expressed by $n - r$ decision variables.

Taking them into inequality group and the objective function, the original n decision variables problem became $n - r$ decision variables problem with only inequality group constraints. So we could only consider problems with only inequality group constraints. The production of initial individuals, offspring produced by crossover operation and individuals after mutation, all were needed to be judged whether they met the constraints, if not, fixed them in time. Such design of genetic operation made solution vectors always bounded in the feasible region.

The concrete realization way of correction operator was:

Each individual was tested whether it satisfied the constraints. If so, continued the genetic operation; if not, let it approach the former feasible individual (assumed $X_1^{(0)}$ and the former feasible individual should be an inner point). The approaching was an iterated process according to the following formula:

$$X_2^{(0)} = X_1^{(0)} + \alpha(X_2^{(0)} - X_1^{(0)}) \tag{105.6}$$

where, α was step length factor. If it still did not satisfy the constraint, then the accelerated contraction step length was used, that was $\alpha = (1/2)^n$, here, n was search times.

Big step length factor could affect the constraint satisfaction and reduce the repairing effect and even affect the search efficiency and speed, whereas, too small step length factor could not play the role of proper correction. So the method of gradually reducing the step length factor could both protect the previous correction result and give full play to correction strategy.

Thus $X_2^{(0)}$ was made to feasible individual after some times of iteration, then $X_3^{(0)}$ was produced as $X_2^{(0)}$ and become feasible individual. In the same way, all the needed feasible individuals were produced. For binary genetic algorithm, these feasible individuals were phenotype form of binary genetic algorithm. Real coding individuals were converted into binary string according to the mapping relationship between genotype and phenotype. Then the feasible individuals of binary genetic algorithm were obtained.

This kind of linear search way of infeasible individual moving to the direction of feasible individual had the advantage of improving infeasible individual, initiative guiding infeasible individuals to extreme point of population, making the algorithm realize optimization in global space. This paper introduced the correction operator to improve the feasibility of infeasible individuals. This method was simple and feasible. And the treatment on infeasible individuals was also one novelty of improving evolution strategy of genetic algorithm.

105.3.4 Fitness Functions

If the objective function was for minimal optimization, the following transformation was applied (Wang et al. 2007):

$$Fit(f(x)) = \begin{cases} c_{\max} - f(x) & f(x) < c_{\max} \\ 0 & other \end{cases} \tag{105.7}$$

Here, $c_{\max}$ was an estimated value which was enough large for the problem.

If the objective function was for maximal optimization, the following transformation was applied:

$$Fit(f(x)) = \begin{cases} f(x) - c_{\min} & f(x) > c_{\min} \\ 0 & other \end{cases} \tag{105.8}$$

Here, $c_{\min}$ was an estimated value which was enough small for the problem.

105.3.5 Selection Operator

Selection operator used the roulette selection method. The selection probability of individual i:

$$p_s = f_i / \sum_{i=1}^{m} f_i \tag{105.9}$$

105.3.6 Crossover Operator

The number of decision variables might be more in practical problems. Because binary encoding and multiparameter cascade encoding were adopted, the one point crossover would make only one decision variable cross in a certain position in this encoding mode, leaving no crossover for other variables. So the segmented crossover mode of decision variables was used, giving each decision variable the probability p_c of single point crossover. Each decision variable had a cross opportunity to produce offspring. This improvement was also another novelty of evolutionary strategy of genetic algorithm.

105.3.7 Mutation Operator

Alleles of some genes were randomly reversed according to mutation probability p_m. Parent population individuals and child population individuals after crossover were sorted together according to their fitness values before mutation and only individuals with low fitness values were mutated. Thus not only good schema could avoid being destroyed, but also mutation probability could be appropriately increased, so generating more new individuals. It was good to increase the population's diversity, to traverse all of the state, and to jump out local optimum.

105.3.8 Population Evolution

In the process of population evolution, parent population individuals and child population individuals after crossover were put together to form a new temporary population, and the fitness value of each individual in the new temporary population was calculated, m individuals with high fitness values were preserved, then m individuals with low fitness values were mutated and the mutated m individuals and the m previous preserved individuals were put together to form a new temporary population. Thereafter individuals in the new temporary population were sorted according their fitness values and m individuals with high fitness value were selected as the next generation to accomplish the population evolution.

The evolution method was based on the traditional elite preserving method, realizing preserving optimal group. The advantage of this method was to reduce possibilities of optimal solution being destroyed by crossover or mutation in the process of evolution. Moreover, premature convergence was avoided which might be present in traditional elite preserving method because all individuals approached one or two individuals with high fitness values quickly. This was another novel place of improving the evolution strategy of genetic algorithm.

105.3.9 Algorithm Stopping Criteria

Two criteria were adopted to terminate algorithm:

(1) The number of generations was more than a preset value;
(2) The difference of fitness value between two successive evolutions was less than or equal to a given precision, namely to meet the condition:

$$|Fit_{\max} - Fit_{\min}| \leq \varepsilon \tag{105.10}$$

Here, $Fit_{\max}$ was the individual's maximum fitness value of a population; $Fit_{\min}$ was the individual's minimum fitness value of a population.

105.4 Experimental Data and Results

105.4.1 Experimental Data and Parameters

In the experiment, simulations of two examples were used to validate the correctness of the algorithm and to test the performance of the algorithm. The hardware environment in the experiment were Intel Pentium Dual-Core E2200@2.20 GHz, 2 GB RAM. The operating system was Microsoft Windows XP, compile environment was MATLAB 7.11.0 (R2010b).

105.4.2 Experimental Results and Analysis

In the below table, the interval lower bound was *a*, the interval upper bound was *b*, the precision was *c* digits after decimal point, the population size was *m*, the maximum evolution generation was *T*.

Example 1:

$$\min f_1(x) = \sum_{i=1}^{n} x_i^2 \tag{105.11}$$

$f_1(x)$ was a continuous, convex, single peak function. It was an unconstrained optimization problem. Only one global minimum in the 0, the minimum was 0. We selected n = 2, n = 5, n = 10 in the simulation experiment to verify the correctness of Improved Evolutionary Strategy Genetic Algorithm (IESGA). 100 times were executed for $f_1(x)$ with crossover probability 0.75, mutation probability 0.05, the end precision 0. All runs converged to the optimal solution. Parameter settings and calculation results were shown in Table 105.1:

Observing the optimization results in Table 105.1, Improved Evolutionary Strategy Genetic Algorithm had faster computing speed and higher accuracy, and could robustly convergence to global optimal solution. With the increment of the number of decision variables, the number of generation to obtain the optimal solution for the first time also increased. This accorded with the objective law, and was also correct.

Example 2:

$$\begin{aligned} & max f_2(x) = -2x_1^2 + 2x_1x_2 - 2x_2^2 + 4x_1 + 6x_2 \\ & s.t.\, 2x_1^2 - 2x_2 \le 0 \\ & x_1 + 5x_2 \le 5 \\ & x_{1,}x_2 \ge 0 \end{aligned} \tag{105.12}$$

The objective function $f_2(x)$ was a quadratic, polynomial function. Under the conditions of inequality, linear and nonlinear constraints, the theoretical optimal value $f_2(0.658,\ 0.868) = 6.613$. In the simulation experiment, the crossover probability was 0.75, mutation probability was 0.05, the end of precision was 0, the maximum number of evolution generation was 70, 100 times were executed for $f_2(x)$, and all converged to the optimal solution. The comparison of simulation results which used methods of Feasible Direction (FD), Penalty Function (PF) (Tang and Wang 1997) and Improved Evolutionary Strategy Genetic Algorithm (IESGA) was shown in Table 105.2.

Observing the optimization results in Table 105.2, the result of using Improved Evolutionary Strategy Genetic Algorithms was better than the two others, and the optimal solution got the theoretical value. This showed that using Improved Evolutionary Strategy Genetic Algorithms to optimize constrained nonlinear programming was correct and effective and it was a reliable and efficient global optimization algorithm.

Table 105.1 Parameter settings and calculation results

$f_1(x)$	a	b	c	m	T	Number of generation to obtain the optimal solution for the first time	Variable values	Optimal solution
$n = 2$	−5.12	5.12	6	80	100	45	(0, 0)	0
$n = 5$	−5.12	5.12	6	80	200	145	(0, 0, 0, 0, 0)	0
$n = 10$	−5.12	5.12	6	80	500	350	(−0.000023, 0, −0.000030, 0, 0, 0, −0.000396, −0.000396, 0, 0.000010)	0

Table 105.2 The comparison of simulation results Of FD, PF and IESGA

$f_2(x)$	x_1	x_2	Optimal solution
FD	0.630	0.874	6.544
PF	0.645	0.869	6.566
IESGA	0.658872	0.868225	6.613083

105.5 Conclusions

(1) The Improved Evolutionary Strategy Genetic Algorithm preserves the optimal groups based on the traditional elite preservation method. The advantage of this method is that it reduces the possibility of optimal solutions being destroyed by crossovers or mutations in the process of evolution. Premature convergence, which may be present in the traditional elite preservation method, is avoided because all individuals quickly converge to one or two individuals with high fitness values.

(2) The correction operator breaks the traditional idea and avoids some problems such as low searching efficiency by refusing infeasible solutions, early convergence by introducing a punishment factor and deviation from the constraint area considerably after mutation operation.

(3) The combination of the improved evolutionary strategy and the method of correction operator can effectively solve many nonlinear programming problems, greatly improve solution quality and convergence speed, realize the linear search method of moving infeasible individuals towards feasible individuals, and effectively guide infeasible individuals.

The disposal of infeasible individuals by the correction operator is simple and effective. It is proved to be an effective, reliable, and convenient method.

Acknowledgments Natural Science Foundation of China (31071331)

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Chapter 106
Simulation and Optimization of a Kind of Manufacturing and Packing Processes

Chun-you Li

Abstract There are many factors that influence each other in production-packaging processes. Resources, objects, processes and their properties and behaviors can be simulated to construct a computer simulation model across the whole production-packing process. Usually, the minimized cost, maximized profit or reasonable utilization was targeted as the decision objective, and concerned parameters was configured as conditions in the simulation model. With enough repeated runs, the optimization module can seek the best equipment combination and the best production schedule.

Keywords Manufacturing and packing · Simulation · Optimization

106.1 Introduction

In some industries such as food and tobacco industry, the terminal product is generally made from the production line and packaged into small boxes or small bags. The basic process is to produce these products through one or more production lines, and delivery or transfer products to packaging. Finally, the small-packaging products are filled into a larger container through one or more packaging equipments continuously or partially and gotten out the lines. Figure 106.1 is the schematic diagram of such production and packaging process, two manufacturing lines produce the same kind of products, then transfer them to three

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E. Qi et al. (eds.), *The 19th International Conference on Industrial Engineering and Engineering Management*, DOI: 10.1007/978-3-642-38391-5_106,

coordinate packing lines through a series of buffer vessels, finally package them into finished goods.

In cases such as designing and recreating a new packaging process or managing an existing process, we often have to face the following questions as: how to reduce process failure? How to reduce the processing cycle time? How much is the reasonable buffer capacity and the buffer stock? How to deal with the change of production scale? And is it necessary to add more and higher ability production lines, packaging lines and container?

To simplify the analysis, we can do analysis and make decision with single process and single factor. For example, the expansion of the production and logistics ability can be determined with the output of production or both speeds. But the whole process is complex and the relationship between processes is uncertain. Additionally, there are various factors influencing mutually in processes and these factors always interact dynamically along with time and events. Once a suggestion was put forward or a measure was imposed, it may be hard to predict the ultimate effect brought by the changes, so it is very difficult to determine the exact priority order of the measures. For example, in order to maintain the reliability and the inventory balance across processes, designers can use greater inventory to deal with the less reliability of equipments. On the contrary, by improving the reliability of the upstream through equipment, he can reduce the storage in the processes. Both measures can ensure to meet the needs of the downstream material and ensure that production runs smoothly. Even if the relationship among production, package or buffer process is certain, there are still many factors interact each other. For example it is difficult to evaluate the influence degree of the mutual isolated factors on the production scheduling, as well as the control of the operation sequence and rhythm, the product quantity, structure of the production, or the characteristics of products and so on. These factors may affect production speed, lead to the failure or production conversion. In addition, due to manufacturing and packing may be arranged in different positions apart from each other, and the difference of scheduling method and the enterprise culture

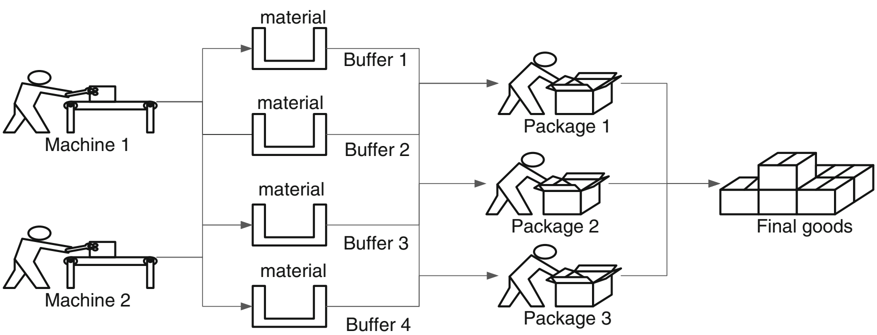


Fig. 106.1 The schema of production and packaging process

require different rhythms of production, the complexity to solve the problems will also be increased.

There is a variety of decision tools and the experimental methods to deal with in this kind of problems that schedule manufacturing and packing with multifactor. This paper presents a simulation method that simulates the process and interacting factors. It analyses and evaluates the problems and forecast the effect of the decision that have been designed or improved. It provides a tool to test design idea or improvement effect by developing a manufacturing-packing simulation model. Just as simulation driving-cabin can help the driver to learn driving in the best way and to build a good habit, a manufacture and packaging simulation model can be used to test and optimize the manufacture and package (Wang et al. 2002).

106.2 Modeling and Simulating Generally

The tool that is used to simulate and solve the problem is the simulation model, or called simulator. Specific simulation model is based on the research goal concerning with the problem to solve. This paper involves a factory to build a new manufacture and packing system. Preliminary design assume there were two production lines in the factory and each production line can produce any kind of the basic specifications. There were three packaging lines to pack the products into kinds of size and the shape of the containers with different labels. There were many parallel buffer tanks between production lines and packing lines which can receive products from any production line, then put the products to any packing line. The production lines and the buffer tanks should be cleaned before transform the line for new products.

The simulation model is developed to solve the following problems: Can the new equipments match the new production combination and schedule? What kind of scheduling strategy will make best operation of new equipment? How many buffer tanks will be need and what is the reasonable specification of buffer tanks? How is the effect of improvement of manufacture and packaging reliability? What influence will the production cycle time brings? Are more packaging lines or production lines needed?

The model is implemented in the *ExtendSim* that is a simulation platform developed and published by *Imagine That*. It is a set of software that contains simulation libraries and tools. It is used to simulate discrete event, continuous process and discrete process based on rate. The continuous flow stands for large-amount or high-speed flow, this software includes controls and schedule parts used for modeling process, and layered structure templates used to represent a higher level (Krahl 2010, 2011).

Figure 106.2 is the general simulation model that shows the two production lines, four buffer tanks and three packing lines. The actual parts of the model are included in a level module. You can double-click any region of higher level modules image to open lower level modules. The timetable, equipment performance, fault characteristics, the

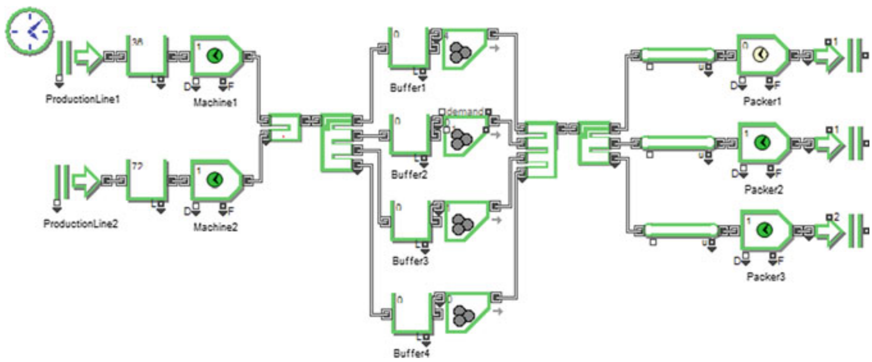


Fig. 106.2 The simulation model of manufacture and packaging

conversion rate and other data are included in a built-in a database table of the model and could be visited through a logical scheduling structure.

In this case, the model manufactures and packs products by running manufacturing machines and packing equipments under the control of a logic scheduler. The scheduler controls the simulation by an order table that lists products and the amount. The utilization ratio of equipment was set by the logical scheduler and we can use the logical scheduler to instruct equipment for conversion when it is necessary. The report submitted by the operation model is like the actual business report. The researcher can check out these subject reports, and points out the existing problems.

The simulator is widely used for helping the project team of the factory, to make sure the number and configuration of the new manufacturing lines, packaging lines and buffer tanks. A few test schedules are developed to represent production requirements in the typical situation and in the extreme cases. These models are based on the existing factory model and a series of packing line designs that are recommended.

106.3 Simulating Objects, Attributes and Activities

106.3.1 Creation and Transformation of Objects

When the simulation model operates, the simulation clock keep recording the running time increasing with simulation steps. Productions and packaging steps are not predefined with a table, but caused by events. In this model, items as objects are produced by a *Create* module, and the production rate of the item is decided by "interval time of two items". The interval can be represented by species and parameters of designated random distribution that depicts the item production condition of the making line. For example, the interval in this case is described with an exponential distribution. The mean value for one conduction line is 0.2 and another is 0.4. Both location values are all zero. Production characteristic of the two production lines is depicted with different values of the parameter (Hu and Xu 2009).

The manufacture or the packaging process could change the measurement unit. For example, five small items of product form a larger one after packing. It can be simulated with a merger module named *Batch*, it allows multiple sources of objects merged into one thing. It will be of great help in coordinating different machines to assembling or fusing different parts. In the module dialog box, we can set the number of each input objects to produce an output objects, as well as objects from other input are not allowed to put into this module if some input objects are not arrive or quantity is not enough.

106.3.2 Production and Packaging

We can simply use a process with time parameters to simulate the manufacturing or packaging. The most important activity module of *ExtendSim* is *Activity*. Its basic parameter is *Delay* that is the processing time of the activity module. In addition, it can also define and deal with several items at the same time. In the module dialog box, the processing time can be designated as a *fixed value*, or *input from the D(Demand)* port of the module, or *fromattribute value* of another module, as well as *from an inquiring form*. The last three ways can realize more plenty and slightly modeling for processes. In this case, the initial processing time of two host machines was set constants, more detailed time table can be set up in the subsequent according to the specific situation of the machine.

In order to coordinate the input and manufacture or packaging, a *Queue* module is needed between input and the activity as a buffer. *Queue* module will store items and wait to release them to next module based on the rules predetermined. In the module dialog box we can select or set queuing rules such as *resource pool queuing, according to attribute value, FIFO(first in first out), LIFO(last in first out), priority*, etc. With rule *Resource pool queuing*, the resource will be caught from the resource pool module where the resource number is limited. A *queue* based *on the attribute value* will sort items by an optional attribute. *FIFO* queue is the most common queuing way; *LIFO* is a kind of reverse queuing, also known as *stack*, which means the latest item into the stack will leave first; under *Priority queuing way*, the module uses the Priority attributes to determine the releasing order of item (Fig. 106.3).

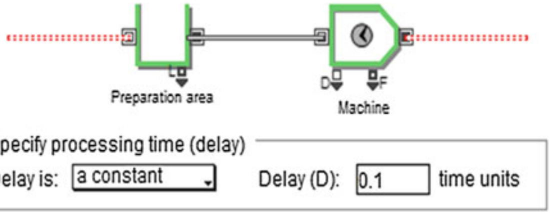


Fig. 106.3 Production process model

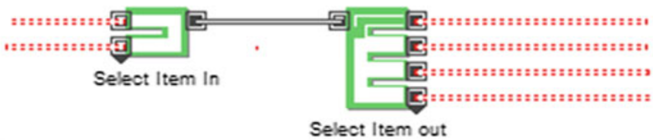
106.3.3 Inventory and Buffer Tank

There exist differences of space distance and rate between the Processing and packing process. In practice, it often use the way of setting up stock in factory or production inventory to coordinate the contradiction. The specific physical form of this inventory may be a universal warehouse, some cargo space or buffer tanks exist between the processing and packing line. In this case we assume the way of buffer tank. A buffer tank store the same kind of products only, but receive the products from different production lines, it can also release to any packing line for packaging.

We still use *Queue* module to realize the simulation of buffer tank. But since there are multiple buffer tanks, the model needs to choose the reasonable buffer tank to store the products from the end of production lines. And because there are more than one packaging lines, the model should also do a reasonable choice when the buffer tanks release products so as to put the products into the free packing line. We can use two kinds of module like *Select Item In* and *Select Item Out* to realize the simulation of the product routing. A *Select Item In* module receives items from more input branches and release items out through its only output port. A *Select Item out* module receives items from its only input port and release items by choosing one of export branches. The selections in the dialog box include based on priority, random selection, sequential selection or based on Select port selection. In this case, between production line and buffer tank, and firstly establish a *Select Item In* with two inputs branches, output randomly to *Select Item out* with four branches, completing the routing of bulk products from the buffer tank to the packing line. Between the buffer tanks and packing lines, establish a *Select Item In* with four input branches, randomly output to a *Select Item out* with three output branches to realize the route from the buffer tank to the packaging line (Fig. 106.4).

106.3.4 About the Schedule

The simulation model is driven to operate and interact by a schedule, just like an opera showing step by step with a script written by the editor. The model can be



	From block	Probabili	Throughput
1	Machine1[2]	0.5	20
2	Machine2[19	0.5	20

	To Block	Probability	Throughput
1	Buffer1[25]	0.2	14
2	Buffer2[24]	0.3	10
3	Buffer3[15]	0.3	11
4	Buffer4[10]	0.2	5

Fig. 106.4 Routing of production lines to buffers

used to evaluate potential of a specific schedule in real-world, or compare one schedule against another, on the basis of how well schedules perform in the model. We can discover which schedule is the best by testing with the different schedules, as well as what kind of scheduling generating rules is the best. Since for each schedule, the model will show real-world operation results such as production, utilization, and down time (Pinedo 2002).

A simulation model of using schedule should be able to introduce a sequence of operations that was created by embedded data table or database, or use an external table or external database to manipulate the schedule. There is a built-in module in some simulation model, for setting scheduling method, rapidly and flexibly to generate the typical schedule or the experimental schedule. It can be based on demand conditions, or on the actual demand schedule. These scheduling modules can calculate some certain evaluation measures, also can put the execution of the schedule to the simulation model to get a complete operation results by capturing the dynamic situation of real world. That is generating any sure schedule for the whole simulation scope, or producing internal schedule obey to the model commands and the set time or conditions in advance in the entire operation (Pinedo and Chao 1999). It can be showed in the model what is the demand degree, as well as the state of all products in the whole time range.

106.4 To Evaluate and Optimize Processes

106.4.1 Evaluation Indexes

The simulation model is used to analysis the manufacturing and packaging system and the problems are to be solved. Some models involve manufacturing operation only or involve packaging operation only, and the other involves both. Normally, it is based on problems which will be solved to determine the corresponding evaluation index such as the equipment utilization, the processing cost and the queue length (Jiang et al. 2009).

Utilization. Utilization is the ratio of the working time and all running time of the equipment. Low utilization means that the resources have not been made fully use, but high utilization rate is sometimes not a good thing because it means ability tension. Once the equipment runs failure, inevitably leads to the production halt and extend the production cycle, which leads to the failure of the production scheduling (Dessouky et al. 1994).

$$\mathrm{Ult} = \frac{\sum_{i=1}^{n} t_i}{T} \tag{106.1}$$

Ult equipment utilization

T_i the processing time of product number i

i ID of products
T running time of the equipment.

Cost. Any manufacturing and packaging process must spend some resource and its cost is a key management tool. An *activity* module has cost parameters in the dialog box that can simulate the cost of the process. We can set the cost information in the cost page in the dialog box. According to the character of cost, we can set two kinds of cost, fixed cost and time cost. Fixed cost is the cost that happens when deal with every product, its value is a constant, unrelated with the delay of products. The time cost is relevant with the processing time, it equals to the multiplication of the cost per unit time and the operation time (Harrell 1993). The module will automatically calculate its cumulative cost and display on the plot.

$$\text{Total Cost} = \sum_{i=1}^{n} t_i \cdot C_{pertimeunit} + q_i \cdot C_{peritem} \tag{106.2}$$

Total Cost total processing cost
$C_{pertimeunit}$ unit time processing cost
$C_{peritem}$ fixed cost of every processing a product
q_i total products exited from the module.

106.4.2 Optimization

The simulated optimization, also named goal seeking, is seeking the optimal answer to the question automatically, or the optimal value of parameters. In parameter range given in the model, we can run the model repeatedly to search the solution space and find out the best parameter-values that satisfy the conditions as well as reach the decision target. In the optimization model including an *Optimizer* module, the issue is usually presented as a target function or a cost-profit equation. In order to realize the cost minimization or the profit maximization, the *ExtendSim* simulation models help researchers not only find the best solution automatically but also put out of the long boring process that repeated trying different parameter-values (Wang et al. 2009).

The running conditions can be changed in the optimization model. For example, we can set the value range, value method and constraint conditions of parameters by limiting value scope of decision-making or defining constraints equations. We can also affect the solving precision by the setting run parameters, such as deciding the total sample cases, the search times of each case, when to check convergence, and optimal number of member cases in the convergence (Zhang and Liu 2010). *Optimizer* does not have the function of refusing faults, so any *Optimizer* maybe converges to the second best solution not the first best solution, especially when its running time is not long enough. So we should consider to run more times and get enough operation results, and ensure getting the same convergence to close to the optimal solution before using the best solution for actual application.

106.5 Conclusion

The simulation is a good tool to study the problems of manufacture and packaging operation. It is because of multiple factors interact through a variety of means. A simulation model can provide more real ways to improve decision effect than other research models. In fact, a simulation model is just like a virtual factory to test the new design idea, or assessment recommended projects. The simulation model discussed in this paper is designed in the *ExtendSim* condition. It can be used to optimize the process of manufacture, package and logistics in the factory.

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Chapter 107
Equilibrium and Optimization to the Unequal Game of Capital-Labor Interest

Ming-liang Wang and Yu Lu

Abstract Imbalance of labor-capitals' interests is the inevitable result of both employers and employees unequal game. Labor for the respect of the existing distribution system just because they have no better choice. The key to reverse the imbalance in the distribution of labor interests is to strengthen labor game ability. Formation of autonomous trade unions will increase the labor collective game capabilities, and specific training will help to expand the labor game resources to enhance the ability of the individual game; a sound social security system will help to ease the worries of the failure of labor negotiations, thus improve the labor's tolerance to the time costs for labor-capital consultation, strengthen the credibility of labor "threat". Meanwhile, the sound signal-transformation mechanism is helpful to build the reputation of incentives to stimulate corporate social responsibility.

Keywords Imbalance of labor-capitals' interests · Unequal game · Signal-transformation mechanism · Multi-dimensional network coordination mechanism

107.1 A Labor-Capital Relation is a Unequal Game with "Strong Capital and Weak Labor"

At this stage, the distribution of labor-capital benefits is severely uneven. According to preliminary estimates, China's Gini coefficient has been over 0.5. How to adjust the distribution to prevent polarization and share the results of the reform has become a hot topic of the current social. Generally speaking, the domestic academic interpretation of reason to the imbalance are mainly the following: First, that China's current economic and population structure led to the imbalance of the interests, which was exacerbated by the economic globalization;

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E. Qi et al. (eds.), *The 19th International Conference on Industrial Engineering and Engineering Management*, DOI: 10.1007/978-3-642-38391-5_107,

second is that China's trade unions and other legal deficiencies in the system resulted in imbalance; the third is that it mainly due to government, whose over-emphasis on the investment environment caused damage to the workers' interest; the last one is that the imbalance stems from the differences between employers and employees capacity to safeguard the rights (Qi 2008).

According to game theory, in market economy conditions, the distribution to the labor-capitals' benefits depends on both employers and employees' game power, and Imbalance of labor-capitals' interests is the inevitable result of the unequal game. In theory, under the existing conditions, the decisive factors to the game power include the resources they have, the credibility of the threat, risk aversion and time preference (Jack 2009). "Strong Capital and weak labor" is an objective fact, which can be said is a worldwide phenomenon. This is determined by the system of market economy in the modern times. As the distribution subject, the corporate system, which dominated by the principle of "absolute ownership", is still dominated by the "shareholders center" Wang 2008). At the same time, from employers and employees' market attributes, the incompetence of the labor market and capital flows around the world further exacerbates the worldwide imbalance of labor game capacity (Zaheer 2003).

Based on the principle of freedom of contract in market economy, labor contract is seen as the one which employers and employees freely negotiate and deal with their respective interests, the labor interests' distribution is also seen as the outcome of the game, which can be a one-time or repeated several times. Macroscopically speaking, existence of market economy depends on the minimum cooperation of employers and employees and thus, the labor relations in the market economy is a long-term competition and cooperation, a bargaining relationship on the distribution of benefits; but from the micro level, the specific employment relationship may be a non-cooperative relationship at random. Reflected in the labor contract, short-term labor contract (or one-time labor contract) means that the one-off game, or non-cooperative relationship between employers and employees; long-term contract (or non-fixed term labor contract) means repeated game, or competition and cooperation between the two parties. Employers and employees concern about the overall benefits in the Long-term labor contracts, and thus there is the possibility to adjust their game strategy, and it can inhibit the "short-sighted behavior" of the game subject to a certain extent. When the interests of labor-management cooperation and win–win cooperation is over the inputs (such as special human capital investment), labor-management cooperation will become the norm.

In addition to the above factors, the general industrial labor supply far exceeds the market demand in our country, which determines the congenital weakness of labor in the game. Meanwhile, low labor skills, absence of the autonomic trade union and the deletion of methods such as "strike" and "threat", as well as defection of unemployment insurance, all compress the game strategy space of the labor, and reduce labor tolerance to time cost required for labor-capital consultation and the credibility of the means. Thus, relative to other developed countries, labor game of power even more unbalanced in China. Determined by the stage of economic development, homogenous competition among cooperation is intense (e.g., the price competition), enterprises lack the power and capacity to improve labor rights, and labor rights lack protection. Therefore, our labor respect a serious injustice distribution system, not because they endorse, nor is a Pareto improvement, but simply because they have no better choice. It is inevitable to adjust the pattern of labor game and strengthen the ability of labor game in order to pursue better social justice, optimize the allocation pattern, avoid the deterioration of labor relations and achieve the stable development of the market economy.

It must be clear that emphasizing the balance of labor interests is not said to fundamentally reinvent the wheel, but is the proper adjustment of distribution of labor benefits under the socialist market economy. In essence, it is appropriate optimization to the game framework with "strong capital and weak labor" to achieve sustainable economic development and create a harmonious social environment.

107.2 Balance of the Capital-Labor Interests in the Unequal Game

The unfair distribution of labor interests is from unequal game power. It is significant to explore the theory to realize balance in the unequal game. Assume that Player A and Player B are on behalf of employers and labor, the game strategy combination as the following table, then, we can make the following analysis on strategy equilibrium of the game.

Player A (capital\employer)	Player B (labor\employee)	
	L	*R*
L	$\Delta_{A,}\ \Delta_B$	$x,\ x + \varepsilon_B$
R	$x + \varepsilon_A,\ x$	$\Delta_{A,}\ \Delta_B$

In this model, if $\Delta_{A,\ B} < x$, then, there will be two equilibrium results, namely *(R, L)* and *(L, R*). Δ value indicates the payment which the perpetrator will get when he fails to reach an equilibrium outcome, or failure value. $\varepsilon_{A,\ B} > 0$, ε is said as the advantages of distribution of behavior.

If $\Delta_A = \Delta_B$, failure values are equal, that means it is a peer-to-peer game. If $\Delta_A > \Delta_B$, or $\Delta_B > \Delta_A$, that means an unequal conditions. In such repeated games with incomplete information

A 's probability (employer) to select R is: $(x + \varepsilon_B - \Delta_B)/(2x + \varepsilon_B - 2\Delta_B)$;

probability to select L is: $(x - \Delta_B)/(2x + \varepsilon_B - 2\Delta_B)$.

Accordingly, B (Labour) probability:

If, $p = (x + \varepsilon_B - \Delta_B)/(2x + \varepsilon_B - 2\Delta_B)$, then B (Labour) have no preference between *L* and *R*.

If, $p > (x + \varepsilon_B - \Delta_B)/(2x + \varepsilon_B - 2\Delta_B)$, then B (Labour) will be preferred to select *L,* and receive less income *x*. *p* is the subjective probability of protocol between the weak B (Labour) and the strong A (employers).

Further it can be deduced:

$\partial p/\partial \Delta_B = \varepsilon_B/(2x + \varepsilon_B - 2\Delta_B)^2$

The significance of the equation is that starting point value also increases with the increase of the failure value. This means that with the decline of the failure value of perpetrator, proportion of strong man whose preference for strategy *L* also falls. This suggests that the weak labor prefer to adopt the strategy of *L* while strong employers are more likely to adopt strategies *R* in the game with strong capital and weak labor.

Tolerance to the time costs and the credibility of a threat to stop negotiation may also affect the game subject's choice. To measure time preference by *d*, if *d* is greater than $x/(x + \varepsilon_B)$, the weaker B (labor) will choose *L* in the bargaining model. The second is the "threat". Credibility of the strong A (employers) will be greater than that of the weak B (Labour) In the unequal bargaining. If the strong A (employers) impose penalties C on the weak B (Labour), which will change the income of the balance of (*L, R*) ($\Delta_B > x + \varepsilon_B - c$). In order to avoid further reduction in revenue, *L* will become the weak B (Labor)'s main strategy. As retaliation (such as resignation) is expensive, if there is no external remedies (such as unemployment insurance), it will be difficult for weak B (Labor)to implement retaliation strategy, and it will not be able to influence the choice of the strong A (employers) for the *R* .

The above analysis shows that even if the labor is not sure about the employer's strategy, when the labor knows he is the weak, he is more likely to accept the other conditions. The attitude of labor depends on the judgment in the strong position of capital, the higher probability he makes, the greater chance to yield. The weaker labor force is, the higher effective the employer's strategy is. A employer with more game recourses will be less dependent on labor consultation results, and more patient to bear the time cost which translates into consultations advantage for employer to influence the outcome of the game. In the game, the "threat" of employers is more credible than that of labor according to the different game resources, influencing weak labor choice and prompting labor more vulnerably to accept the conditions mentioned by the employer.

107.3 Allocation Mechanism of Labor Interests Based on Collective Bargaining

There is no doubt that labor relations in the market economy exists congenital defect of "strong capital weak labor". How to take appropriate measures to reverse unfavorable situation of the labor and coordinate capital-labor interests is the common problem faced by all market economy countries. The academic community discussed much and put forward a variety of theoretical models and policy recommendations, which can be summarized as the following:

The first is the new classical school. It abandons ethical factors in classical economics, emphasizing that the natural order of the market and economic exchange is the main way to resolve labor conflicts. It advocates mobilizing labor enthusiasm for production through the adoption of wages, bonuses and other incentives to realize capital-labor win–win situation. The second is the management school. It sees the limitations of "pure market" regulation and labor conflicts triggered and emphasizes the common development of both employers and employees on the basis of the same interests. The third is the new system school. It believes that capital-labor conflict of interest can be solved by constructing common interests and advocates establishment of a diversified economy and political system to ensure the bargaining right between employers and employees and independent trade unions to ensure the labor's interest and eliminate labor conflicts through institutionalized ways. The fourth is freedom of reform school. It advocates the establishment of strong trade unions, develop a strict legal to regulate labor relations. It also believes that the government should implement positive economic and social policies to restrict and change the recurrent negative impact on the market economy. The fifth is the new Marx school. It maintains that a system should be established so that the labor becomes the owner and manager to participate in corporate decision-making and profit-sharing (Zhao 2009). All the above make certain sense and to some extent, reflect the basic requirements of the labor relations adjustment under market economy conditions, and are adopted in some countries.

From the practice in the world, the adjustment models of labor relation are various and different. As a result of congenital defect, "strong capital and labor weak ", of the market economy, all countries have the same objective which is to strengthen the labor game ability, let the government and other social subjects play appropriate ole in coordination and prevent excessive imbalance. Among them, allocation mechanism of labor interests based on collective bargaining has become the mainstream to solve imbalance.

The unequal bargaining model shows that the hinge to decide the labor force are the game resources, time preference and the credibility of the "threat". Therefore, the key to optimize labor allocation pattern is to strengthen the game ability of labor and optimize labor game structure. Achieve above goals, the following steps should be taken. One is to enhance individual labor game ability. Theory and Western experience have shown that the level and specialization of labor skills connects closely with the game capacity."Asset specificity" decides comparative advantage of the parties (Oliver 2002). Therefore, strengthening school education, vocational training and work skills training is critical to enhance labor game capabilities. The second is the formation of the labor collective game force. Reform the existing trade union structure, strengthen the union representative, and actively build autonomous trade unions in the enterprises, progressively develop the industrial trade union to strengthen the capacity of the labor collective game, at the same time, improve labor "threat" power. Draw on Western experience and moderate trade unions power of "limited monopoly" and "orderly lay-off", improve the unemployment insurance and other social security measures to alleviate the worries of labor, and strengthen the credibility of the labor policy of the "threat" to enhance the labor tolerance to the time for the negotiation process. The third is to establish Dynamic Labor Standards, develop appropriate laws and regulations, timely adjust game expectation, form a new "focal point" of labor game to promote the labor interests of the coordination to a higher level.

With the rapid development of knowledge-based economy and globalization, "mass customization" has increasingly become multinational prevailing production. It strengthened the advantages of technological innovation of the developed countries and promoted the process of industrialization in developing countries; on the other hand, it formed the imbalanced value in the international industry division, reconstructed the international labor relations. For the reputation, the multinational companies launched the "Production Code" to constraint the foundry company's employment practices. The strategy which compete to the bottom among developing countries weakened the government's ability to coordinate labor interests and gave birth to various types of labor rights protection organizations (NGOs). At the same time, the relocation of production processes also led to domestic structural unemployment in developed countries. In order to ease domestic political pressure, the developed countries began to strengthen the global labor standards. All of these mean that labor relation is undergoing a fundamental change in the world (Wang 2011). Therefore, we must actively adjust the concept of social management and give full play to the community, smooth information disclosure channels, improve the delivery mechanism of the "signal", let concerning subjects play an active role, and effectively connect informal mechanisms such as labor game with legal and other formal mechanisms, to build multi-dimensional network coordination mechanism based on the labor collective bargaining (Aoki 2001).

In short, the imbalance of labor interests is an objective reality, and it is necessary to optimize t distribution of benefits. The importance and complexity of labor relations determines that the adjustment of labor interests needs all kinds of formal and informal mechanisms of coordination and cooperation. Strengthen the labor ability through various means and build the labor collective bargaining system and improve the labor game platform. Meanwhile, play government's role, make up market failures, mobilize all parties to build a multi-dimensional network coordination mechanism based on a labor collective bargaining and achieve capital-labor long-term cooperation and win–win.

Acknowledgments Fund Project: The article is the achievement of the humanities and social science planning project of the Ministry of education (project number:10YJAZH079), Natural Science Fund Project of Guangdong Province (project number: 10151009001000003), Guangzhou society and" eleven five" planning fund project (project number:10Y73).

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Chapter 108
Innovative and Entrepreneurship Education in Underdeveloped Western Regions of China

Chang-jiang Lu, Yan Feng and De-wen Chen

Abstract This paper makes an analysis on the major problems for innovative and entrepreneurship education (IEE) in underdeveloped western regions of China, and outlines a set of implications for local governments and universities. The authors suggest that a more practical and flexible cultivation system rooted in regional contexts should be established for bringing a radical change to the backward IEE in western China. It is important to implement the "4C" concepts in IEE, namely cross-culture, cross-region, cross-discipline and cross-specialty through strengthening international cooperation and mutual regional support, integrating the IEE into the university curriculum, and building a four-dimensional nexus via partnerships between universities, industries, governments and families. While the paper is written mainly from the perspective of underdeveloped western regions of China, the discussion allows for generalization, and thus should be applicable to the development of IEE in other nations facing similar problems.

Keywords Western China · Innovative and entrepreneurship education

108.1 Introduction

Along with the occupied population boom, China is entering a new economic transformation phase. The two words "innovation" and "entrepreneurship" (IE) are more closely combined than ever before and have become an important

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E. Qi et al. (eds.), *The 19th International Conference on Industrial Engineering and Engineering Management*, DOI: 10.1007/978-3-642-38391-5_108,

internal force for China's economic growth. Social development is in urgent need of innovative and entrepreneurial (IE) talents. With innovation and entrepreneurship education (IEE) in universities as its focus, cultivation of IE talents forged ahead by Chinese governments at various levels is in full swing across the country. Provinces throughout China have been making great efforts in developing IE talents cultivation modes fitted in regional contexts. The number of start-up businesses sees a continuous increase, yet most of the enterprises are not established on the basis of innovative concepts, knowledge, skills or innovations. Therefore, it has become a great concern for Chinese local governments, educators and researchers on how to produce more quality IE talents through integration of innovation and entrepreneurship.

108.2 What is Innovative and Entrepreneurship Education

Innovation, according to the 2004 Report "Innovate America" by the United States Council on Competitiveness, refers to turning ideas and technologies into new products, new processes and methods as well as new services that can create new market values drive economic growth and improve people's living standards. Entrepreneurship means one who undertakes innovations, finance and business acumen in an effort to transform innovations into economic goods. This may result in new organizations or may be part of revitalizing mature organizations in response to a perceived information, resource or opportunity. There is an obvious strong relationship of the two terms: first, they are not always with the same understanding, but in essence there is a considerable overlap between them in such aspects as denotations, functions, objectives and processes; second, innovation forms a significant part of the foundation for entrepreneurship, and entrepreneurship is the carrier and manifestation of innovation (Xie 2009). IEE, developed by western scholars in the 1980s, can be simply defined as an educational system aimed at cultivating IE talents through fostering their IE awareness, spirit, knowledge, competencies and skills.

108.3 Review on Innovative and Entrepreneurship Education in China and Abroad

IE Research and practice spreads across the world, though in varying degrees. In developing countries like the United States where entrepreneurship receives general recognition and concern, entrepreneurial enterprises contribute to 40 % of the value created by all enterprises and have created 75 % of the new job opportunities in that country.

Entrepreneurship in China, which started from the 1970s when China adopted the open-up policy, has gone through six stages in its development marked with four climax periods. Chinese governments at various levels have begun to build entrepreneurial cities since 2009, followed by national wide popularization of IEE.

Internationally, researches on entrepreneurship education (EE) began from the 1940s and witnesses fruitful results. In the past decade, western scholars carried out studies on EE centered on thirteen hotspots, such as EE adjustment and cultural interpenetration, business and management education, entrepreneurship management, business models and EE courses (Li 2007).

In China, there has been a remarkable improvement in EE research and practice since 2006. Some successful EE modes were formed to solve problems like ambiguous orientation, unsuccessful localization of western IEE concepts and modes, ineffective teaching and practice (Lu 2011). Chinese scholars from various disciplines began to show interest in IEE from the very beginning of the 21st century and expressed their views on IEE from different perspectives. In respect of performance evaluation, Professor Xie Zhiyuan employed an analytic hierarchy process in the qualitative research on the performance evaluation system for China's IEE (Xie and Liu 2010); Vesper's Seven Elevation Factors was introduced into the comprehensive evaluation on IEE in Chinese universities. These researches are important for us to learn about the development of IEE in China. However, it appears that most studies are introductions of western IEE concepts and experiences or generalized suggestions, and there is an obvious lack of studies on IEE in regional contexts, especially empirical studies, of more practical value.

108.4 Major Problems for Innovative and Entrepreneurship Education in Western China

It has always been a serious common problem for western China in developing IEE that very little progress could be made, though a large amount of manpower, materials, money and time have been devoted into it, and IEE research and practice are still on a superficial level where innovation has not been fully substantialized. To be specific, IEE in western China is confronted with big impediments in respect of resources, concepts as well as educational and supporting systems.

First, most of the western regions in China are undeveloped with relatively limited resources and educational funds. Local governments, as the policy maker and allocator of various social resources, are still clinging to conservative administrative concepts and beliefs, while subordinate departments, affected by such work style and attitude of their higher authorities will usually hold a wait-and-see attitude toward the polices for IEE. This has led to the current situation of IEE that policy making far outweighs implementation.

Second, economic structure, development level and entrepreneurship environment vary greatly in different regions. Conservative concepts from the society and families confront university graduates, who are the mainstay of potential entrepreneurs, with making a choice between getting employed and starting up a business. And the fact is that most graduates who choose to start up a business are "necessity entrepreneurs" rather than "entrepreneurial" ones.

Third, IEE in western China is still at its initial stage with many pressing problems crying out for solutions. Inside the university, there are not enough specialized teachers, especially teachers with entrepreneurial experiences; students, because of little access to IEE, lack in entrepreneurial awareness, knowledge and experiences, which will lead to low entrepreneurial competencies. Outside the university, ineffective encouragement and supporting systems fail to promote a robust entrepreneurial culture and strong motivation for IEE development.

Therefore, not many successful startup-businesses are seen so far in western China, though local governments have adopted many encouragement and preferential policies to promote entrepreneurship, and some governments even set up special funds for financial support.

108.5 Implications for Developing Innovative and Entrepreneurship Education in Western China

Local governments and universities play a very important role in making a radical change to the backward IEE in western China. Local governments, as the policy maker and allocator of resources, should be more IEE-supportive and promote effective utilization of intellectual, manpower, financial and material resources. Universities, as the main implementer of IEE, is responsible for achieving substantial progress in IEE by integrating mass education with elite education on the basis of introducing advanced international IEE concepts. On one hand, they should popularize basic IE knowledge among all students, guide students to internalize IE concepts and develop IE competencies. On the other hand, intensive education should be accessible to students with entrepreneurship mindset, aptitude and potentials. We hereby would like to outline some preliminary policy and educational implications for governments and academics on establishing IEE cultivation mode rooted into the regional contexts in western China.

108.5.1 Develop Students-Oriented IEE Concepts

Concept determines how we act, so it is a must that universities should break away from the conservative concept which prevents people from risk-taking, which is one of the main causes for the slow development of IEE in western regions. IEE, in essence, is quality-oriented education which targets at the all-round development of people. Thus, great efforts should be made by local universities in the following aspects for promoting sound development of IEE in Western China.

First, enhance the exchanges and communication between universities, teachers and students for achieving a common understanding that the students are wrongly positioned in the education system and the current situation must be changed from "university-and-teachers-orientated" to "students-oriented", and think about what they can do for students with entrepreneurship intensions.

Second, integrate IEE into the university curriculum and promote innovative campus culture. A more open learning environment needs to be created which entails a flexible IEE practice system and a corresponding diversified evaluation system. Innovative concepts should be deeply integrated into each step of the educational process of each discipline. In this way, IE will become an internal need for students themselves.

Third, based on the intervention-process education concept, create a non-boundary "macro-learning" environment that integrates the outside society and jobs with classroom teaching and learning, and provide students with more opportunities for IE practice to facilitate the internalization and reinforcement of their IE awareness, knowledge and competencies, and thus, vigorous engagement in IE practice.

Forth, encouragement and support from families and education by the university are two of the most influential factors for students' entrepreneurship intentions (Wu and Zhang 2008), according to the findings of empirical studies. The implication is that universities should also strengthen their connection and communication with the students' families to achieve their recognition on IE and support for the students' entrepreneurship intentions and actions.

108.5.2 Integrate and Optimize Various Resources to Open New Channels for Cultivating IE Talents

To realize the effective integration and optimization of limited resources is of crucial importance for IEE development in western regions. Solving this problem needs joints efforts from governments and universities.

On one hand, universities should take advantage of opportunities brought by internationalization of education and preferential policies made by governments to achieve the following goals. First, based on the cross-disciplinary attributes of IEE, employ the 4C cultivation concepts, namely cross-culture, cross-region, cross-discipline and cross-specialty throughout the IEE process. Second, enhance international cooperation and regional mutual support. Third, improve the cultivation mode via promoting integration of disciplines and specialties to improve students' knowledge structure, upgrade their concepts and beliefs and develop their competencies.

On the other hand, a supporting system of government-led four-dimensional nexus which involves partnerships between universities, industries, governments and students' families need to be established for universities to adopt a more flexible credit system for IE courses and practice which allow teachers and students to work or study in governments or enterprises. And government officials and entrepreneurs should be absorbed into the university teaching faculties, which is a key to the problem of lacking in specialized teachers with entrepreneurial experiences. Only in this way can we realized the integration and optimization of limited resources from various regions, industries and fields.

108.5.3 Integrate IEE into the Whole Education System to Benefit People from all Walks of Life with Entrepreneurship Intensions

A research team from the Experimental Zone for the Reform Pilot Project to Cultivate Interdisciplinary Entrepreneurial Talents in China-ASEAN Free Trade Zone conducted survey on the current situation of IEE in underdeveloped western regions of China in 2010. One of the focuses of the survey is to learn about university students' self-evaluation on IE. According to its empirical analysis, students think themselves of medium level in terms of the first-level entrepreneurship indicators which consist of awareness, psychological qualities, knowledge and competencies. For most of the students, entrepreneurial knowledge is lower than the other three indicators and is considered of greater need for university students with entrepreneurship intentions. Among the 28 second-level indicators, professional abilities, innovative abilities, learning abilities and foreign language communicative abilities are considered most important. Result of the survey is recognition on the necessity and feasibility of popularizing IEE in universities in western China. Yet, IEE is a continuous and dynamic life-long process and should be integrated into the whole education system. Universities, while popularizing IEE among students throughout their university study on a basis of the process-oriented education concept, which will help students to lay a solid foundation for future business-startup, should also provide opportunities for graduates and people from all walks of life with entrepreneurship intensions to get access to IEE via continuing education or in more flexible ways, such as distance training programs, lectures, and the like. This during-and-after-university mode of IEE sees better IE prospects. So we maintain that university students do not need to make a choice between getting employed and starting up a business upon graduation. The choice should be made when everything is ready.

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Chapter 109
Network-Based Optimal Design for International Shipping System

Er-shi Qi, Lian-yu Zhu and Meng-wei Yu

Abstract Lean concept and lean thinking are means of expressions for industrial engineering reflect in different countries, enterprises and environment. Cost management in international shipping system is an application of system optimization used lean management theory and method. After optimization, lean cost management can be realized.

Keywords Cost · Lean · Network · Optimization · Shipping

109.1 Introduction

Based on analysis of plenty of literatures and summaries, so far related research usually adopt one time, single phased, static decision making using minimized vessel amount and transportation cost, major in transporting a certain kind of cargo, specific quantity, constant port of call, fixed freight and a clearly transportation period. There are rare strictly route integrated optimization model for tramp transportation, same as balance in multi phased transportation and scheduling suitable tonnage in existing research. The inevitable trend of the future research is to establish a series of decision supporting systems including route optimization, marketing, ship management, safety management, cost management, performance appraisal, business pattern and fleet development (Lu 2008; Liu 2010).

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E. Qi et al. (eds.), *The 19th International Conference on Industrial Engineering and Engineering Management*, DOI: 10.1007/978-3-642-38391-5_109,

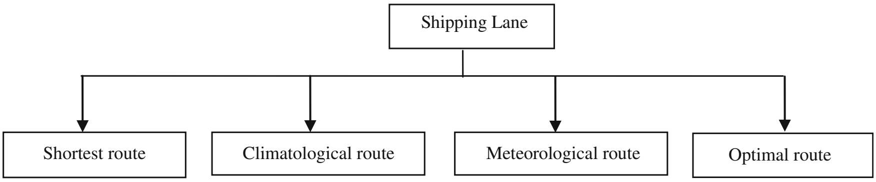
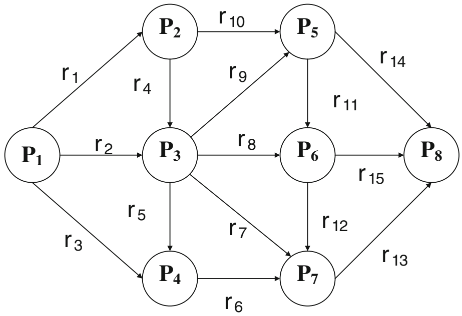


Chart 109.1 Shipping lane-2 (Zhang 2011)

Chart 109.2 Optimization of shipping lane



At present, China is continuously exploring in lean management theory, related theory and method still imperfect. Improve work efficiency, reduce management cost and waste by introducing and exploring advanced lean theory will dramatically affect survival and development of the industry (Yang 2010; Liang 2010).

In international shipping system, it usually involves complicated network system, and lean cost in management of international shipping is the goal which enterprise pursue. An optimal sailing route is the key in shipping system. Optimal sailing route is usually defined as, with respect to the navigation safety, the route which has shortest transit time and best economic benefit. Optimal sailing route infinitely close to the ideal condition will bring higher economic benefit that has an important practical significance especially for long distance ocean transportation (Guo 2008; Hu and Wang 2011; Zhao and Xiao 2009).

109.2 Methodology

Marine cargo transportation is very important in international shipping. The profit point lies in the lean cost management. There are many factors which affect the cost, for example ship's tonnage, stowage, port of call and order, optimal shipping lane etc. Shipping lane is most important one. There are many factors which affect the shipping lane for instance meteorological condition, sea condition, barrier, location, ship's condition and practice course. Meteorological condition is relatively obvious among the above including monsoon, depression, sea mist, drift ice

Table 109.1 Shipping lane-1 (Huang 2007)

Shipping lane	Philosophy of measurement
The rhumb line	When sailing in low latitudes, near north and south or in short voyage, the rhumb line is very close to the shortest route.
Great circle sailing line	Great circle sailing line is an aggregation of plenty of rhumb line.
Parallel sailing line	Define as sailing follow a same latitude circles, it is an exception of the rhumb line.
Composite sailing line	The shortest route under limited latitudes, it is a combination of great circle sailing line and parallel sailing line.

and iceberg. Sea condition such as ocean circulation, swell. Ship's conditions comprise vessel age, draft, speed, tonnage, stowage and ship's crew.

Voyage cost, usually refers to cost of unit time in navigation (*Pa*) multiplied by the transit time (*Ta*) plus the sum of cost of unit time in port when loading/ discharging (*Pp*) multiplied by the time in port (*Tp*).

Computational formula:

$$P = \sum (Pa \times Ta \oplus Pp \times Tp) \tag{109.1}$$

The semi-submersible vessel operated by Group K is a typical representative of ocean transportation, this cross ocean transportation we call it shipping lane. Far off coast, sailing route is regularly long and easily affected by meteorological condition is the outstanding features of shipping lane. During transit, it is hard to avoid severe sea condition. Especially during transit in unfamiliar regions, ship's crew can only rely on the bridge documentation. In particular, region vessel needs to apply to sail with convoy in order to avoid being exposed under the risk of piracy attack and transit time and route will be restricted.

The Table 109.1 lists four basic shipping lanes (Liu 1992).

Considering hydrological and meteorological conditions.

109.3 Results

Based on lean theory, assume workflow and continuity of the workflow as object, research on how to ensure the continuity of the workflow, reduce waste in workflow in uncertain period condition synthetically applied Cycle Operation Network (CYCLONE), Genetic Algorithm (GA), 4D-CAD, Line of balance (LOB), Theory of Constraints (TOC), Extensible Markup Language (XML), and established workflow integrated management method, and realize project work-flow lean management. Workflow integrated management consists of following three modules: simulation module, optimization module, visual module.

There are plenty of optimization models in shipping system based on different view points. For example queuing system targeting in maximizing the benefit of the vessel or make it most economical in certain index requirement. In general condition, improving service level both in quantity and quality will reduce the wait expenses of shipper and increase the cost of service supplier, hence the optimal condition is to minimize the total amount of two expenses, take both shipper's and ship owner's interest into consideration, optimize fleet size, and minimize costs and expenses. In steady state circumstance, all kinds of cost and expenses are calculated on time basis, Z represents the sum costs in unit time, which is the optimization of the accumulated cost.

Shortest route is a sticking point when choosing sailing route. Moore-Dijkstra algorithm is widely used in shortest route design and optimization. It is a kind of tagging method, the basic ideas starts from origin, explores path of shortest length and marked every vertex in the process, gets the fixed tag from the previous vertex or the temporary tag from the origin (Du 1995; Wu 2010; Yang 2010; Xu 2011; Liu 2006).

First make $L(P_1) = 0$, $L(P) = +\infty (P \neq P_1)$,

$$T_1 = P_1,\ S_0 = \{P_n\} \tag{109.2}$$

$$L(P_j) = \min\{L(P_j),\ S(P_n) + K_{nj}\} \tag{109.3}$$

$$\text{Make}\, L(P_{jn}) = \min\{L(P_j)\}\ (P_j \in S_n) \tag{109.4}$$

we can get four kinds of shipping lane.

When $j = 0$, $L(P_2) = r_1$ minimum
When $j = 1$, $L(P_3) = r_2$ minimum
When $j = 2$, $L(P_5) = r_1 + r_{10}$ minimum
When $j = 3$, $L(P_6) = r_2 + r_8$ minimum
When $j = 4$, $L(P_4) = r_3$ minimum
When $j = 5$, $L(P_7) = \min\{(r_3 + r_6), (r_2 + r_7)\}$ minimum
When $j = 6$, $L(P_8) = \min\{(r_2 + r_8 + r_{15}), (r_1 + r_{10} + r_{14})\}$ minimum

109.4 Conclusion

Refer to the different quality, quantities, forms, value, units of measurement of various goods, the demands for transportation presents the hierarchical characteristics, different in freight, time, safety level and frequency. In the meantime, with the rapid development of social economy and constantly improved of regional comprehensive transport network, multimodal transportation has become the direction and goal of modern transportation and logistics development. In this context, it is with great significance in considering complex cargo, choosing the optimal dispatch, type of transportation and route, highlighting the effect of characteristic to optimize comprehensive transportation system.

International marine logistic network is defined as an aggregation of connected organization and facilities in goods flow between different countries and regions. It serves to prompt international trade, transnational operation and accordance of marine system in difference countries. Regional marine logistic network is defined as an aggregation of connected organization and facilities in special cargo flow within different regions. It has realized the optimal allocation of resources and prompted logistic system accordance in different regions, countries and ports.

Various shipping companies, ship owners and charterers are very concerned about a shorter, economic and safety route, it is also a significant issue in shipping development. So far there isn't a complete, comprehensive and practical route optimization theory in worldwide, and existing methods are combination and iteration based on various kinds of algorithm that meet the different needs of user.

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Chapter 110
A Dynamic Analytic Approach to Study on the Interaction Between Product Innovation and Process Innovation of the Equipment Manufacturing Enterprises

Ting Wang, Ying Wang, Jing Liu and Yang Gao

Abstract The coordinated development of product innovation and process innovation is an important factor for enterprise' technology innovation success. In this work, a systematic dynamic model is proposed to explore the correlation between product innovation and process innovation. The model is based on system dynamics theory and methodology. In the case study, experimental analysis of JY Kinetics Co Ltd. has been carried out with the proposed model. The results show that the model is able to analyze the correlation between product innovation and process innovation. It is useful for enterprises to develop technology innovation strategies and promote its implementations.

Keywords Equipment manufacturing · Interactive relationship · Product innovation · Process innovation · System dynamics (SD)

110.1 Introduction

From the industrial point of view, the technology progress has a deep impact on advanced and rationalized industrial structure of the equipment manufacturing (Feng 2008). As technological innovation is the main source of the technological progress in equipment manufacturing, the coordinated development of product innovation and process innovation is an important factor for enterprise' technology innovation success (Kim and Choi 2009). Guizhou Province is a traditional manufacturing province which has good foundations and development opportunities. However, the rise of the emerging manufacturing provinces through the

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E. Qi et al. (eds.), *The 19th International Conference on Industrial Engineering and Engineering Management*, DOI: 10.1007/978-3-642-38391-5_110,

country is a great challenge to Guizhou equipment manufacturing in recent years. At present, the equipment manufacturing in Guizhou Province is in urgent need for technical innovation in order to improve the competitiveness and survivability, so this research needs to be strengthened. As the relationship between product innovation and process innovation has the characteristics of complexity, nonlinearity, delay, dynamic.ect (Sun 2007), this paper takes the Guizhou JY Kinetics Co Ltd. for example, through building the system dynamics model to explore the interaction between product innovation and process innovation and provide policy analysis tools to help decision-making for equipment manufacturing enterprises, and finally lay a foundation for the following study of the technological innovation of the Guizhou regional equipment manufacturing.

110.2 Literature Review

In the 1970s, William J. Abernathy and James M. Utterback put forward the AU model of the innovation type and innovation degree changing with technology lifecycle (Utterback and Abernathy 1975), which creates a precedent for collaborative research of product innovation and process innovation (Bi et al. 2007). After the AU model was built, Hayes and Wheelwright promoted the formalized relation model of product innovation and process innovation, namely product—process matrix conceptual model. This model provides a quantitative basis for enterprise production and market diversification decision-making choices (Hayes and Wheelwright 1979). Peter M.Milling and Joachim Stumpfe innovatively used the system dynamics (SD) method, starting from the complexity of product and process which makes changes with the innovation, so the research of the interaction between them becomes more systematic (Milling and Stumpfe 2000). Some domestic scholars put forward the interactive model of product innovation and process innovation corresponding to Chinese national conditions on the basis of oversea studies. Bi Kexin built the SD model of the interaction between product innovation and process innovation to have a simulation study on a particular manufacturing enterprise (Bi et al. 2008). Now, domestic studies rarely use the SD method to study the interaction between product innovation and process innovation of the equipment manufacturing. Therefore, it has an important practical significance to have a study on SD simulation for an equipment manufacturing enterprise.

110.3 The Establishment of SD Model

110.3.1 Model Assumption

According to assumptions of the resource scarcity in economy and the actual situation of the majority manufacturing enterprises, this paper assumes that the manufacturing enterprise innovation resources are limited. Increasing innovation investment to a subsystem means reducing another subsystem innovation investment (Jackson 2005).

Considering that there are many ways of investment of resources in technology development, but some input methods are difficult to quantify (Zhu 2009), such as technological innovation incentive policies, science and technology information, science and technology personnel, etc. But these factors are also affected by the total investment of technological innovation funds, so this article defines the investment of research and development (R&D) resources as the capital investment.

This article studies product innovation and process innovation in R&D and technology transfer process which is transferred with new products and technology based on patented technology (Chen et al. 2009).

110.3.2 The Overall Structural Analysis of the Model

From the process of product innovation and process innovation, the interaction between product innovation subsystems and process innovation subsystem occurs mainly in decision-making process, R&D process and the manufacturing process. In the decision-making stage, decision-maker should allocate resources for product innovation and process innovation to determine the proportion of technology development inputs and product process innovation (Labeaga and Ros 2003). In the early R&D stage, product development and design department should exchange information more frequently with the R&D department (Guo 1999). The main purpose is to set the framework for the development of process and product. In the manufacturing stage, there will be more exchange of technical information between the various departments (Eswaran and Gallini 1996). The overall structure which displays the interaction between product innovation subsystems and process innovation subsystem is shown in Fig. 110.1.

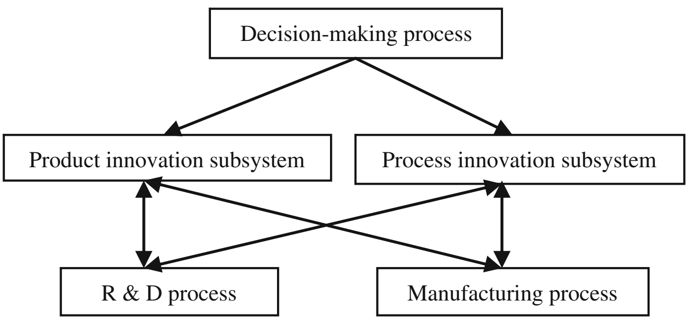


Fig. 110.1 The overall structure of the model

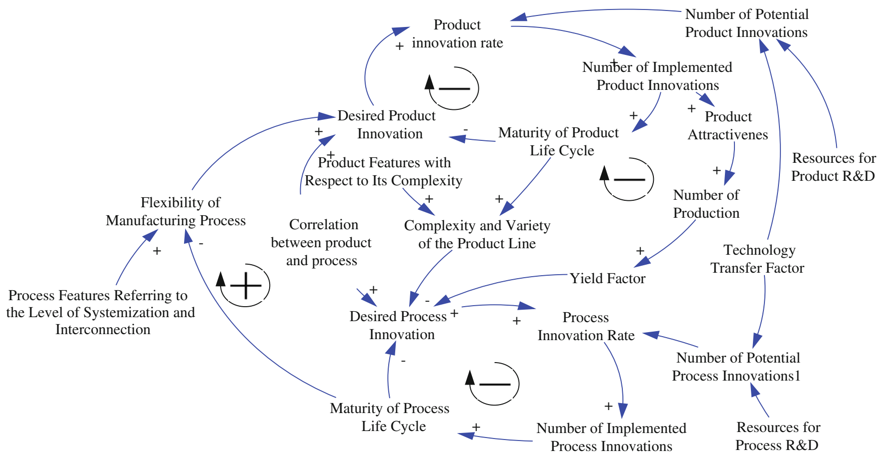


Fig. 110.2 Product and process causal loop diagram

110.3.3 Causal Loop Diagram

The main effect variable in the subsystem of product innovation and process innovation is only selected to structure the causal loop (see Fig. 110.2) according to the actual situation of equipment manufacturing and the point of view of availability and maneuverability.

110.3.4 Research Model

The variables are quantified and structured simple SD model (see Fig. 110.3) according to the causal loop diagram. In this model, number of implemented

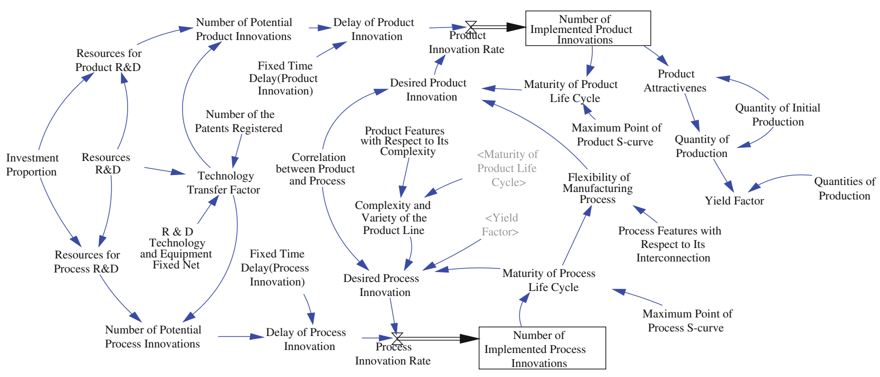


Fig. 110.3 System dynamic simulation of product innovation and process innovation

product innovations and number of implemented process innovations are two level variables, while product innovation rate and process innovation rate are two rate variables, and other variables are auxiliary or constant variables.

110.4 Simulation Analysis Model

The simulation target of this paper is a famous equipment manufacturing enterprise, the JY Kinetics Co Ltd. in Guizhou Province. JY Kinetics Co Ltd. has more than 30 years research and development history, which is very popular in Guizhou. This company is a typical example, which has ability to innovate, and the new data of product innovation and process innovation in this company have been obtained from interviews and questionnaires.

The SD software, vensim_ple 5.11a is used to do the simulative analysis. The operation time of the model is from 2006 to 2015, and time step is one year.

110.4.1 Calibration of the Model

As far as possible, the model was calibrated to make the consistency of model's behavior and system behavior. The model passed the unit consistency test and model test firstly. Then according to the practical data of JY Kinetics Co Ltd., the model is repeatedly calibrated, and at last the behavior of the model becomes very close to the reality. In the end, the relative error is less than 10 %.

110.4.2 Policy Tests

From the simulation of product innovation and process innovation, Fig. 110.4 shows the tendency of JY Kinetics Co Ltd.'s product-process interaction at present. In this graph, product innovation rate is gradually diminishing, at the time, process innovation rate is surpassed by product innovation rate in 2012.

Because this paper focuses on the political simulation and effect prediction in order to aid decision making. Thus we choose the three variables as below which can be regulated and controlled by the managers.

Change investment proportion. Under the circumstance which other variables are not changed, adjust investment proportion = 2 (current strategy) to investment proportion 1 = 0.5, investment proportion 2 = 8. Then we got Fig. 110.5.

Compared with Figs. 110.4 and 110.5, we can figure out that when investment proportion reduces, the resources for product R&D reduce and then product innovation rate reduces a lot. At the same time, the resources for process R&D increase and process innovation rate increases in certain extent. However, along

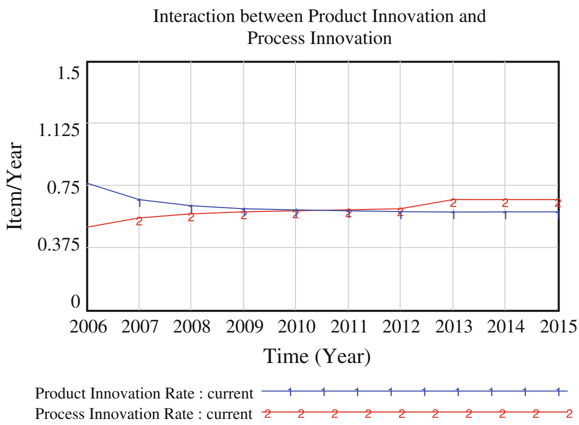


Fig. 110.4 The result of SD simulation based on basic strategy

with the passing time, process innovation rate will gradually reduce. When investment proportion increases, the resources for product R&D increase too while product innovation rate is higher than ever before based on basic strategy, but it still tends to go down as time goes by. Process innovation rate increases, which causes a small-scope fluctuation.

Change resources R&D. Under the circumstance which other variables are not changed, adjust the resources R&D = 15 Million Yuan (current strategy) to resources R&D1 = 7.5 Million Yuan, resources R&D2 = 30 Million Yuan. From the result of the simulation shown in Fig. 110.6, we can figure out that when resources R&D reduces, both product innovation rate and process innovation rate reduce by a large margin. When resources R&D increases, both product innovation rate and process innovation rate are higher than ever before, but the tendency of product innovation rate is down and the amplification of process innovation rate last long as time goes by.

Change correlation between product and process. Under the circumstance which other variables are not changed, adjust the correlation between product and process = 0.6 (current strategy) to correlation between product and process 1 = 0.3, correlation between product and process 2 = 0.9. The result of SD

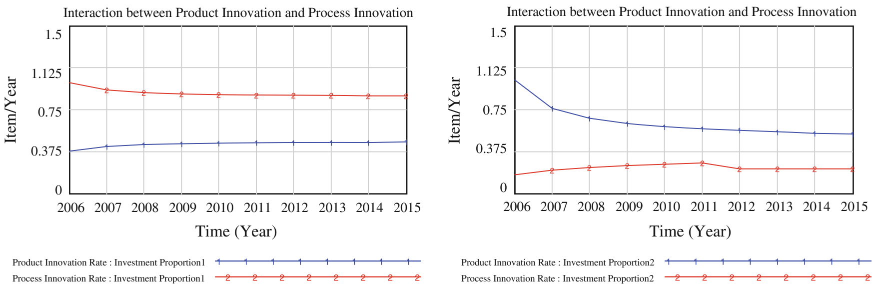
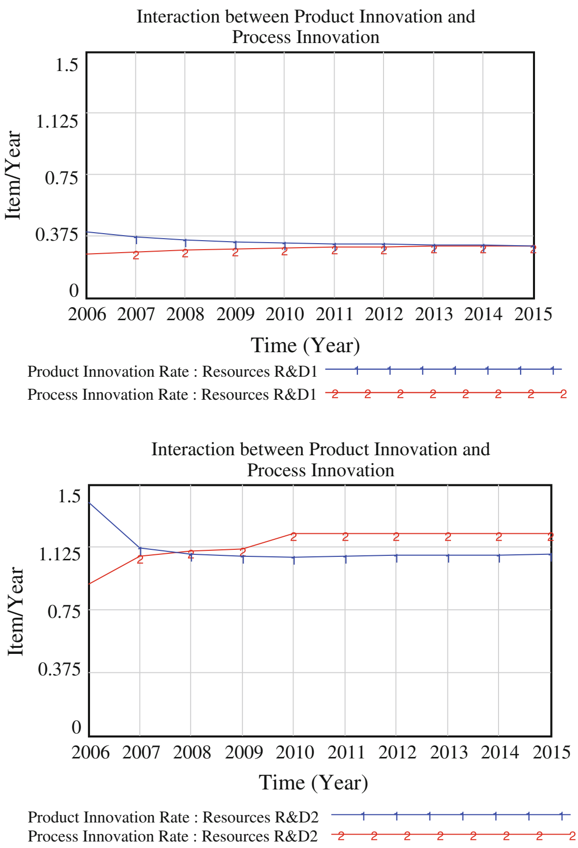


Fig. 110.5 The result of SD simulation by adjusting investment proportion

Fig. 110.6 The result of SD simulation by adjusting the resources R&D



simulation by adjusting the correlation between product and process is illustrated in Fig. 110.7. When the correlation between product and process reduces, process innovation rate don't increase very much until 2014, which is affected by yield factor. When the correlation between product and process increases, product innovation rate and process innovation rate gradually converge as time goes by.

110.5 Conclusions and Policy Implications

By means of computer simulation, it can help to learn about dynamic complexity and the sources of policy resistance, as well as provide more effective policy suggestions (Lee and von Tunzelmann 2005). It's important for equipment manufacturing enterprises to develop technology innovation strategies and promote its implementations. These SD simulation results show that the development of JY Kinetics Co Ltd's product innovation and process innovation is relatively slow. Thus, the policy suggestions of this paper are as follows. First, the scale value

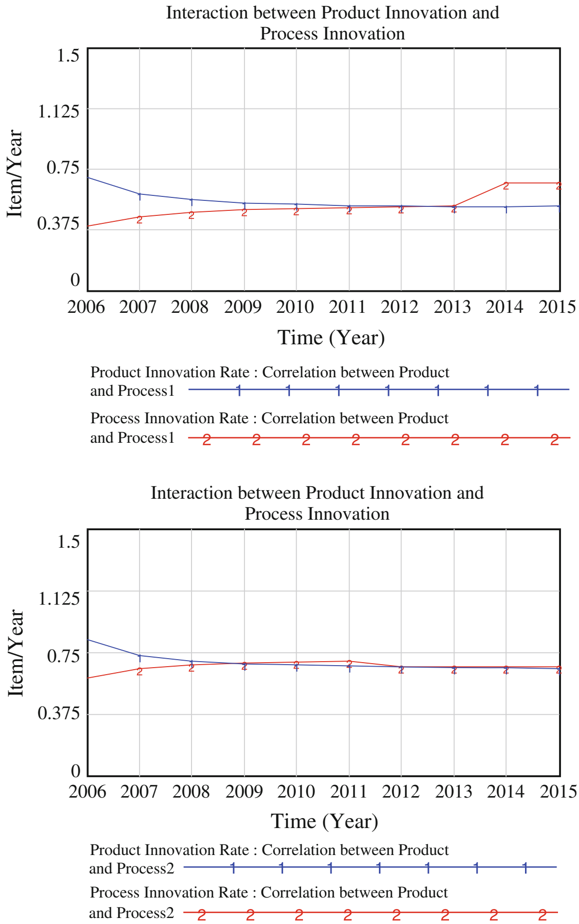


Fig. 110.7 The result of SD simulation by adjusting the correlation between product and process

between the investment of product and process innovation should be kept in a certain scope, and the advisable investment proportion is among 0.5–2 for JY Kinetics Co Ltd. Second, equipment manufacturing enterprises should paid more attention to the process innovation. The simulation results show that increasing the resources for process R&D makes very positive effects on the process innovation and these effects will last for a long time. Compared to this, the resources for product R&D which maintains the increase can only make sure the stable development of product innovation. Third, the higher the correlation between product and process is, the more attention the company should paid to the management of product innovation and process innovation. Moreover, from the long-term development trend of the equipment manufacturing enterprises, they should focus on the coordinated growth of product innovation and process innovation as well as pay more attention to the coordinated management of product innovation and process innovation. With the help of system dynamic method to analyze the development trend of product innovation and process innovation, we try to make out the optimal strategy about how to make these two factors which can develop steadily. Fourth, enterprises should have more people who have strong ability on conversion achievement, and only by this way can the transfer ability of company's research be enhanced. It's very important to communicate with stakeholders, and then it's possible for us to make a positive and active innovative environment to attract innovative personnel and promote technological innovation.

Acknowledgments This project is supported by Humanities and Social Sciences Foundation of Department of Education in Guizhou Province and soft science Foundation of Guiyang Science and Technology Department under the grant number 2010-2-27.

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Chapter 111
A Multi-agent Simulation System Considering Psychological Stress for Fire Evacuation

Fan-xing Meng, Qin-lin Cai and Wei Zhang

Abstract Multi-agent simulation is an important method to study fire evacuation. The present study developed a multi-agent simulation system for fire evacuation. This system adopted a new-proposed EID (External stimuli-Internal status-Decision making) behavior model, emphasizing the influence of psychological stress to people's escape behavior. Some simulation trials were conducted to compare the difference between simulation without and with psychological stress. It was shown that when the influence of psychological stress was not considered, the simulation results tended to be more "optimistic", in terms of number of escaped people and average escape time.

Keywords Fire evacuation · Multi-agent · Psychological stress · Simulation system

111.1 Introduction

Modeling and simulation tools for analyzing fire evacuation are useful in public place design for enhancing passenger safety (Sharma et al. 2008), and different tools have been developed to study fire safety (Owen et al. 1996; Galea and Galparsoro 1994). Among these tools, multi-agent simulation system is used in a

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E. Qi et al. (eds.), *The 19th International Conference on Industrial Engineering and Engineering Management*, DOI: 10.1007/978-3-642-38391-5_111,

growing number of areas (Drogoul et al. 2003; Zhang et al. 2009; Gonzalez 2010). This tool is based on a computational methodology that allows building an artificial environment populated with autonomous agents. Each agent is equipped with sensors, decision-making rules and actuators, which is capable of interacting with environment (Pan et al. 2007). In the area of fire evacuation study, for moral and legal reasons, we are not permitted to deliberately expose normal experimental participants to real fire condition, which will pose a life-threatening degree of risk (Hancock and Weaver 2005). Multi-agent simulation technique can potentially help in achieving a better understanding of fire evacuation process without safety threatens to real people.

Unfortunately, there is a lack of multi-agent simulation frameworks to allow human factors, such as psychological stress, to be taken into account (Sharma et al. 2008). Fires are perceived as very stressful and a person, who has to decide how to get out of a building, and away from an uncontrolled fire, is under extremely psychological stress (Benthorn and Frantzich 1999). According to theories of information processing, how people interpret information depends on the degree of stress they are experiencing (Janis and Mann 1977; Miller 1960). Thus, psychological stress in fire will affect people's perception of various environmental factors and thereby influence their actions in the process of fire evacuation (Ozel 2001; Nilsson et al. 2009). For example, a person's interpretation of emergency information and other people's actions, as well as his or her subsequent behavior, i.e., decision to evacuate, choice of exit and pre-movement time, is partly related to his or her psychological stress level (Nilsson et al. 2009).

Psychological stress is an important factor affecting people's evacuation behavior, which must be considered in multi-agent simulation system. This paper proposed a new model to describe individual evacuation behavior and developed a new multi-agent simulation system for fire evacuation, where people may behave differently depending on their psychological stress level. This simulation system considered the uncertainty in behavior under psychological stress, which could obtain more realistic results about fire evacuation.

111.2 System Architecture and EDI Behavior Model

111.2.1 System Architecture

System architecture is shown in Fig. 111.1. In this multi-agent simulation system, the simulation environment is defined in the "Simulation Environment Module", such as environment size, layout, and number of exits. The crowd population in the simulation environment is first initialized in "Crowd Initialization Module" by setting different types of agents based on their ages, genders and relations with other agents. In simulation, each agent behaves based on the pre-defined behavior model, to interact with other agents, as well as the simulation environment. "Data

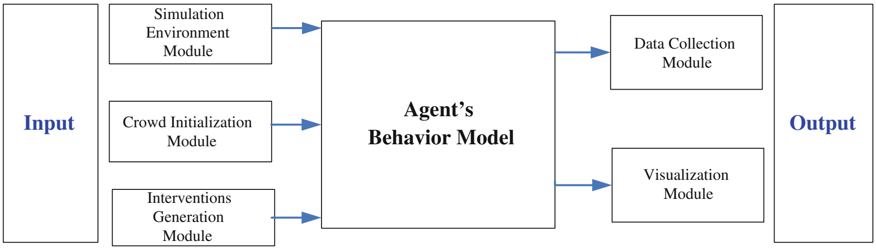

Fig. 111.1 System architecture of the multi-agent simulation

Collection Module" is used to collect simulation data, including changes of internal attributes of agents, evacuation time of each agent, etc. By the "Visualization Module", the 2D and 3D scenes of evacuation are displayed, which are valuable to investigate the behavior of each agent and to get comprehensive understand of fire evacuation process. Furthermore, some intervention methods can be added to simulation to study their effects on fire evacuation by "Intervention Generation Module". For example, the effect of leaders in a crowd, the effect of different warning signals, etc.

111.2.2 EDI Behavior Model

In multi-agent simulation system, the most important part is the behavior model of agent, which determines the validity of simulation results. The behavior model in this study adopts the process of "External stimuli-Internal status-Decision making" (see Fig. 111.2), which is called EID model in the present study. The basic idea in EID model is that external stimuli have direct effects on a person's internal status, which in turn influence the process of decision making (Luo et al. 2008).

In EID model, external stimuli are divided into four categories by people's sensory system: visual stimuli, auditory stimuli, thermal stimuli and olfactory stimuli. Visual stimuli include the burning fire and smoke, which are quantified by fire size and smoke density, respectively. The scale of fire and smoke will increase with simulation time goes on. Auditory stimuli include the sound of fire alarm and the sound of burning fire. They are quantified by their sound intensity. Fire alarm is activated when the fire breaks out, and its sound intensity keeps constant during fire. The sound intensity of burning fire varies with the scale of fire. Thermal stimuli represent the heat caused by burning fire, which is quantified by environment temperature. The olfactory stimuli represent the smell of smoke, which is quantified by smoke density. All these quantified parameters have five levels from 0 to 5. "0" means there is no stimulus and "5" means the stimulus has reached its maximum. All these external stimuli collectively impact a person's psychological stress level. Psychological stress influences people's decision making process, mainly including route choice and travelling speed.

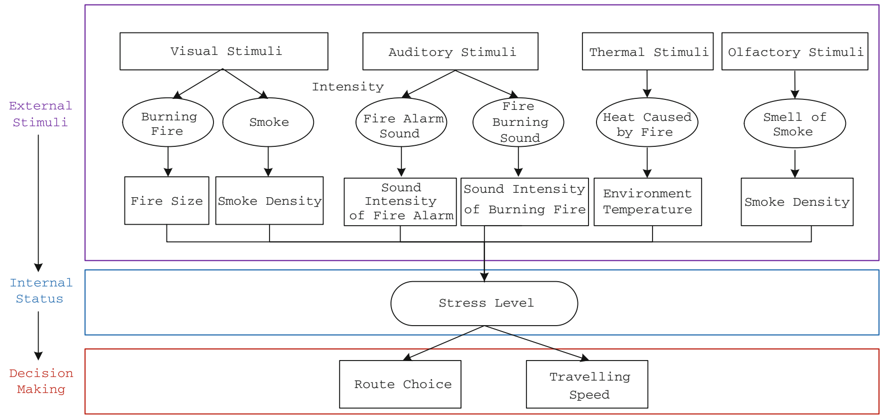

Fig. 111.2 EID behavior model in the multi-agent simulation system

Emergency signs are set up at each intersection, which direct agents to the exit by the optimal route. The decision of route choice is a two-stage process. In the first stage, agents recognize the directions given by emergency signs at intersections. Previous studies showed that most participants in fire evacuation do not pay enough attention to emergency signs (Tang et al. 2009), thus whether an agent can find signs at intersection is a probability event, whose probability is influenced by psychological stress level of this agent. It is believed that agents tend to neglect emergency signs under high psychological stress, thus the probability of finding emergency signs is negative correlated with agents' psychological stress level. In the second stage, agents evaluate the hazard level of each direction by scale of fire and smoke. If an agent doesn't find signs in the first stage, it will choose the direction with least hazard level from all optional directions; if it recognizes the directions given by signs, it will continue to judge whether the hazard level of the given direction exceeds the pre-defined threshold. If no, it will travel to the direction given by the sign; if yes, it will choose the direction with least hazard level from other directions. It is believed that people will increase walking speed under stress, and even start to run when surfing extreme psychological stress. In the behavior model, agents' travelling speed is positively correlated with their psychological stress level (Fig. 111.3).

111.3 System Development and Simulation Results

111.3.1 System Development

Based on the system architecture described above, a multi-agent simulation system is developed. The test scenario is a public place where all the passengers are

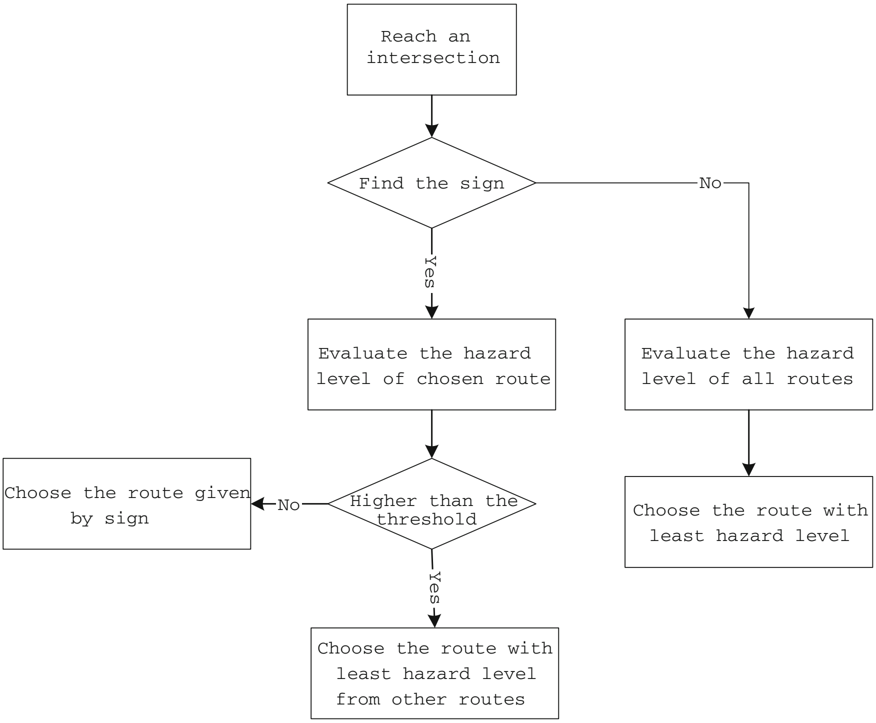

Fig. 111.3 The decision process of route choice

unfamiliar with the layout of environment. Human behaviors in normal and emergency conditions are simulated.

The simulation environment is set up in the "Simulation Environment Module". It is created as a virtual public place where seven horizontal and vertical corridors are crossed (see Fig. 111.4), forming an area of 75 $\times$ 75 m. The width of each corridor is 3 m.

The crowd is initialized in "Crowd Initialization Module". 100 agents are uniformly dispersed along these corridors. Under normal condition, their travelling speed is set as 0.8 m/s, which will be increased according to agents' psychological level in fire emergency. The maximum value of travelling speed is 5 m/s.

At the beginning of simulation, all agents travel normally in the environment. A fire in the middle of the environment can be activated by a pre-defined button and fire alarm is also sounded. Fire and smoke spread along the corridor and agents begin to escape based on their behavior model. In "Visualization Module", 2D and 3D scene of evacuation are displayed (see Fig. 111.5). 2D scene provides us macroscopic view of the simulation process, which can show the travel characteristic of agent flow, for example, how fire and smoke influence the route choice of different agents. 3D scene can give more detailed view of agents' escape behavior and the interaction between different agents can be observed clearly.

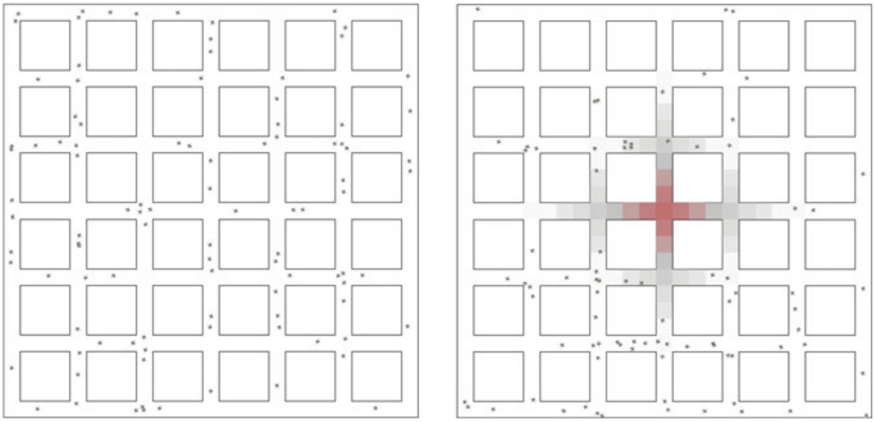

Fig. 111.4 The top views of test environment in normal condition (*left*) and in fire emergency (*right*)

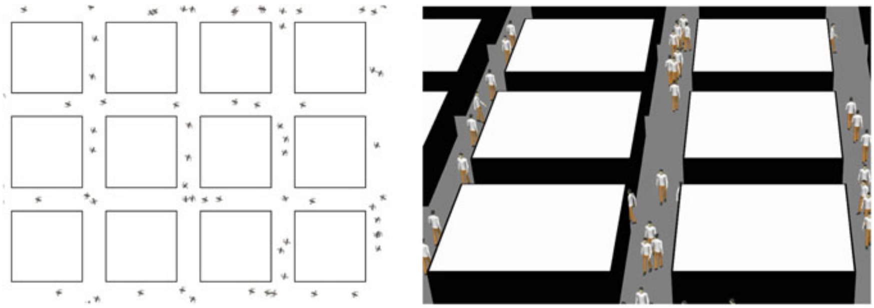

Fig. 111.5 2D (*left*) and 3D (*right*) scenes of simulation environment

"Data Collection Module" is used to collect real-time data of each agent during simulation. The data include: travel speed, psychological stress level, probability of recognizing emergency signs and escape time. These data are used to analyze the efficiency of fire evacuation.

111.3.2 Simulation Results

The most important part of the present simulation system is to consider the influence of psychological stress. To demonstrate the effect of psychological stress, two different kinds of simulation are conducted, and their results are compared. In the first kind of simulation, agents' psychological stress level is not taken into consideration, that is, agents' behavior are not affected by external stimuli. In the other simulation, the influence of psychological stress is added, just

Table 111.1 Summary of simulation results

	Number of escaped agents		Average escape time/s	
	mean	s.d.	mean	s.d.
Without stress	94.9	2.5	37.5	3.0
With stress	83.8	3.7	43.9	4.3
p value	<0.001		0.002	

as what is described above. For each kind of simulation, ten trials are conducted. In each trial, the number of escaped agents, which represents how many agents have escaped before the fire spreads all around the environment, and the average escape time of each agent, which indicates how much time an agent spends to reach the exit averagely, are recorded to make comparison.

Summary of simulation results are displayed in Table 111.1. The *t*-test is conducted to compare the difference between the two simulations. The number of escaped agents in the simulation without stress (mean = 94.9, s.d. = 2.5) is significantly higher than that in the simulation with stress (mean = 83.8, s.d. = 3.7), with a p value of less than 0.001. The average escape time is 35.5 s (s.d. = 3.0 s) and 43.9 s (s.d. = 4.3 s) in the simulation without stress and with stress, respectively, and their difference is significant (p value = 0.002).

111.4 Discussion and Conclusion

In the present study, a multi-agent simulation system is developed, where the influence of psychological stress to escape behavior is considered. An EID behavior model is proposed to describe how external stimuli affect the internal status (psychological stress) of people and further change their decision making process. Based on this model, agents in simulation system can behave more realistically and can be more similar with a real person. To demonstrate the influence of psychological stress to people's evacuation behavior, two different kinds of simulation, without and with psychological stress, were compared. Simulation results also showed that there was significant difference in whether psychological stress was taken into account or not. Under high psychological stress, agents exhibited poor performance, and the evacuation efficiency was also low.

However, there are still some limitations in the present study. First, the group behaviors are not considered. The social behaviors, such as queuing and herding, were believed to have some influence on people's evacuation behaviors (Yuan and Tan 2011), which will be focused on in the future studies. Second, other indicators of internal status are not included. For example, visibility range can affect the human behavior significantly (Yuan and Tan 2011). More human factors should be considered to promote the validity of multi-agent system.

Acknowledgments The authors would like to acknowledge the support of research program of Foxconn Technology Group.

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Chapter 112
A Multi-Granularity Model for Energy Consumption Simulation and Control of Discrete Manufacturing System

Jun-feng Wang, Shi-qi Li and Ji-hong Liu

Abstract The sustainable manufacturing makes the discrete industry considering the energy efficiency of the production process. Energy consumption becomes a very important indicator of energy efficient manufacturing. Discrete event simulation plays a vital role in evaluating the performance of the production plan. Energy related decisions making of the production plan by simulation need a formal energy consumption model to evaluate the manufacturing process. In this paper, a multi-granularity state chart model is proposed to simulate and control the energy consumption process of the production. A general energy consumption profile is defined and some key states in a working cycle of a CNC machine are clarified for energy audit and saving control purpose. A CNC machine with five energy consumption states is used as an example to illustrate the use of the model. Some performance indicators are collected from the simulation and compared to show the effective of the model.

Keywords Discrete manufacturing system · Energy consumption · Simulation · State chart model

112.1 Introduction

With the climate change of the earth and the unsecured energy supply, the efficient use of available energy resources is one of the key approaches in the modern society and industry. Companies today are becoming increasingly interested in

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E. Qi et al. (eds.), *The 19th International Conference on Industrial Engineering and Engineering Management*, DOI: 10.1007/978-3-642-38391-5_112,

measuring and reducing the environmental footprint of their products and activities. The manufacturing industry, with its about 75 % of the world's yearly coal consumption, 20 % of global oil consumption, 44 % of the world's natural gas consumption and 42 % of all electricity produced (IEA 2007), is one of the main energy consumer and largest emitters of carbon dioxide (CO_2). The pressures coming from energy prices, environmental regulations with their associated costs for CO_2 emissions and the changing purchasing behavior of customers make the manufacturing industry adopt new methodology and techniques for a sustainable manufacturing (Bunse et al. 2011).

Energy efficient manufacturing (Rahimifard et al. 2010), which aims to integrated manage the energy efficiency and the production performance, can be beneficial to industrial companies for economic, environmental or societal aspects by reducing energy consumption and maintaining the system throughput. Although energy intensive industries (e.g. steel, cement, pulp and paper, chemicals) remain in the focus (Solding and Petku 2005), research finds challenges for small and medium sized enterprises and the non-energy intensive industries (e.g. discrete mechanical manufacturing industry). They should be not neglected but was lacking of research attention in the past (Ramírez et al. 2005). Studies show that there is a significant potential to improve energy efficiency in discrete manufacturing. Even with already available technologies, improvements of 10–30 % are likely to be achieved (Devoldere et al. 2007; Herrmann et al. 2011).

The introduction of energy consumption as a parameter to support the decision making process may help to forecast and manage the energy costs associated to the production plan while maintaining the suitable throughput. As a very effective approach and tool for problem solving and optimizing in manufacturing systems design, operation and control, discrete event simulation (DES) provides engineers with a flexible modeling capability for extensive analysis of a production flow and its dynamic behavior. Currently, the main parameters measured in DES are throughput, utilizations, and time-span. A review of commercially available manufacturing simulation tools (e.g. Plant Simulation, Arena, Quest et al.) reveals that they do not support the energy evaluation for production schedules. With the development of real time electrical signal monitoring technologies, the information-rich energy data can be collected and analyzed in the ICT systems (Vijayaraghavana and Dornfeld 2010). A holistic energy consumption model is required to simulation applications for discrete manufacturing system. In this paper, a multi-granularity energy consumption model will be constructed to simulate and control the discrete machining manufacturing system for energy management purpose.

112.2 Related Work

Planning and operating energy-efficient production systems require detailed knowledge on the energy consumption behavior of their components, energy consumption of production processes. Most of research work focuses on the energy consumption models of machine tools in manufacturing system based on the machine components in various running states.

Gutowski et al. (2006) broke down the energy consumption of machine tools according to functional components such as computer and fans, servos, coolant pump, spindle, tool changer and so on. The electrical energy requirements of each component are measured for understanding the energy consumption source.

A modular modeling approach to simulate the power consumption of production systems is proposed in Dietmair and Verl (2009) which have been detailed for process, component and system aspects. The basic structure of a generic energy consumption model in the form of a digraph with discrete states and transitions was derived by analyzing the activity of the components.

From the manufacturing of a unit product (Rahimifard et al. 2010), the theoretical energy is calculated by the Arena simulation tool using appropriate mathematical models representing various processes. This calculated data is complemented with actual (real) data related to the auxiliary energy and indirect energy, recorded by advance metering devices and commercial energy management systems used within empirical studies. The idle energy is not considered Weinert et al. (2011) developed a planning system for the detailed prognosis of a production system's energy consumption with a concept of Energy Blocks. The methodology is based on the representation of production operations as segments of specific energy consumption for each operating state of the production equipment. Energy-saving potentials are addressed and the approach is applied on the basis of a simulation based evaluation of the energy consumption of a job-shop manufacturing system for a predetermined production program.

The SIMTER project (Heilala et al. 2008) calculated energy use for specific equipment or process activities using equipment energy specifications (often obtained from equipment manuals or vendors) coupled with equipment operation data (e.g. number of hours the equipment is in different modes of operation). While such calculations are not very precise, they can indicate the order of magnitude of energy use.

He et al. (2012) proposed a modeling method of task-oriented energy consumption for machining manufacturing system. An event graph methodology has been exploited to model the energy consumption driven by tasks in production processes. But the stochastic failures of the machine are not considered in the model.

Johansson et al. (2009) indicated the potential use of utilizing DES in combination with LCA data to generate requirements specification for designing sustainable manufacturing systems and decreasing CO_2 emissions. The traditional idle, busy, and down state are used for energy consumption modeling.

A process module based on state depiction of machine/energy with technical building services (TBS) module is proposed by Herrmann et al. (2011). An energy oriented manufacturing system simulation environment is developed using AnyLogic. When starting a simulation run, single consumption profiles of production machines lead to cumulative load curves for the manufacturing system.

TBS-related energy demand of the actual production equipment (e.g. compressed air) serves as input for appropriate partial TBS-models.

It is observed that there can be a significant amount of energy savings when non-bottleneck (i.e. underutilized) machines/equipments are turned off when they will be idle for a certain amount of time. By clarifying the energy consumption state as start up energy, make part energy, idle energy and turn off energy, several dispatching rules were proposed to analysis the energy consumption decreasing effect of especially underutilized manufacturing equipment (Mouzon et al. 2007).

A Finite-State Machines were used to describe the energy consumption model (Le et al. 2011). A number of different operation states which are linked to the status of machine components and power consumption. Each operation state is defined according to the functionality of the machine.

Mori et al. (2011) classified energy consumption of machine tool into constant power consumption regardless of the running state, power consumption for cutting by the spindle and servo motor, and the power consumption to position the work and to accelerate/decelerate the spindle to the specified speed. Most of the current energy consumption models are for energy statistical purpose and can not be used for energy consumption control of production process. The different state partitions of machine are specific and not flexible, which have not a holistic view from the simulation aspect.

112.3 A Multi-Granularity State Chart Model for Energy Simulation

In order to setup an energy consumption model of machine for manufacturing system simulation, the model will have appropriate granularity, scalability and lower computational loading. The energy simulation model should not only support the energy audit for different view (e.g. plant view, process view and product view), but also can be used to control the state of the manufacturing system/facilities in order to reducing the system level energy consumption, for example changing the state of the facilities to a lower energy mode or power off mode.

112.3.1 Energy Consumption Profile Definition for Simulation

From the experimentation of current researches, the energy consumption profile of a manufacturing facility has many distinct states during a working cycle. Here the energy consumption profile of a CNC machine is analyzed and the method can be extended to other equipment, such as robotics, conveyor and AGV. The following factors should be considered when defining the energy consumption profile for simulation application.

- The partition method of energy consumption process of equipment can be applied to different facilities used in manufacturing industry.
- Several energy consumption states can be merged to one state or vice versa for different simulation granularity object.
- The energy consumption state should accommodate important concerned energy resources (i.e. electricity, gas, heat, and coal) in simulation of production system.
- Some instantaneous state with higher energy consumption must be included in order to evaluate the energy efficiency of the control strategy by simulation.

From the literatures (Rahimifard et al. 2010; Gutowski et al. 2006; Dietmair and Verl 2009; Weinert et al. 2011; Heilala et al. 2008; He et al. 2012; Johansson et al. 2009; Mouzon et al. 2007; Le et al. 2011; Mori et al. 2011), it is known that a typical electrical consumption profile of a CNC machine has a number of different operational states which are arose by the activities of its components and determine the power consumption. In each state, other types of energy resources can be appended to different state according to the practical requirement for specific machine. In this paper, the states are clarified to the following types with different characteristics and simulation intention.

- Power off: The machine power if off and all the energy resources are not consumed.
- Shut down: The machine will consume some energy to be shut off even if the duration of this state is very short.
- Warm up: The electrical switch is on and some peripheral equipments of the machine are start up. Although the warm up time is short, the required energy is higher.
- Power on: This is an idle state with no material removal. The whole machine consumes the basic energy in this state. This state can serve as a lower energy saving mode when no production activity take place.
- Start up: This state is the transition between the power on and production modes. The main components of the machine (e.g. the spindle and coolant system) will change to working state. This state is an acceleration process which consumes higher amplitudes of power consumption with short duration.
- Stand by: This is also an idle state. All drives and pumps of the machine are in stand-by but with no material removal.
- Production: This is a working state with the material removal process. There is some short duration with no material remove because of interspaces between the machining paths. In this paper, the duration of this state is defined as the time from the product loaded into the machine until it is dropped out the machine.
- Maintenance: The machine is maintained according to preventive maintenance (PM) schedule or stochastic failure (SF). The energy type and quantity can be defined for maintenance activities if they are concerned issue.

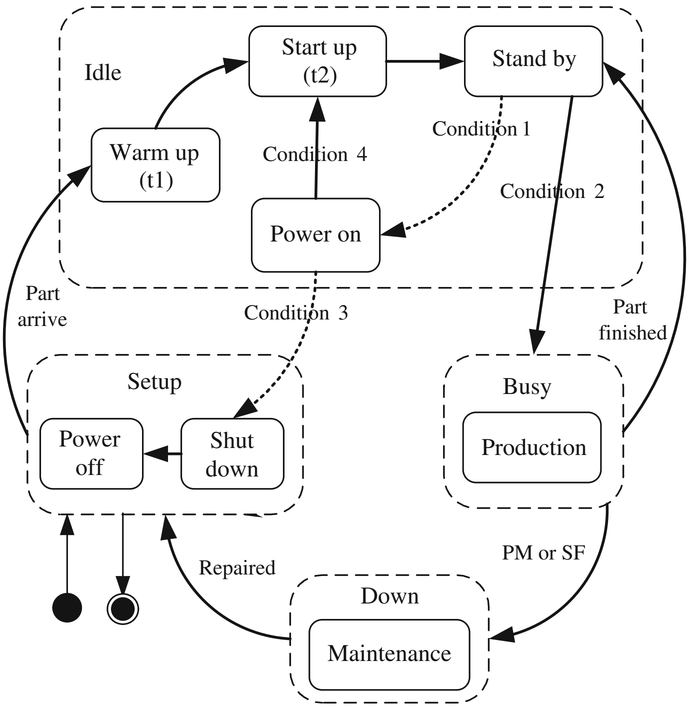


Fig. 112.1 State chart model for energy consumption simulation and control

112.3.2 A Multi-Granularity State Chart Model for Energy Consumption Management

Based on the analysis of the energy consumption profile, a holistic state chart model for energy consumption simulation and control of discrete manufacturing system is shown in Fig. 112.1. The model has a multi-granularity form in order to adopt the different requirements of simulation and control. The dot line in the model will be used to control the machine state in manufacturing process for energy saving purpose. The state changing conditions can be related with the arrival time of the next part or the current state has lasted for a predefined duration. Some states have a constant duration in production process. For example, execution time of the warm up (t1) and start up state (t2) will be a constant for a specific machine. The model has a nested structure which makes it general enough to be extended and modified for different application scenarios. This modeling method also can be applied to other faculties such as the conveyor, robot and AGV.

The characteristic and the parameters of each state are summarized in Table 112.1. The practical duration of state can be constant or stochastic, and the consumed energy type can be obtained for the specific machine. After the simulation, the required energy and the throughput for a shift of a production plan can

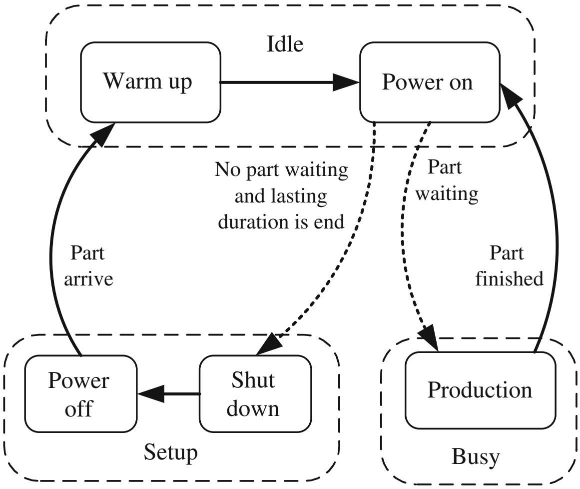
Table 112.1 The characteristics of the energy consumption state

Energy profile		Duration characteristic	Main energy types
State	Sub-state		
Setup(Power off)		Constant, stochastic	No
Idle	Warm up	Constant	Electricity
	Power on	Stochastic	Electricity
Busy	Start up	Constant	Electricity
	Stand by	Stochastic	Electricity, heat, gas
	Production	Constant, stochastic	Electricity, heat, gas
Down (maintenance)		Stochastic	No or Electricity

be reported. For a specific amount of part production, the energy and the overall makespan time can also be obtained for decision making. The model has the following classical using scenarios.

- For a coarse granularity simulation aiming to energy audit, only three states can be reserved, i.e. power on (idle), production (busy) and maintenance (down), which are supported by most of the current simulation software. By endowing with energy consumption data for each state, the energy quantity can be accumulative by multiplying the state duration and its required energy amount during the simulation process.
- For both the energy audit and energy saving control simulation, all the states in Fig. 112.2 can be used. Particularly, after the busy state, if the machine queue is not null (i.e. there are parts waiting for to be machined), the next part will be machined at once. Otherwise the machine will choose a suitable state (i.e. stand by, power on, shut down) in order to reduce the energy consumption from the view of the system level considering the arrival time of the next part or the idle state lasting for a predefined duration.

Fig. 112.2 The five states model for energy consumption control



- For a finer granularity energy consumption management purpose, the production state can be further decomposed to more sub-states and then the detailed energy consumption in production mode will be visualized.

112.4 Experimentation

The experiment is partly based on a case provided by Mouzon et al. 2007, Le et al. 2011. The data herein presented are for the purposes of demonstration of our method and do not necessarily imply an actual plant floor data.

One hour production ability will be evaluated for a single CNC center. The inter-arrival time and service time of parts are exponentially distributed with a mean of 20 and 6 s, respectively. The initial condition of the machine is assumed to be power off. The warm up takes 5 s and consumes 4 unit powers per second. The production and power on (i.e. idle) power are 6 and 2 unit powers per second, respectively. Shutting down a machine takes 2 s, consuming 1 unit powers per second. The state chart model for energy audit and energy saving control is shown in Fig. 112.2. When a part production is finished, the machine state will be changed to different state according to the following rule. If there are parts waiting for machining, the machine will be changed to production state at once. Otherwise, the machine will be idle at power on state. When the idle (power on) state lasts for a predefined duration (e.g. 5 s), the machine will be shut down for energy saving purpose until there is part arrival for machining.

An ARENA simulation model (Fig. 112.3) has been developed for the state chart model of the CNC machine with energy saving control strategy. Apparently,

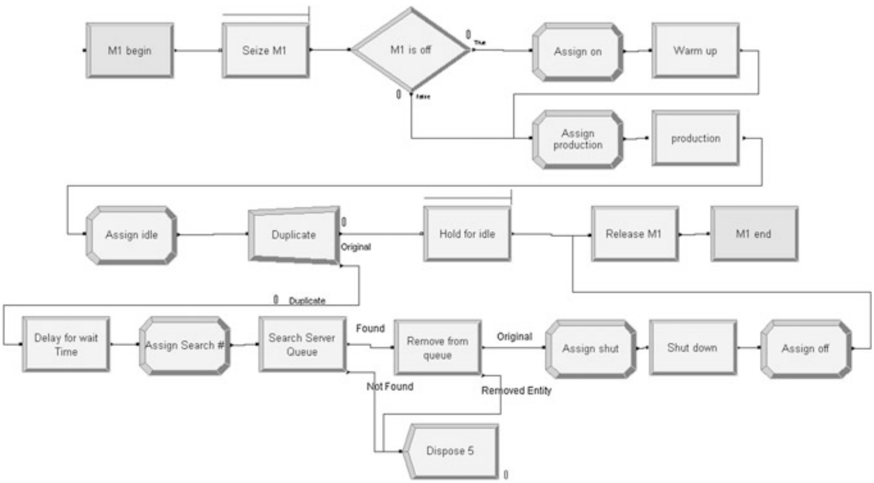


Fig. 112.3 The arena model for energy consumption simulation and control

Table 112.2 Performances of two scenarios in 1 h production

Performance indicator		Part throughput	Energy consumption
Strategy	No control	173	11917
	Control	162	8743
Performance result		6.4 % reduce	26.6 % saving

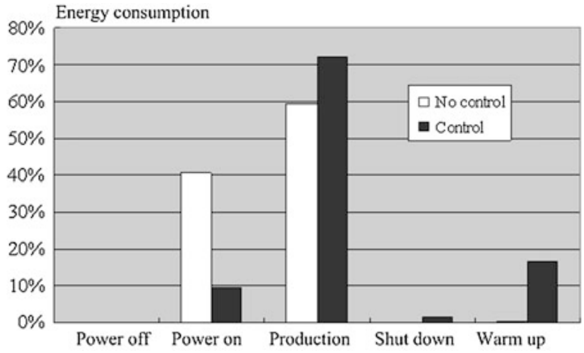


Fig. 112.4 The energy consumption ratio of five states in two scenarios

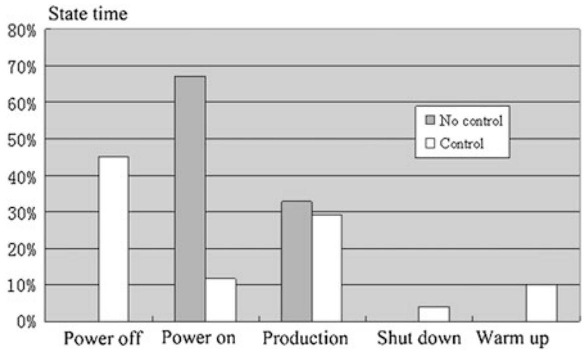


Fig. 112.5 The state time ratio of five states in two scenarios

if a machine has more states, the simulation flow module and their logic relation will be more complex. The five states in Fig. 112.2 are all included in the simulation model by using ARENA StateSet module. By changing the condition in some modules, the model in Fig. 112.3 can be only used to collect energy consumption data with no energy saving control. That is to say, the machine will stay at power on state when there is no part to be machined.

Table 112.2 shows the performance of the above two scenarios for 1 h production. From the Table 112.2, the state control scenario will have 6.4 % decreasing in thought with 26.6 % energy saving.

Figures 112.4 and 112.5 show the energy consumption ratio and the state time ratio of five states in two strategies. Apparently, the power off state in Fig. 112.5 has a relative longer time but have no energy consumption in Fig. 112.4 under the energy saving control strategy.

112.5 Conclusion

In order to evaluate the energy consumption of the discrete manufacturing system, a multi-granularity state chart model is proposed for energy consumption process of the manufacturing equipment. The general energy consumption states are analyzed and composed for different granular simulation applications. The method will be extended to other manufacturing faculties and a multi equipments plant floor will be studied in the future.

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Chapter 113
Analysis on System Archetype of High College and University Competitiveness Based on Hierarchical Structure

Li-qing Li and Ying-ting Yu

Abstract The paper combined hierarchical structure with system archetype analysis technology of Peter M. Senge, with the research on the spot in the concrete high colleges and universities and systematical analysis, proposed the key influencing factors of high college and university competitiveness and analyzed the hierarchical relation of them, then constructed the key variable feedback system archetypes based on the influencing factors and analyzed it systematically and qualitatively, at last put forward corresponding management countermeasure, which has certain theoretical and practical significance to analyzed the problem of improving the competitiveness of high college and university.

Keywords Hierarchical structure · Competitiveness of high college and university · System archetype

113.1 Introduction

Systems archetypes analysis was an effective method that can grasp the structure of system. Masters of modern management Senge (1992) built 9 system archetypes in the book of the Fifth Discipline—the Art & Practice of the Learning Organization. Regarded the system archetype as a key tool to analyze the issue of organization and management, and made it to be the core content of the learning organization theory, but in the book, he did not discuss how to build systems archetypes. To improve the competitiveness of high college and university is a system engineering project. Based on the method of system archetype, the authors analyzed the issue of how to enhance the competitiveness of high college and

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E. Qi et al. (eds.), *The 19th International Conference on Industrial Engineering and Engineering Management*, DOI: 10.1007/978-3-642-38391-5_113,

university, and provided an effective method to research the complex problem in the management with the analytic hierarchy principle.

113.2 Analyze the Influencing Factors of High College and University Competitiveness Based on Hierarchy Structure

In the twenty-first century, competition became an unavoidable practical problem of many social organizations. With the evolution of the overall external environment of higher education, the problem of competition that ignored for a long time between high colleges and universities is gradually appearing. Under the new situation of economic and technological globalization, China will integrate with the world in educational development deeply, which will bring both opportunities, but also have to face great challenges. There are different competitive advantages in different industries (Zhu and Liu 2007). To high college and university, its competitiveness is the organic integration and harmonization of various factors, resources and capabilities, a comprehensive capacity that promote comprehensive, healthy and orderly development of high college and university. This capability is the result of an effective integration and interaction of multiple factors.

According to in-depth interviews, literature reading and system analysis on the specific high college and university, the paper identified the main influencing factors of competitiveness: school reputation, image of school, scientific research, teaching faculty, social resources, the number of students, among them the most directly factor is school reputation, and school reputation is influenced by school image, scientific research, teaching faculty, social resources, student number. Therefore, the competitiveness of high college and university is expressed by $C = F(S)$, $S = f(s1, s2, s3, s4)$, S denotes as school reputation, s1, s2, s3, s4 denotes as image of school, scientific research, teaching staff, social resources, the number of students. The hierarchy structure of influencing factors of as showed as Chart 113.1.

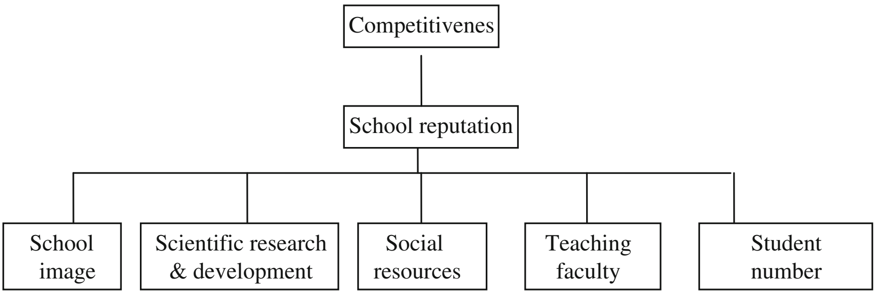

Chart 113.1 Hierarchy structure of influenced factors of high college and university competitiveness

113.3 Build System Archetype of High College and University Competitiveness Based on Hierarchy Structure

From the Chart 113.1, top-layer variable is the competitiveness of high college and university, the first layer variable is school reputation that affects the top-layer variable directly (Jia and Ding 2002), the causal structure is positive feedback, $v1 \xrightarrow{+} v2 \xrightarrow{+} v1$, the variables in the second layer are key factors to affect the school reputation which affected by other factors that include some positive factors and some negative factors, the former improve the competitiveness, the latter restrict the development of high college and university competitiveness. The paper built the feedback system archetypes based on the second layer variables, analyzed its complex relationship, and propose the effective countermeasures to enhance the high college and university competitiveness.

113.3.1 Limits to Growth Feedback Archetype Based on School Image-Oriented

To high college and university, image of school is an invisible business card, at the meanwhile (Sun and Liu 2010), it also is the valuable educational resources, its essence of image of school is the high college and university objective reality external performance, however, improve the perfect school image, some colleges pour large money on school size expansion or new campus construction. In fact, in that way, it isn't useful to add luster to school image, but also may be caught in huge debt, which has brought a series of negative impact to high college and university. Therefore, through systematic analysis, the paper built feedback archetype based on the school image-oriented showed as Chart 113.2.

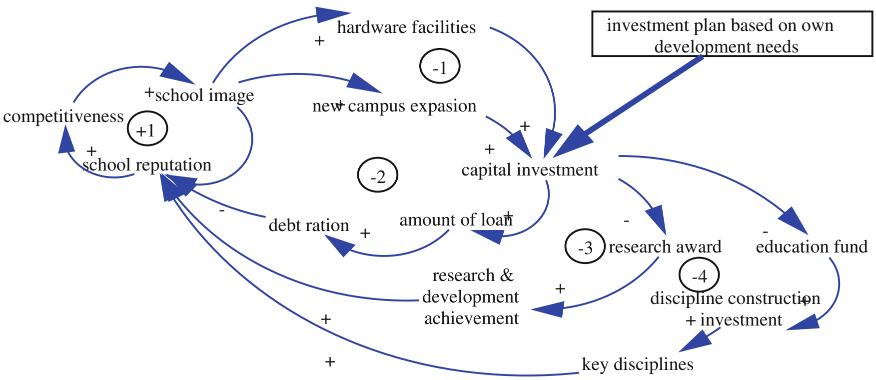

Chart 113.2 Limits to growth feedback archetype based on school image-oriented

From Chart 113.2, the feedback archetype based on the school image-oriented is composed of a positive feedback and four negative feedbacks, in the chart, the left feedback loop is a positive feedback loop that promote system development, the right feedback loop is a negative feedback loop that strict system development. The positive feedback loop reveals the mutual promotion between the school image, school reputation, and school competitiveness, however, in order to improve school image or reputation, some high college or university spend most large money on expanding new campus, regardless of the school affordability of a large number of loans. The results of a heavy debt ratio seriously affect school teaching, research and the normal operation of the subject building work. All of these lead a direct damage to school reputation and school image, and have a bad affect on the promotion of competitiveness.

Therefore, in order to effectively promote the healthy and orderly development of high college and university, each school must think over and over before investment, blindly to follow the example is not conducive to the enhancement of competitiveness.

113.3.2 Shifting Burden Feedback Archetype Based on Scientific Research & Development Achievements-Oriented

With introducing competition into the education, scientific research & development becomes more and more important to improve the teaching quality, school reputation and social influence (Li 2011). Colleges and universities which used been a single place to impart knowledge turned into the base of production and innovation and became an important pillar of national economic and technological development. First prize winner of the State Technological Invention Award, President of Central South University, academician Boyun Huang said: "in addition to teach the most advanced knowledge, the more important function of higher education is creating new knowledge." Therefore, scientific research & development becomes the most important evaluation index of measuring the colleges and universities competitiveness.

More and more high colleges and universities lay emphasis on scientific research & development. It directly influence academic standards, it also represents the school's overall strength and competitiveness. However, research & development achievements become a huge invisible pressure to high college and university teachers. Although the moderate pressure of research can not only make teachers concentrate on scientific research, maintain a strong scientific research ambition, but also enhance teachers' level of business as soon as possible, too much scientific research pressures also do harm to teachers. As it is showed on Chart 113.3, shifting burden feedback archetype based on research & development pressure-oriented, revealed universities did not correctly handle the question of

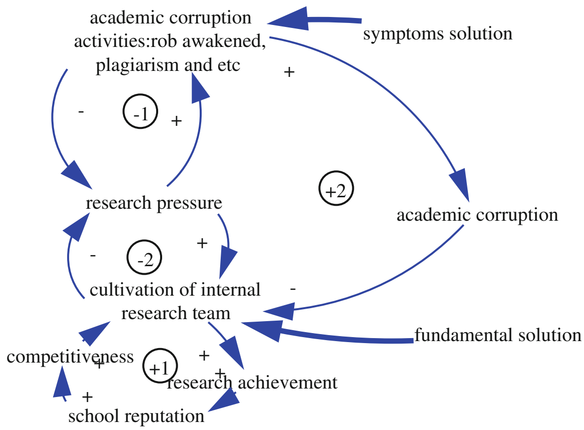

Chart 113.3 Shifting burden feedback archetype based on research & development pressure-oriented

research & development pressure. In Chart 113.3, positive feedback 1 shows promotion function between scientific research achievements and competitiveness, positive feedback 2, negative feedback 1, negative feedback 2 is a shifting burden archetype.

The numbers of paper and research project become the key index to measure the level of scientific research, school rankings and teacher promotion. Academic corruption becomes more and more serious under this background, for example, plagiarize others' paper after modifying it, one paper but multiple submissions, or publish other's paper after translating it into Chinese paper for its own purposes.

The management countermeasure for shifting burden feedback archetype is that focus on the fundamental solution. However, research labor is spiritual production, long cycle and slowly effective. To high college, effective way to improve scientific research & development is that constructing research team, *encouraging* college teachers to improve the quality of the research and enhance research competitiveness.

113.3.3 Vicious Competition Feedback Archetype Based on Teaching Faculty-Oriented

"Teacher is essential for that a school whether can be able to train qualified personnel to the socialist construction or not." said Deng Xiaopeng (Li and Xia 2011). To a high college or university, teacher is the foundation to cultivate talented person, it is the root to form school characteristics and advantages, and it also is the pledge to keep sustainable development. Some school according to the own development needs, spend large money on attracting talents to keep up with the pace of development of the schools, but some high colleges blindly follow, regardless of their own needs whether it is reasonable. This is a typical vicious competition, as shown as in Chart 113.4.

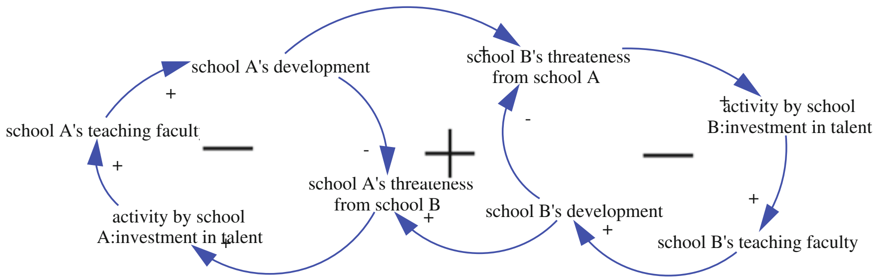

Chart 113.4 Vicious competition feedback archetype based on teaching faculty- oriented

From Chart 113.4, we can see clearly that two universities each see their welfare as depending on a relative advantage over the other. Whenever one side gets ahead, the other is more threatened, leading it to act more aggressively reestablish its advantage, which threatens the first, increasing its aggressiveness, and so on, each side sees its own aggressive behavior as a defensive response to the other's aggression, but each side acting "in defense" results in a buildup that goes far beyond either side's desires.

The vicious competition feedback archetype management principle is that to look for a way for both sides to "win", or to achieve their objectives. In many instances, one side can unilaterally reverse the vicious spiral by taking overtly aggressive "peaceful" actions that cause the other to feel less threatened.

113.3.4 Success to the Successful Feedback Archetype Based on Social Resources-Oriented

Development of social resources is the internal need of high colleges and universities, and the only way to improve educational level and quality. Due to the scarcity of resources, a fierce competition for the limited social resources is showed between the different colleges and universities. The more successful one becomes, the more support it gains, thereby starving the other, as show as Chart 113.5. Therefore, the management principle is looking for the overarching goal for balanced achievement of both choices. In some cases, break or weaken the coupling between the two, so that they do not compete for the same limited resource.

113.3.5 Limited to Growth Feedback Archetype Based on the Number of Students-Led

Student is the lifeblood for university normal operation, affected by the popularization of higher education, the competitiveness of snatching students becomes

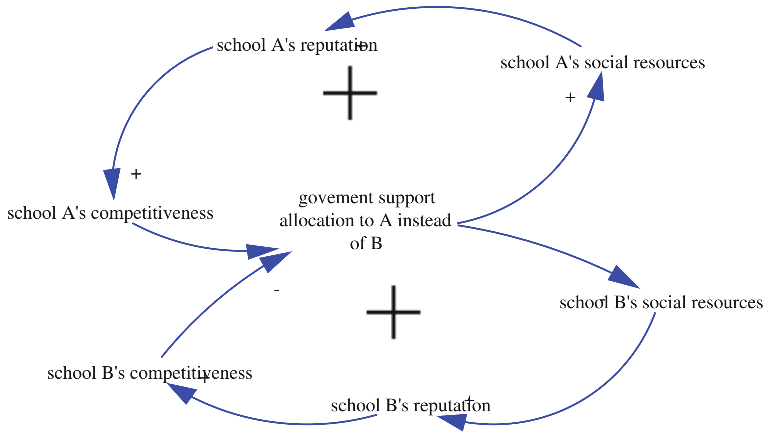

Chart 113.5 Success to the successful feedback archetype based on social resources–oriented

more and more intense. However, different universities have different capacity for students. Reasonable student number can promote health and orderly development, too many students do may be harm to the sustainable development of the university, as show as Chart 113.6, in the left of the chart, positive feedback causal relationship reveal student number play an important role in improving the school reputation and competitiveness; on contrary, in the right of the chart, the negative feedback reveals too many students isn't conducive to the improvement of the university.

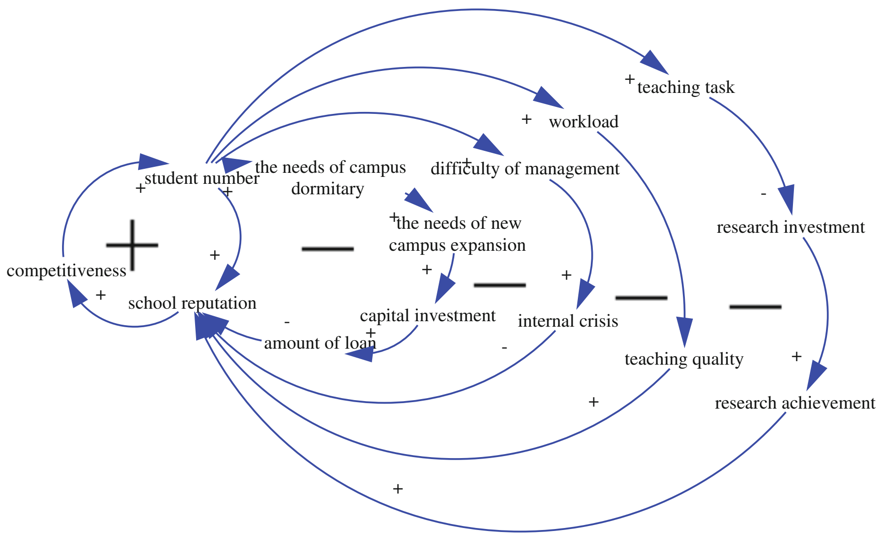

Chart 113.6 Limited to growth feedback archetype based on student number-oriented

First of all, too many students lead to more dormitories and campus expansion which force many schools to pour into blindly, and lead to loan burden. Secondly, too many students lead to difficulty of management, which result in more and more internal crisis (Li and Jiang 2011). Finally, too many students will bring more teaching load for teachers. Due to everyone's energy is limited, too much teaching task is bound to teachers may be difficult in being focus on research. Therefore, high colleges and universities have to be consistent with their own reasonable capacity in enrollment.

113.4 Conclusion

With the research on the spot in the concrete high colleges and universities and systematical analysis, the paper proposed the key influencing factors of high college and university competitiveness, combined hierarchical structure with system archetype analysis technology of Peter M.Senge, constructed the key variable feedback system archetypes based on the influencing factors, at last put forward corresponding management countermeasure, which has theoretical and practical significance for improving high college and university competitiveness.

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Chapter 114
Analysis on the Operation Effects of Logistics Park Based on BP Neural Network

Jun Luo

Abstract With the rapid development of the construction and operation of Logistics Park, the operation effects and the development level of Logistics Park will become the focus of attention. In this paper, the factors affecting the operation effects of logistics park are proposed firstly. Then a set of evaluation metrics of the operation effects of logistics park is given. Besides, based on BP neural network, a model for calculating the operation effects is built. Finally, a case study has been studied with the model.

Keywords BP neural network · Logistics park · Operation effects

114.1 Introduction

With the development of logistics, logistics park has become a kind of emerging logistics management way. In Japan, Germany and other developed countries logistics park has developed rapidly. The construction of logistics park of our country began in Shen Zhen city in 1990s, and other cities also began the construction of logistics park rapidly. By 2008 in September, according to statistics, there had been 475 logistics parks in our country. Among them, 122 logistics parks have operated already, 219 were under construction, and 134 were being planned (China Federation of Logistics & Purchasing).

In the western developed countries, the rate of return on investment of logistic park is about 6–8 %. The income gained by the investors of logistics park usually comes from the return of rental and the land appreciation. In China, the vacancy rate of logistics park is more than 60 %, and even some logistics park is used for

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E. Qi et al. (eds.), *The 19th International Conference on Industrial Engineering and Engineering Management*, DOI: 10.1007/978-3-642-38391-5_114,

other purposes. With the rapid development of the construction and operation of logistics park, the operation effects and the development level of logistics park will become the focus of attention. In this paper, a set of evaluation metrics of the operation effects of logistics park will be built, and the method of BP neural network will be used for analysis of the operation effects of logistics park.

114.2 The Set of Evaluation Metrics

114.2.1 The Factors Affecting the Operation Effects of Logistics Park

In the guidance of the government planning, logistics park is the large place in which several sorts of modern logistics facilities and several logistics organizations layout. Through sharing the infrastructure and the supporting service facilities, logistics park can give full play to its whole advantage and complementary advantages. The intensification and scale of logistics can promote the sustainable development of the city (Zhang 2004; Richardson Helen 2002; Marian 2006). When we plan the logistics park, we should consider regional economic level, customer industry, distribution of retail industry and the entire functional orientation.

The factors affecting the operation effects of logistics park have two aspects which are external factors and internal factors. The external factors include government's support and relative policy, the economic situation and the market environment. The internal factors mainly refers to the own operation ability of logistics park.

The policy environment mainly reflects the government's support to the development of logistics park. The local governments have provided some policies to logistics park, but these policies are not comprehensive and perfect. On the whole, in our country, the policy support to the development of logistics park is not enough. Soon, this situation will be changed, as we pay more and more attention to logistics and promulgate some related policy. The market demand of logistics park mainly includes target market's service demand, the adaptability of logistics park service and the matching degree of supply and demand of logistics park service. These factors directly affect the operation effects of logistics park.

The service ability of logistics park its own mainly includes: transportation, warehousing, distribution, packing and sorting, circulation processing, market development and maintenance, informatization level and management ability, etc. The internal factors are the foundation of the operation effects of logistics park.

114.2.2 The Set of Evaluation Metrics of the Operation Effects of Logistics Park

According to the influencing factors and the set of metrics of related documents (Mingming 2010; Dai 2010; Zhong 2009), a set of evaluation metrics of the operation effects of logistics park is built, which includes the economic benefits, the condition of the enterprises in the park, park ability and social benefits four parts, as is shown in Table 114.1.

114.3 The Operation Effects of Logistics Park Evaluation Model Based on BP Neural Network

In 1985, the BP neural network model was brought out by D. Rumelhart from Stanford University. As BP neural network can solve the nonlinear problem well, it has become one of the most widely applied neural networks. BP algorithm solves the connection weight problem of the hidden layer in the multi-lever network model, improves the learning and memory function of neural, and especially solves the XOR problem. The BP neural network model is the prior to connection model that constitutes of input layer, output layer and some hidden layer (Yin 2003; Liu and Lu 2011; Hagan et al. 2002).

Table 114.1 The set of evaluation metrics

First level index	Second level index
Economic benefits	Return on capital employed(X_1)
	Debt-to-asset ratio(X_2)
	Asset maintaining and increase ratio(X_3)
The condition of the enterprises in the park	Number of enterprises in the park (X_4)
	Gross asset of the enterprises in the park(X_5)
	Annual gross income of the enterprises in the park(X_6)
	Satisfaction degree of the enterprises in the park(X_7)
	Loyalty of the enterprises in the park(X_8)
Park ability	Storage area(X_9)
	Annual freight Volume(X_{10})
	Delivery capacity(X_{11})
	Processing capacity(X_{12})
	Estate service capacity(X_{13})
	Informatization level(X_{14})
	Goods damage rate(X_{15})
Social benefits	Number of new employment(X_{16})
	Influence on the urban traffic(X_{17})
	Full Load Rate(X_{18})
	Energy saving and emission reduction(X_{19})

The BP neural network can also deal with qualitative and quantitative knowledge. It's operation is very fast, and has strong learning and forecast ability. Therefore this paper using BP neural network model evaluates the operation effects of logistics park. The specific procedure is as follows:

(1) *The number of neurons*: In this paper, the BP neural network will use three layer structures, namely, input layer, hidden layer and output layer.

   a. *Input layer node*: The number of input layer node is the set of evaluation metrics. There are 19 input nodes.
   b. *Hidden layer node*: The number of hidden layer node is related to the number of input layer node, the character of sample data and the character of the unsolved problem. To determine the number of hidden layer node, we usually use the experience formula: $q = \sqrt{n + m} + a$. Among them, n is the number of input layer node, m is the number of output layer node, a = 1, 2,…, 10. Through several tests, 10 is the optimal number of hidden layer node.
   c. *Output layer node*: The results of the evaluation are output layer node. According the analysis, the number of input layer node is 19; the number of hidden layer node is 10; and the number of output layer node is 1.

(2) *The initialization of weight value and threshold value*: According to the set of metrics, the index is divided into two kinds of indexes, namely, qualitative index and quantitative index. Dealing with qualitative index, we generally use the expert scoring method, and for the quantitative index we use normalized processing. Generally, weight value and threshold value of initialization is the random number from −1 to 1.
(3) *The positive information transmission*: In this paper, we use sigmoid function to process network transmission, and purelin function to process transmission is in output layer. After confirming the number of each layer node and transmission function, we initialize the BP network again.
   The output vector of hidden layer is $y = f_1\left(\sum w_{ij}x_i + a_i\right)$, the output vector of output layer is $y = f_2\left(\sum w_{jk}y_j + a_j\right)$.
(4) *The reverse error transmission*: Calculation the error E of network. If error E is less than the previously set error ε, the network training process is over, and the output value is approximated the expected value. Otherwise we proceed the reverse error transmission of output layer and hidden layer node.
(5) *Confirm the final evaluation results*. Calculating the global error function $E = \sum \varepsilon_k$, if E < ε the training process is over. According to the final output value results, the greater the output value, the better the operation effects of logistics park. From very good to very bad, the output value is divided to six levels, very good (0.9–1), good (0.8–0.9), preferably (0.6–0.8), general (0.4–0.6), bad (0.2–0.4), very bad (0–0.2).

114.4 The Model Training and Testing

According to the set of evaluation metrics and the BP neural network theory, we establish the model steps. Using the initial, training and simulation functions of Matlab7 neural network tool box, it can quickly complete the network training process.

(6) *Selection of sample data*: Let the 19 indexes of the set of metrics as the input node, the simulation data of the set of metrics of front five logistics park W_1–W_5 as the training sample, and the back three logistics park W_6–W_8 as the testing. Normalizing the input data, the input data is shown as Table 114.2.

(7) *Determination of network structure*: The number of input layer node is 19, the number of hidden layer node is 10, and the number of output layer node is 1. The network structure figure is shown as Fig. 114.1. The transmission function of hidden layer node is sigmoid, and the transmission function of output layer node is purelin.

(8) *Model training*: The training time is 265, target error is 0.001, learning rate is 0.01, using Matlab to calculate the algorithm.
After 800 times training, the network overall error is in the range of target allowable error. The prediction error figure is shown as Table 114.3. The training is over.

Table 114.2 Normalization input datas

Index	W_1	W_2	W_3	W_4	W_5	W_6	W_7	W_8
X_1	0.046	0.035	0.058	0.035	0.044	0.040	0.031	0.052
X_2	0.043	0.037	0.055	0.037	0.041	0.026	0.036	0.040
X_3	0.038	0.033	0.052	0.029	0.049	0.036	0.037	0.049
X_4	0.037	0.023	0.048	0.032	0.033	0.041	0.042	0.033
X_5	0.033	0.030	0.050	0.030	0.036	0.046	0.046	0.026
X_6	0.030	0.026	0.042	0.029	0.042	0.048	0.044	0.022
X_7	0.045	0.032	0.047	0.031	0.037	0.039	0.053	0.048
X_8	0.044	0.034	0.049	0.033	0.040	0.051	0.058	0.046
X_9	0.085	0.092	0.067	0.111	0.078	0.056	0.099	0.088
X_{10}	0.075	0.072	0.055	0.094	0.069	0.053	0.082	0.086
X_{11}	0.068	0.085	0.056	0.087	0.062	0.062	0.076	0.079
X_{12}	0.071	0.078	0.057	0.094	0.065	0.061	0.065	0.070
X_{13}	0.074	0.081	0.055	0.105	0.059	0.067	0.063	0.092
X_{14}	0.068	0.075	0.060	0.092	0.071	0.072	0.061	0.093
X_{15}	0.060	0.066	0.058	0.084	0.063	0.078	0.059	0.085
X_{16}	0.050	0.055	0.043	0.020	0.049	0.060	0.031	0.014
X_{17}	0.049	0.049	0.046	0.016	0.046	0.053	0.033	0.012
X_{18}	0.051	0.050	0.050	0.030	0.059	0.069	0.044	0.038
X_{19}	0.033	0.047	0.052	0.011	0.057	0.042	0.040	0.027

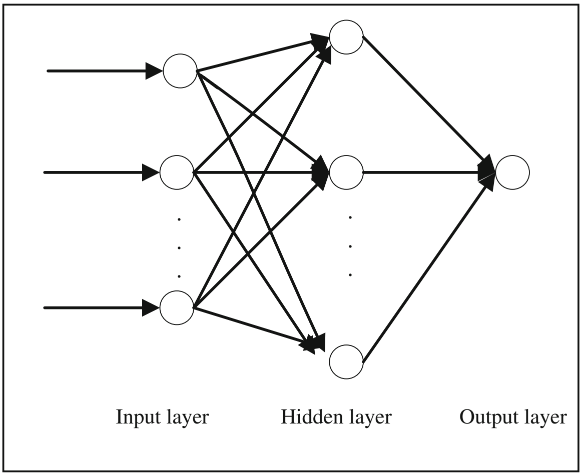

Fig. 114.1 The network structure figure

Table 114.3 Forecast error table

Sample	W_1	W_2	W_3	W_4	W_5
Expect output	0.613	0.411	0.513	0.783	0.535
Network forecast	0.607	0.395	0.509	0.788	0.533
Forecast error	0.006	0.016	0.004	−0.005	0.002

(9) *Model testing*: Using the network which has already been trained, we can get network output value of the three samples. The network output value of W_6 is 0.488, W_7 is 0.752, W_8 is 0.613. The network output of W_7 is the better one.

114.5 Conclusion

In this paper, we have studied the influence factor of the operation effects of logistics park, and establish the set of evaluation metrics of the operation effects of logistics park. Through the BP neural network model, the operation effects of logistics park have been analyzed, then the manager of the logistics park can find the shortage of the operation process, and furthermore, can improve the operation of logistics park.

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Chapter 115
Application of Ant Colony Algorithm on Secondary Cooling Optimization of Continuous Slab

Ji-yun Li and Hong-xing Pei

Abstract Continuous casting secondary cooling water is one of the key factors to the quality of slab. Reasonable surface temperature maximum rate of cooling and surface temperature rise speed of every secondary cooling stage can reduce the factors that causing inside and surface crack of the slabs. The optimized model of continuous casting secondary cooling was established according to metallurgy criterion (include Goal surface temperature, Straightening spot temperature, surface temperature maximum rate of cooling, surface temperature rise speed, fluid core length etc.) and equipment constraints request. The water of continuous casting secondary cooling was optimized by ant group algorithm to improve the quality of slabs.

Keywords Ant colony algorithm · Continuous casting · Optimization · Water assignment of secondary cooling

115.1 Introduction

The continuous casting of steel solidification technology is important innovation, Second cooling is continue strengthening cooling to slab that out from mould to accelerate the cooling process of slab (Laitinen et al. 2003). Through the improvement of secondary cooling system, optimize the secondary cooling water, can realize the uniform cooling slab, then get higher inner and surface quality of the casting slab. Therefore, the optimization to second cooling is one of the

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E. Qi et al. (eds.), *The 19th International Conference on Industrial Engineering and Engineering Management*, DOI: 10.1007/978-3-642-38391-5_115,

important measures of efficient continuous casting technology. Highly effective casting has become important technologies to optimize steel industry structure of our country (Natarajan and El-Kaddah 2004).

115.2 System Optimization Model

Slab, in the continuous casting process, under certain assumptions (Ying et al. 2006), ignores heat slab width direction, can be simplified as one-dimensional heat transfer, the solidification and heat transfer equation (Radovic and Lalovic 2005).

$$\rho C \frac{\partial T}{\partial t} = \lambda \frac{\partial^2 T}{\partial x^2}$$

where: ρ is density of every phase of steel, kg/m^3, C is specific heat capacity of every phase of steel, J/(kg•K), λ is thermal conductivity of every phase of steel, W(m·K).

Slab along the direction of the casting speed is separated into (0 to n) cross-sections. Get the integral of each different spatial position in a unit on heat transfer partial. The result is the ordinary differential equations relative to temperature T on the time derivative. Derivative that temperature on the time calculated through chase method to ordinary differential equations. By the time derivative of the temperature on the slab surface temperature can be obtained (Lotov et al. 2005).

Secondary cooling system determined by continues casting metallurgical criteria, device constraints, heat transfer model of different kinds of steel type. The aims that integrate optimization secondary cooling system are to let the temperature distribution of slab rationalization. This can get the best slab quality and yield. The optimization method is: The value of objective function constructed by metallurgical criteria is Minimum. Assuming second cooling paragraphs water and converted into integrated heat transfer coefficient under constraint of industrial conditions. Substitute these into simulation model of heat transfer calculation as third boundary condition. To obtain transfer function distribution of second cooling zone that meet the various metallurgical criteria and determine the distribution of secondary cooling water quantity.

Optimization model of the system expressed by M. Control vector $\lambda = [\lambda_1, \lambda_2, \ldots, \lambda_n] \cdot T$. Where, n is the number of segments of cooling water section. Optimization model determined by metallurgical criterion and equipment constraints (Bergh and Engelbrecht 2006). Optimal control parameters based on the performance guideline that establishment of comprehensive evaluation on object function. And the object function must optimize according to certain rules. Optimization model in the derivation use the following symbols:

$$f^* = \begin{cases} f & f > 0 \\ 0 & f \leq 0 \end{cases}$$

115.2.1 Optimal Model Determined by Metallurgical Criteria

1. Target temperature of surface
   T_z, target temperature of slab surface, is determined by steel type and production technology. The actual surface temperature $T_{(h,z)}$ should close enough to target temperature of slab surface.

$$J_1 = \left[T_{(h,z)} - T_z\right]^2 \tag{115.1}$$

2. Straightening point temperature
   Control $T_{(tc,h)}$, surface temperature of slab, at straightening point above the T_c, brittle temperature (Santos et al. 2006), when strong cold. Avoid brittle "pocket area".

$$J_2 = \left\{\left[T_c - T_{(tc,h)}\right]^*\right\}^2 \tag{115.2}$$

3. The maximum cooling and surface temperature rise rate
   Control cool rate less then T_d (°C/m) to avoid the slab surface temperature in the low ductility zone led to crack propagation. When slab out from model, temperature rise rate must be controlled less than T_r (°C/m) to prevent the solidification front within the slab under the action of the tension cracks (Lan et al. 2002)

$$J_3 = \left\{\left[\frac{\partial T_{(h,z)}}{\partial z} - T_r\right]^*\right\}^2 + \left\{\left[\frac{\partial T_{(h,z)}}{\partial z} - T_d\right]^*\right\}^2 \tag{115.3}$$

4 Liquid core lengths
  Liquid hole in the slab must be completely solidified before straightening point T_d.

$$J_4 = [(L_m - L_d)^*]^2 \tag{115.4}$$

5 Bulging of slab
  Bulging of slab solidification will cause front tensile stress, may lead to breakage and segregation solidification front. Surface temperature $T_{(h,z)}$ of slab should be controlled less than 1100 °C (Gutjahr 2002) to prevent large bulging.

$$J_5 = \{[(T_{(h,z)} - 1100)]^*\}^2 \tag{115.5}$$

115.2.2 Optimal Model Determined by Equipment Constraints

Casting speed and actual water of secondary cooling sections are in a certain range in the production.

$$J_6 = \{[(V_{\min} - V)^*]^2 + [(V - V_{\max})^*]^2\} \tag{115.6}$$

$$J_7 = \sum_{i=1}^{n} \{[(\omega_i - \omega_{i\max})^*]^2 + [(\omega_{i\min} - \omega_i)^*]^2\} \tag{115.7}$$

Normalize the Formula 115.1–115.7 can obtain Optimization model of system.

$$J = \sum_{i=1}^{n} \frac{J_i - J_{i\min}}{J_{i\max} - J_{i\min}}$$

115.3 Ant Colony Algorithm

115.3.1 Principle of Ant Colony

Ants release pheromones in action. The information less volatilize in the shorter path. The pheromone effect as a signal to the other's actions, And then the pheromone left by the original pheromone is enhanced by latecomers. The results of continue cycle is that more ants visit the path, more probability of path chosen. Within a certain period of time, the shorter path will be visited by the more ants. Thus there will be more pheromone in the shorter path. More pheromone means a shorter path, which means better answer (Gao and Yang 2006).

115.3.2 Algorithm Described and Procedures to Ant Colony

Optimization of continuous casting secondary cooling can be described as a minimization problem. It means that find an optimal solution in feasible solution set, so objective function M has a minimum value, m ants are randomly placed on the structural map of the nodes. The ants move random according to the pheromone in path of the current point. The movement of ants is limited by the constraints w. The program of the arithmetic as follows:

N according to the first section of the secondary cooling zone to calculate the actual water surface temperature

1. Calculate the surface temperature of the nth section in second cooling zone according to actual water flow;
2. Initialize the parameter; Set the maximum number of iterations N_{max}, and number of ants K;
3. Construct solutions for the ants in accordance with the following formula (Wang et al. 2008);

$$P_{i,j}^{k}(t) = \begin{cases} \frac{[\tau_{i,j}(t)]^{\alpha} \cdot [\eta_{i,j}(t)]^{\beta}}{\sum_{j \in tabu_k} [\tau_{i,j}(t)]^{\alpha} \cdot [\eta_{i,j}(t)]^{\beta}}, & j \in tabu_k \\ 0 & , others \end{cases}$$

where $tabu_k$ is node set that ant k has scanned at point c_k.

4. Update pheromone
   To every ants that completed construct solution, the pheromone volatilize in accordance with the following formula.

$$\tau_{i,j}(t+1) = (1-\rho) \cdot \tau_{i,j}(t)$$

   where, $\rho \subset (0,1)$, is evaporation coefficient of pheromone.
   Let $\hat{s} \subset S$, is the best feasible solution found so far. Increase the pheromone that $\hat{s}'$ path in accordance with the following formula.

$$\tau_{i,j}(t+1) = \tau_{i,j}(t) + \rho \cdot \Delta\tau$$

5. Let $\tau_{\min} > 0$ is the minimum pheromone value requirements. $\tau_{i,j} = \max\{\tau_{\min}, \tau_{i,j}\}$;
6. Repeat steps 3–5 until all the ants converge to one path or reached the maximum number of iterations *Nmax*.
7. Let $n = n+1$. Repeat steps 1–6 until the last section of the secondary cooling zone.

115.4 Optimization Results and Analysis

The secondary cooling of continues slabs are optimized according to the actual production equipment, process parameters, physical properties parameters of steel.

The restriction are straightening point temperature greater than 900 °C, surface cooling rate less than 200 °C/m, surface temperature rise rate along casting less than 100 °C/m, metallurgy length 21.58 m. No-optimized and optimized surface temperature of slab is as Fig. 115.1.

After optimization, the maximum cooling rate and surface temperature rise rate are both lower than before. The maximum cooling rate is drop from 152 to 72 °C/m. The maximum surface temperature rise rate is drop from 34 to 12 °C/m. The surface temperature distribution is flat. These reduce the stress factors that induced slab inner and surface cracking.

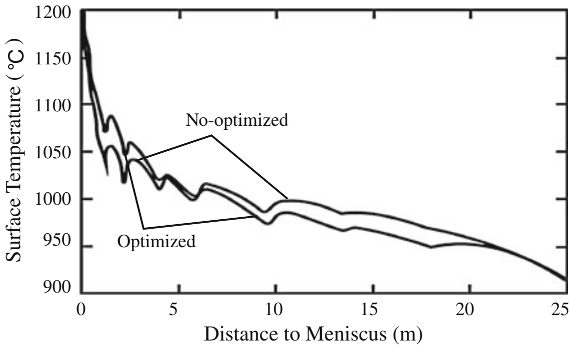

Fig. 115.1 No and optimized surface temperature of slab

115.5 Concluding Remarks

The optimized model of continuous casting secondary cooling was established according to metallurgy criterion (include Goal surface temperature, Straightening spot temperature, surface temperature maximum rate of cooling, surface temperature rise speed, fluid core length etc.) and equipment constraints request. It is in favor of continues casting real-time control that fast optimization to system model using ant colony.

Use ant colony to optimize continues casting second cooling water flow. It is tends to reasonable after optimization that surface temperature maximum rate of cooling and surface temperature rise speed of every secondary cooling stage. These reduce the stress factors that induced slab inner and surface cracking. It meets the criteria for the improvement of metallurgical slab cooling process and improves product quality requirements.

Acknowledgments The correspondent of paper is Hong-xing Pei. His research area is Mechanical and Electronic Engineering, application of computer and automation.

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Chapter 116
Application of the Catastrophe Progression Method in Employment Options for Beijing, Shanghai and Guangzhou

Qun Yuan, Ting Chen and Yang Gao

Abstract Aimed at the choice problem of employment city among Beijing, Shanghai and Guangzhou, working conditions, living conditions and other indicators about employment in the various cities are studied in this paper. To get the comprehensive evaluation score situation of the three cities, the catastrophe progression method was applied to establish the corresponding index system and make a specific analysis and comprehensive evaluation. It provides a theoretical basis to choose the employment of the three cities. The application of the catastrophe progression method is more appropriate and accurate than the fuzzy mathematics method without giving a weight to the evaluation indicators.

Keywords Catastrophe progression method · City system · Employment · Normalization formula

116.1 Introduction

Beijing, Shanghai and Guangzhou are China's three first-tier cities, there are thriving and talent. From the economy, the culture to the standard of living, the three cities are the elites of China's cities. Thousands of people arrived here dreaming to create their own place in the world. So which city is the right city to work in? All the data in the article is rooted in the three cities "statistic almanac" (2011).

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E. Qi et al. (eds.), *The 19th International Conference on Industrial Engineering and Engineering Management*, DOI: 10.1007/978-3-642-38391-5_116,

116.2 The Basic Idea of the Catastrophe Theory and Evaluation Steps

116.2.1 The Basic Idea of the Catastrophe Theory

Catastrophe is a process that its stationary state suddenly and discontinuously changes to a new steady state. Catastrophe theory is an emerging discipline of catastrophe study created by the French mathematician R. Thom in 1972. It is a mathematical theory based on singularity theory, topology and stability theory to discuss the compliable relationship between those control variables and the characteristics of system state variables. It is recognized as "a revolution in math after calculus". The basic features of this theory is make an classification of the critical points of the system based on a potential function of the system, study the features of state changing nearby the classified critical points, then sum up a number of elementary catastrophe models as the basis to explore the natural and social catastrophic phenomena (Dou 1994). It has been a useful tool in studying in-continuous phenomena since it was established. By means catastrophe progression method that derived from the catastrophe mode of catastrophe theory can be widely applied in multi-criteria decision problem.

The total evaluation index is divided by multi-hierarchical contradictory groups at first, then with the catastrophe fuzzy subordinate function which is from the combination of catastrophe and fuzzy mathematics, the total function value can be got through recursion operation with the unitary formula, finally comprehensive evaluation results obtained.

116.2.2 Evaluation Steps of Catastrophe Progression Method

(1) Firstly, establish the catastrophe assessment indexes system. According to the purpose of the evaluation system, the total indicators is divided into multi-hierarchical contradictory groups and the system arranged in tree structure of the level of purpose, obtain the more concrete quantifying indexes. Some indexes may have to be decomposed further. The decomposition will be stopped until the metered indexes are obtained. But the number of control variables in catastrophe system should not be more than 4, so the sub-indexes of a single index had better not be more than 4 (Liang et al. 2008).

(2) Determine the index system of each levels catastrophe system model. R. Thom had classified a special kind of mapping f: Rn → R of singularities, namely smooth mapping f: Rn → Rd a r parameter family (for any limited n and all r $\leqq$ 4) locally equivalent to one of the seven kinds of structural stability family of functions, called the seven elementary catastrophe (Zhang et al. 2009). And there are several commonly used catastrophe systems: cusp catastrophe system, swallowtail catastrophe system and butterfly catastrophe system. The feature of

several basic catastrophe models and each model's details is showed in Table 116.1.

The f(x) is the potential function of the state variable x. The coefficient a, b, c, d indicated the control variable of system in Table 116.1. State variable and control variables of system potential function are two contradictory aspects, and their relations are showed in Table 116.1. Usually, the primary control variable is write in front and the secondary control variable in the back. If the total evaluation index in this system is only divided into two sub-indexes, it is called cusp catastrophe system. If the total evaluation index is divided into three sub-indexes or four sub-indexes, the system can be regarded as swallowtail catastrophe system or butterfly catastrophe system.

Deduce the normalization formula from bifurcation equation. By the equation in Table 116.1, the following are the procedure: let the potential function of the catastrophe system be f(x). According to catastrophe theory, the critical points of the potential function form an equilibrium surface, The equation of the surface is obtained by a first derivative $f'(x) = 0$ and the singular point set of the balanced curved surface can be obtained through a second derivative $f''(x) = 0$. So by $f'(x) = 0$ and $f''(x) = 0$, we can obtain the equation of the set of bifurcation points of the catastrophe system by eliminate x in the equation (Li 2004).

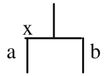
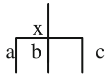
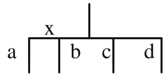
The decompose difference equation reflects the relationship between the control variables and the state variables is received by the state variables. The normalization formula is derived from the decomposition forms of the equation of the bifurcation point set. Through the normalization formula, the different states of the control variables of the catastrophe system are transformed into states (Yu 2008).

In the normalization formula, the value range of x and those control variables are form 0 to 1. and we must follow two principles in the calculation: complementary and non-complementary (He and Zhao 1985). The complementary principle implies that the control variables complement each other so that each of them tends to reach the average value, which is calculated by $x =$ average (x_a, x_b, x_c, x_d). And the non-complementary principle indicates that the control variables of a system, such as a, b, c and d cannot make up each other's shortage (Shi et al. 2003). Therefore, when finding the value of the state variable x using the normalization formulas, the smallest of the state variable values corresponding to the control variables is chosen as the state variable value of the whole system (Huang 2001).

(3) Implement comprehensive evaluation by the normalization formula. Based on the theory of fuzzy multi-objective decision making, to the same solution, in a variety of target, if put A_1, A_2,…,A_m for fuzzy goal, the ideal strategy should be $C = A_1 \cap A_2 \cap \ldots \cap A_m$, and its membership functions is $\mu(x) = \mu_{A1(x)} \wedge \mu_{A2(x)} \wedge \ldots \wedge \mu_{Am(x)}$, which $\mu_{Ai(x)}$ is the membership function of A_i (Wan et al. 2006).

Different program for C_1,C_2, …, C_m, the membership functions of the program C_i can regard as $\mu_{ci}(x)$. Because the initial mutations are series the bigger the better type, so total membership functions are also the bigger the better. So if $\mu_{ci}(x) > \mu_{cj}(x)$, it means the program C_i is better than C_j. Then we can get the

Table 116.1 Several basic catastrophe models

Type	Cusp catastrophe system	Swallowtail catastrophe system	Butterfly catastrophe system
Model	$f(x) = x^4 + ax^2 + bx$	$f(x) = 1/5x^5 + 1/3ax^3 + 1/2bx^2 + cx$	$f(x) = 1/6x^6 + 1/4ax^4 + 1/3bx^3 + 1/2cx^2 + dx$
Diagram			
Variables	a, b	a, b, c	a, b, c, d
The equation of bifurcation	$a = -6x^2$ $b = 8x^3$	$a = -6x^2$ $b = 8x^3$ $c = -3x^4$	$a = -10x^2$ $b = 20x^3$ $c = 15x^4$ $d = 5x^5$
Normalization formula	$x_a = \sqrt{a}$ $x_b = \sqrt[3]{b}$	$x_a = \sqrt{a}$ $x_b = \sqrt[3]{b}$ $x_c = \sqrt[4]{c}$	$x_a = \sqrt{a}$ $x_b = \sqrt[3]{b}$ $x_c = \sqrt[4]{c}$ $x_d = \sqrt[5]{d}$

result of advantage and disadvantage ordering of every evaluate target by the score of the total evaluation index (Liang et al. 2008).

116.3 Establishment of a Catastrophe Index System

According to the different levels and the application of analytic hierarchy process and categories of the evaluation indicators, the establishment of assessing indicators system for employment options is shown in Table 116.2. The original data is adopted by "Statistic Almanac" (2011) to ensure the accuracy (Shanghai Municipal Bureau of Statistics 2011; Guangzhou Municipal Bureau of Statistics 2011; Beijing Municipal Bureau of Statistics 2011).

Based on the requirement of catastrophe theory, the primary control variable write in front and the secondary control variable write in the back. According the divided of catastrophe system, from Table 116.2, the third-class indexes from top to bottom are swallowtail catastrophe system, swallowtail catastrophe system, cusp catastrophe system, butterfly catastrophe system, butterfly catastrophe system, swallowtail catastrophe system, swallowtail catastrophe system, cusp catastrophe system, swallowtail catastrophe system, cusp catastrophe system, swallowtail catastrophe system, which consist of 32 indexes and record these as x_1, x_2, x_3,…,x_{32}; The second-class are cusp catastrophe system, swallowtail catastrophe system, cusp catastrophe system and butterfly catastrophe system respectively, which consist of 11 indexes and record these as y_1, y_2, y_3…y_{11}; The first-class is butterfly catastrophe system which consist of 4 indexes and record these as z_1, z_2, z_3, z_4 (Gao et al. 2008).

116.4 The Process of Calculation

According to the requirements of the catastrophe progression method, at first normalize the control variables of the catastrophe model. In this system, there is a positive index (the larger the better) and negative index (the smaller the better),among the indices x_4, x_6, x_{18}, x_{19}, x_{20}, x_{22}, x_{17}, x_{21}, x_{30}, x_{31}, x_{32} are negative index and by using Eq. (1) form 0 to 1, the other indices are positive index and by using Eq. (2) shape 0–1 (Liang et al. 2008). If the value of the control variable is between 0 and 1, data processing is not needed (Yao et al. 2008).

They can be used directly to catastrophe progression calculation. Finally, according to the normalization formula of each catastrophe program, we can combine upward gradually of the indicators, until the highest assessment is realized (Chen 2004).

Table 116.2 The indexes of employment of options

First-class index	Second-class index	Third-class index
Work conditions	Employment opportunity	1. New employment posts (million)
		2. Urban units in average salary (yuan)
		3. The employment agency success rate (%)
	Employment security	4. Labor dispute number (count)
		5. Minimum wage for employees (yuan)
		6. Unemployment rate (%)
Living conditions	Infrastructure	7. Public investment (billion yuan)
		8. Municipal construction investment (billion yuan)
	Environment	9. Good rate of environmental air quality (%)
		10. Per capita green area (m^2)
		11. Green coverage rate (%)
		12. The environmental protection investment proportion of GDP(%)
	Transportation	13. Per capita roads length (km)
		14. Every per capita operation public vehicles number
		15. Every per capita taxi operation vehicle number
		16. Passenger volume (millions · miles)
Living costs	Housing	17. Lease contract dispute number (count)
		18. The average selling prices of residential (yuan/square)
		19. Average house lease price index
	Consumption	20. Resident consumption level (yuan for each person)
		21. Consumer spending as a percentage of disposable income (%)
		22. Consumer spending per person (yuan)
Livelihood	Social security	23. Basic annuities minimum standards (yuan)
		24. Minimum living standard of urban residents (yuan)
	Health care	25. Per population doctor number
		26. Per population number of beds
		27. The fitness activity places number
	Education	28. Regular institutions of education number
		29. Every ten thousand people collect books
	Urban security	30. The criminal case number of knowledge
		31. A civil case number of knowledge
		32. The traffic accident number

For The-Larger-The-Better indices:

$$x_i = \frac{x\max - x}{x\max - x\min} \tag{1}$$

For The-Smaller-The-Better indices:

$$x_j = \frac{x - x\min}{x\max - x\min} \tag{2}$$

For example of Beijing, the calculating process is as follows:

(1) According to complementary catastrophe model, the second-class index of employment opportunity gets the catastrophe function which is calculated by normalization formula:

$$U_{x1} = \sqrt{0}; U_{x2} = \sqrt[3]{1}; U_{x3} = \sqrt[4]{1};$$

Average these results:

$$U_{y1} = (U_{x1} + U_{x2} + U_{x3})/3 = 0.6667$$

Similarly:

$$\begin{array}{lll} U_{y2} = 0.5757 & U_{y3} = 0.4523 & U_{y4} = 0.75 \\ U_{y5} = 0.9453 & U_{y6} = 0.3245 & U_{y7} = 1;\ U_{y8} = 0.5 \\ U_{y9} = 0.9788 & U_{y10} = 0.9182 & U_{y11} = 0.3639 \end{array}$$

(2) According to complementary catastrophe model, the first-class index of the working of city gets the catastrophe function which is calculated by normalization formula:

$$U_{y1} = \sqrt{0.66671};\ U_{y2} = \sqrt[3]{0.5757};\ U_{y3} = \sqrt[4]{0.4523;}$$

Average these results:

$$U_{z1} = \left(U_{y1} + U_{y2} + U_{y3}\right)/3 = 0.8242$$

Similarly: $U_{z2} = 0.8557$; $U_{z3} = 0.7848$; $U_{z4} = 0.874$;

(3) According to complementary catastrophe model, the total index of employment opinions gets the catastrophe function which is calculated by normalization formula:

$$\begin{array}{ll} U_{z1} = \sqrt{0.8242} & U_{z2} = \sqrt[3]{0.8557}; \\ U_{z3} = \sqrt[4]{0.7848} & U_{z4} = \sqrt[3]{0.874} \end{array}$$

Average these results:

$$U_z = (U_{z1} + U_{z2} + U_{z3} + U_{z4})/4 = 0.945$$

Similarly, the ultimate catastrophe function of Shanghai and Guangzhou and the catastrophe functions of the subsystems of other two cities can be realized (Tan et al. 1999). And the results of calculation are summarized in Tables 116.3 and 116.4.

116.5 The Results of Evaluate Indexes

As can be seen in the Table 116.3, the results of the optimization Beijing > Guangzhou > Shanghai. As the capital of our country, Beijing's total scores are the

Table 116.3 The results of the optimization

Position	1. Beijing	2. Guangzhou	3. Shanghai
Work conditions	0.8242	0.8751	0.69
Living conditions	0.8557	0.7173	0.8237
Living costs	0.7848	0.7487	0.7495
Livelihood	0.874	0.8549	0.6002

highest in the three cities. But its working is not as good as Guangzhou, Guangzhou which is china's leading opening up the city, and in 2010 succeeded in held the 16th Asian games, success made many employment opportunities and improve the quality of life. we can know the low standards of Shanghai is mainly due to the town average salaries is lower and the unemployment rate is higher compared with other city from the working of Table 116.4, and the inadequate of livelihood is mainly due to doctors and beds per capita (Gao et al. 2005).

116.6 Conclusion

(1) Urban system evaluation is a multi-level, multi-index and multi-criteria comprehensive evaluation problem. The inherent logic relation among indexes is used in catastrophe progression instead of the weight factor, so that the evaluation only need to consider the comparative importance of the indicators, avoiding the deficiency of static evaluation methods and human subjectivity, thus the results obtained are more quantitative and more subjective. The catastrophe function progression method adopts the normalization formula which of the calculation is small, so that making it easy to program and master. It is much more effectively and precise than general fuzzy mathematics to solve multi-objective evaluation problems for decision-making (Chen and Chen 2011).

Table 116.4 The low standards of Shanghai

Number	Shanghai	Beijing	Guangzhou
Employment opportunity	0.3333	0.6667	0.7901
Employment security	0.5171	0.5757	0.639
Infrastructure	0.6667	0.4523	0.2974
Environment	0.5897	0.75	0.4656
Transportation	0.4431	0.9453	0.4779
Housing	0.4624	0.3245	0.8254
Consumption	0.5492	1	0.2042
Social security	0.407	0.5	0.6616
Health care	0	0.9788	0.8372
Education	0.5	0.9182	0.3458
Urban security	0.6667	0.3639	0.58
Total score	0.945	0.9325	0.9004

(2) Through the evaluation analysis of three cities, establish the employment options index system of three cities, and according to the basic principle of catastrophe theory, carries on sorting to each influence factor by the importance of its objectives, respectively for the first-class index and the second-class index, and choose the third-class index able to represent the second-class index to calculate and analysis, and carries on the normalized computation gradually upwards, finally gets the evaluation results. It can be found the deficiencies of the cities from the evaluation results of the urban employment and provide the reasonable reference for the selection of employment city.

(3) Because the method can only handle within four control variables, it is not suitable for more than four control variables decision problem. Therefore the total indicators need to be divided into multi-hierarchical contradictory groups (Zhang 2009). There are various problems about score problem of the lowest indicators, all levels of decomposition problem, order of importance between the indexes of the same level and the complementary and the non complementary relationship between the indexes and so on, the catastrophe progression method needs to be researched and improved further.

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Chapter 117
Cooperation Relationship Analysis of Research Teams Based on Social Network Analysis and Importance Measures

Zheng-sheng Han and Zhi-qiang Cai

Abstract To overcome the disadvantages of qualitative methods in team relationship analysis, we introduce an adjacency matrix to modeling the cooperation relationships between team members and use the importance measures to evaluate the effect of a member on the team and the performance of the whole team. First of all, the weight adjacency matrix is developed based on adjacency matrix to describe the research team. In the weight adjacency matrix, a node means a member in the team, while the weight describes the cooperation relationship between members. Then, the social network analysis and importance measures are used to estimate the cooperation of members. Finally, the case study of a research team from Northwestern Polytechnic University is implemented to show the cooperation relationship results of the proposed methods.

Keywords Cooperation relationship · Importance measure · Research team · Social network analysis

117.1 Introduction

A team is a group of professionals working together for a common task, where a variety of disciplines may be represented. Because of the stimulation of shared knowledge and the advantage of a greater diversity of skills, teamwork offers benefits to all team members to achieve higher reputations (Young 1998).

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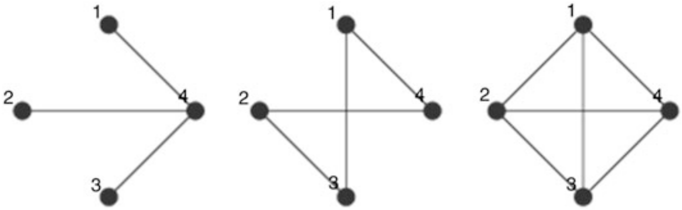
E. Qi et al. (eds.), *The 19th International Conference on Industrial Engineering and Engineering Management*, DOI: 10.1007/978-3-642-38391-5_117,

In science, research used to be implemented by single researcher. Nowadays, research team plays a very importance role in the student education and research innovation. It will be imperative for researchers to break the mentality of a single laboratory/single research focus and develop an interdisciplinary research team aimed at addressing real world challenges (Dodson et al. 2010). However, there are also some potential conflicts in research teams with poor relationships between team members, especially in huge research teams. It is very interesting to analyze the cooperation relationships of research teams to improve the performance of the whole team.

For several years, researchers have been focused on the cooperation relationships which affect potential benefits and costs of teams much. Ghobadi and D'Ambra (2012) conceptualized and implemented the multi-dimensional construct of cross-functional competition, and presented an instrument for measuring this construct. Dekker et al. (2008) investigated whether members of virtual teams from the U.S., India, and Belgium perceived the same cooperation behaviors to be critical for team functioning as Dutch members. LePine et al. (2011) reviewed the theoretical and empirical research on the role of personality in team cooperation, and found that team member personality is associated with various aspects of team functioning and effectiveness. Pagell and LePine (2002) reported a qualitative study aimed at identifying factors in operational systems that influence team effectiveness, including work organized around the team's output, opportunities for cooperation, novel problems to solve in work, and management trust in teams. Salmi (2010) analyzed case studies in the context of industrial business networks to explore the collaboration in international research teams and interest in business between international customers and their suppliers. Adams et al. (2005) explored recent trends in the size of scientific teams and in institutional collaborations according to the data derived from 2.4 million scientific papers written in 110 top U.S. research universities over the period 1981–1999.

However, most of the research works use the qualitative methods to describe the cooperation relationships in teams and to reflect their functions in team works. These results can provide little practicable suggestions for team leader in team managements. In this paper, we introduce an adjacency matrix to modeling the cooperation relationships between team members and use the social network analysis and importance measures to evaluate the effect of a member on the whole team.

The paper in all has 5 Sections and is organized as follows. In Sect. 117.2, the adjacency matrix is introduced to model the cooperation relationships in research team. The social network analysis and importance measures are applied to analyze the cooperation relationship in research team in Sect. 117.3. In Sect. 117.4, a case study is presented to show the implementation process of the proposed methods. Finally, Sect. 117.5 concludes the contributions of this work.



$$\begin{pmatrix} 0 & 0 & 0 & 1 \\ 0 & 0 & 0 & 1 \\ 0 & 0 & 0 & 1 \\ 1 & 1 & 1 & 0 \end{pmatrix} \quad \begin{pmatrix} 0 & 0 & 1 & 1 \\ 0 & 0 & 1 & 1 \\ 1 & 1 & 0 & 0 \\ 1 & 1 & 0 & 0 \end{pmatrix} \quad \begin{pmatrix} 0 & 1 & 1 & 1 \\ 1 & 0 & 1 & 1 \\ 1 & 1 & 0 & 1 \\ 1 & 1 & 1 & 0 \end{pmatrix}$$

Fig. 117.1 Examples of adjacency matrix

117.2 Methodology

117.2.1 Adjacency Matrix

In mathematics and computer science, an adjacency matrix is a means of representing which nodes of a graph are adjacent to which other nodes (Wikipedia 2012a). Specifically, the adjacency matrix of a finite graph G with n nodes is a $n \times n$ matrix. The non-diagonal variable a_{ij} may be 1 to represent an edge from node i to node j. It may also be 0 to represent none edge from node i to node j. The diagonal variable a_{ii} is always 0. There exists a unique adjacency matrix for each isomorphism class of graphs, and it is not the adjacency matrix of any other isomorphism class of graphs. If the graph is undirected, the adjacency matrix is symmetric. Figure 117.1 shows some examples of adjacency matrix (Wikipedia 2012a).

117.2.2 Modeling Research Team with Weight Adjacency Matrix

Because the traditional adjacency matrix can only represent the connectivity between nodes, we present a new weight adjacency matrix (WAM) to describe the characteristics of research team. It can evaluate the cooperation relationships between team members quantitatively.

A WAM also represents which nodes of a graph are adjacent to which other nodes. The diagonal variable a_{ii} is still 0. However, the non-diagonal variable $a_{ij}, -1 \leq a_{ij} \leq 1$ can represent an edge from node i to node j with weight. If $a_{ij} = 1$, it shows that node i and node j are connected with absolute positive relationship. If $0 < a_{ij} < 1$, it shows that node i and node j are connected with part positive

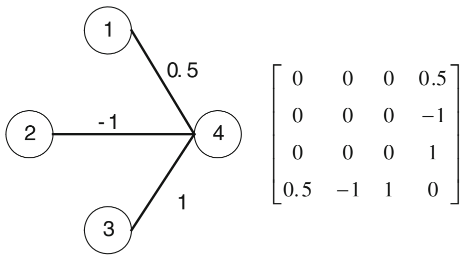


Fig. 117.2 An example of WAM

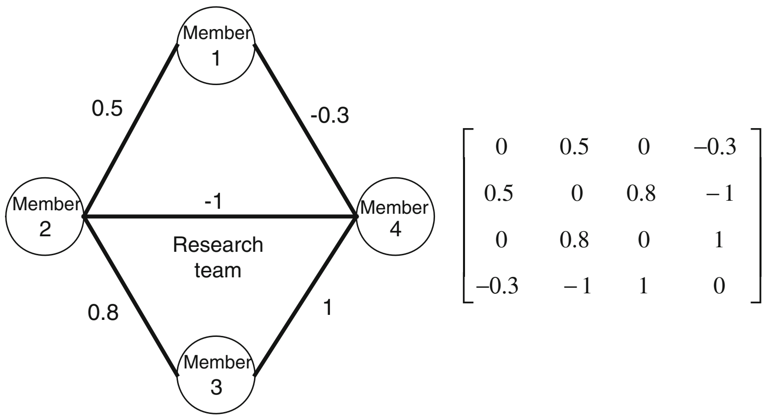


Fig. 117.3 An example of WAM for research team

relationship. If $a_{ij} = 0$, it shows that node i and node j are isolated with none relationship. If $a_{ij} = -1$, it shows that node i and node j are connected with absolute negative relationship. Figure 117.2 shows an example of WAM.

Usually, a research team is represented with a WAM. In the WAM, a node i means a member i in the team, while the weight a_{ij} describes the cooperation relationship between member i and member j. The research team can also be represented with the corresponding graph to get a more direct understanding. Figure 117.3 shows an example of WAM for research team.

117.3 Analysis of Research Team

117.3.1 Social Network Analysis of Research Team

Social network analysis (SNA) is the mapping and measuring of relationships and flows between people, groups, organizations, computers, URLs, and other connected information/knowledge entities. It provides both a visual and a mathematical analysis of human relationships (Krebs et al. 2012).

SNA has emerged as a key technique in modern sociology. It has also gained a significant following in anthropology, biology, communication studies, economics, geography, information science, organizational studies, social psychology, and sociolinguistics (Wikipedia 2012b). There are some popular measures of node and network in SNA, as follows.

Degree—the number of direct edges a node has. It means how many people this person can reach directly.

Density—the ratio of the number of edges in the network over the total number of possible edges among all pairs of nodes.

In the WAM of research team, the degree of member i is calculated as in (117.1). The density of the whole research team is computed as in (117.2).

$$a_i = \sum_{j=1}^{n} a_{ij} \tag{117.1}$$

$$a = \sum_{i=1}^{n} a_i \Big/ (n * (n-1)) \tag{117.2}$$

117.3.2 Importance Measures of Research Team

Components importance measures were first introduced by Birnbaum (1969). The Birnbaum importance measure quantifies the contributions of individual components to the system performance. Based on this achievement, a wide range of importance measure definitions have been proposed in the engineering field. The Fussell-Vesley importance measure was introduced by Vesley (1970) and used by Fussell (1975) in the context of fault tree analysis which depends on the current reliability of basic events.

Assuming that objective n-component system S under study is a binary system, the system has corresponding restrictions in analysis. First of all, the system S consists of n components which are described as $\{C_1, C_2, \ldots, C_i, \ldots, C_n\}$. Secondly, the system and all components in it can only have two mutual states, where $C_i = 0$ represents the function state and $C_i = 1$ means that the component C_i is failure.

The Birnbaum importance measure represents which impact has a component on the reliability of a system. So the Birnbaum importance measure is also called reliability importance. It can be calculated as (117.3), where $R(\cdot)$ represents the reliability function of system and components (Birnbaum 1969).

$$I(BM)_{C_i}^{S} = \frac{\partial R(S)}{\partial R(C_i)} \tag{117.3}$$

If the failure function of system and components is written as $F(\cdot)$, the Birnbaum importance could also be measured as (117.4).

$$I(BM)_{C_i}^{S} = \frac{\partial R(S=0)}{\partial R(C_i=0)} = \frac{\partial(1-F(S))}{\partial(1-F(C_i))} = \frac{\partial F(S)}{\partial F(C_i)} \tag{117.4}$$

From the aspect of probability distributions, (117.3) can be transformed as (117.5), which denotes the system reliability decrease when the component C_i degrades from function to failure state.

$$I(BM)_{C_i}^{S} = \frac{\partial R(S)}{\partial R(C_i)} = P(S=0|C_i=0) - P(S=0|C_i=1) \tag{117.5}$$

According to (117.5), in the WAM of research team, the Birnbaum importance of member i is calculated as (117.6) and (117.7).

$$BP_i = (a|a_i = n-1) - a \tag{117.6}$$

$$BL_i = a - (a|a_i = 0) \tag{117.7}$$

BP_i is the positive importance. Its physical meaning is the density increase of research team when member i is full connected with others. The one with highest BP_i should be paid attention for deep cooperation.

BL_i is the independent importance. It means the density decrease of research team when member i is full independent with others.

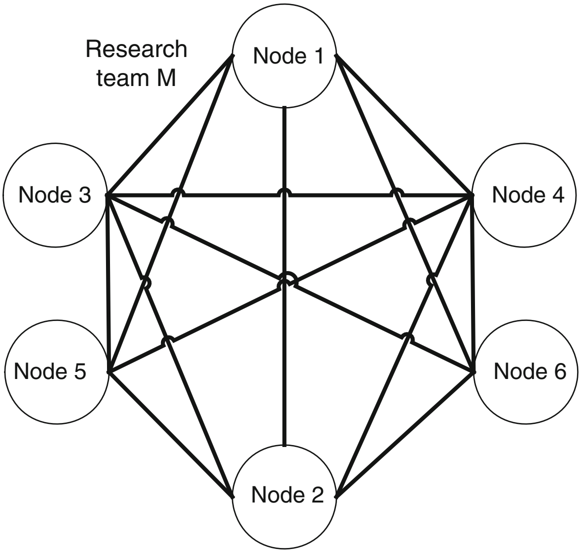
117.4 Case Study

We take a research team M in Northwestern Polytechnical University, China as an example to implement the case study. This research team has 6 full time faculties, including 2 professors, 3 associate professors and 1 assistant professor. Their research interests focus on mechanical engineering and have published more than 30 papers last year.

According to the concept of WAM, each member is represented with a node, such as professor 1 = node 1, professor 2 = node 2, associate professor 1 = node 3, associate professor 2 = node 4, associate professor 3 = node 5, assistant professor 1 = node 6. All members are connected with edges.

The weight of each edge represents the cooperation relationship between two members. So we introduce the co-author index to estimate the weight of each edge. The co-author index is calculated as (117.8).

Fig. 117.4 The practical WAM for research team M



$$\begin{bmatrix} 0 & 0.47 & 0.68 & 0.61 & 0.58 & 0.74 \\ 0.47 & 0 & 0.37 & 0.31 & 0.28 & 0.24 \\ 0.68 & 0.37 & 0 & 0.32 & 0.39 & 0.81 \\ 0.61 & 0.31 & 0.32 & 0 & 0.63 & 0.29 \\ 0.58 & 0.28 & 0.39 & 0.63 & 0 & 0.18 \\ 0.74 & 0.24 & 0.81 & 0.29 & 0.18 & 0 \end{bmatrix}$$

$$a_{ij} = \frac{\begin{pmatrix} \text{the number of papers published} \\ \text{by both node i and node j} \end{pmatrix}}{\begin{pmatrix} \text{the number of papers published} \\ \text{by node i or node j} \end{pmatrix}} \quad (117.8)$$

Finally, the established WAM of research team M is shown in Fig. 117.4

Based on (117.1) and (117.2), the degree of each member and the density of the whole research team M are listed in Table 117.1.

From Table 117.1 it is clear that professor 1 has the highest degree which verifies that he is the head and center of the team. Professor 2 has the lowest degree. This is because she paid more time on international cooperation which can't be revealed in this model. The rest members have similar degree. The Team density is 0.46, which shows that there are stable cooperation relationships in this team.

Table 117.1 SMA results of research team M

Member	Node	Degree
Professor 1	Node 1	**3.08**
Professor 2	Node 2	1.67
Associate professor 1	Node 3	2.57
Associate professor 2	Node 4	2.16
Associate professor 3	Node 5	2.06
Assistant professor 1	Node 6	2.26
	Team	Density
	Team M	0.46

Table 117.2 Birnbaum importance results of research team M

Node	a	a|ai = n−1	a|ai = 0	BPi	BLi
Node 1	0.46	0.588	0.255	0.128	**0.205**
Node 2	0.46	0.682	0.349	**0.222**	0.111
Node 3	0.46	0.622	0.289	0.162	0.171
Node 4	0.46	0.649	0.316	0.189	0.144
Node 5	0.46	0.656	0.323	0.196	0.137
Node 6	0.46	0.643	0.309	0.183	0.151

Then the Birnbaum importance of each member in research team M is computed with (117.6) and (117.7). The results are shown in Table 117.2. From Table 117.2, it is clear that professor 2 has the highest BP_i value, which means that if she is full connected with others, the density of research team will get the biggest increase. So, the team should paid attention to professor 2 for more cooperation. Professor 1 has the highest BL_i value, which means that if he leaves the research team, the density of research team will get the biggest decrease.

117.5 Conclusion

In this paper, we introduce a weight adjacency matrix to modeling the cooperation relationships between team members and use the social network analysis and importance measures to evaluate the effect of a member on the whole team. The case study of a research team from Northwestern Polytechnic University is implemented to verify the effectiveness of the proposed methods.

Acknowledgments The authors gratefully acknowledge the financial support for this research from the National Natural Science Foundation of China (Grant No. 71101116).

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Chapter 118
Establishment of Construction Standard System Based on the Complex System Theory

Zhi Sun and Shou-jian Zhang

Abstract Construction standard system is an organic whole, which is formed scientifically by construction standards within certain range. The systematic effect of standard system can make the construction activities get the optimum benefit. Construction standard system has dynamic, open and nonlinear characteristics in structure, environment and behavior aspects, and it is a typical complex system. This paper uses system science theory to reveal the complex adaptive characteristic of the standard system, provides the mathematical form of the system, and analyzes the emergent property mechanism of construction standard system. Finally, the structure modeling method of complex system is given according to the complex characteristic of standard system. This paper provides a new method and theory bases for the establishment of standard system.

Keywords Emergent property · Complex adaptive system · Complex system · Construction standard system (CSS)

118.1 Introduction

The quantity of construction standards has sharply increased along with the rapid development of construction industry. Most of these standards were formulated according to the foretime condition, and it caused some issues between construction standards after several years' development, such as discordance, imperfect supporting, unreasonable content, mutual repeated, and conflict. The

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E. Qi et al. (eds.), *The 19th International Conference on Industrial Engineering and Engineering Management*, DOI: 10.1007/978-3-642-38391-5_118,

standard system structure becomes more and more complicated, and it is hard to guarantee the normal operation and function properly.

Construction standard system has been investigated in a number of research studies. Existing research in this important area focused on the function and institution of the system. There are two trends of the construction standard system in the future: the developed countries' standard system will become the global standard with their business expansion around the world, the other trend is the mature standard system will still maintain the primary position along with their own construction industry development (Bredillet 2003). The reasonable supply of construction standard system can satisfy the building quality requirement of the enterprises and the consumers, and it also can bring the ideal economic and social benefits (Ofori and Gang 2001). Both "mandatory article" and "recommended standard".

Come along at the present stage in China. This management mode will be replaced by the "technical regulation" and "technical standard" management mode in order to adapt the new requirement of the market environment (Mu 2005; Yang 2003). Construction standards are divided into 18 professional categories in China. Each category's structure can be described by four levels: synthesis, base, general, and specialized level (Wang 2007). Construction standard system should contain the analysis of standard current situation, reasonable standard management system, flexible operating mechanism, demand of standard in 5–10 years and the harmonizing relationship of "technical regulation" and "technical standard". This is the development trend of the construction standard system (Mu 2005).

"So generally, project is more complex, the cost is higher, and the time limit for the project is longer" (Baccarini 1996). Along with the development of economic, the subject of investment of a construction project is diversification, and it makes huge investment project possible. More and more complicated management objects of organization, technology, time, quality go along with that, and it enhances the demand of construction standard. The standard system reflects the features of complex system gradually. Despite of the significant contributions of the above research studies, there is no reported research that focused on: (1) complex features of standard system; (2) emergent property of complex system; (3) establishment method of construction standard system based on complex system theory. Accordingly, there is an urgent need for additional studies to address these there critical research gaps, as shown in Fig. 118.1.

118.2 Analysis of Construction Standard System Complexity

Complex system is formed by a certain number of interaction elements. The interaction of each element can make system generate the self-organized behavior as a whole (Wu 2006). Standard is a scientific organic whole constituted by associated

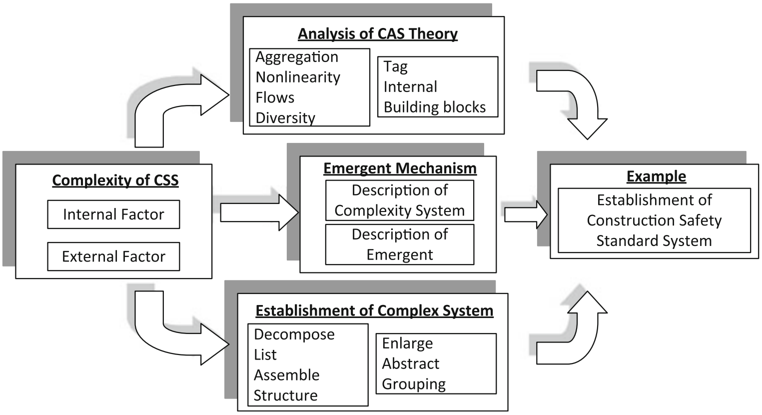

Fig. 118.1 The establishment model based on the complex system theory

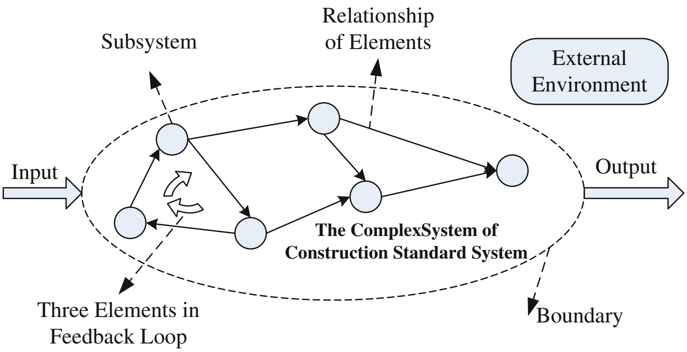

Fig. 118.2 The general concept of construction standard system

standards within a certain range. The system effect can make the economic activities get the best benefit. Construction standard system is an interdependence, mutual constraint, mutual complement and cohesion organic whole, which is formed by interconnected standards in construction field.

Figure 118.2 shows that the construction system is a complex system, and it is constituted by many elements and subsystem. The system is a multilevel, multiple target system formed by a number of construction standards. The complexity factors of construction standard can be described as external factor and internal factor. The external complexity is the condition of system complexity including open and dynamic. The internal factor is the reason of complexity, which contains complexity of elements, organizational relationship and information.

118.2.1 External Complexity Factor

Construction standard system is an open system, and it causes the complexity of the system. An open system has the exchanges of material, energy, information and knowledge with the environment. The way and degree of a system open, the way of system and environmental interactions will influence the complexity of the system. The elements and the subsystem of the standard system exist within the scope of certain constraints and space–time. The system has various contacts with all aspects of the construction field, and there are information, function, and benefit exchange between them. These dynamics cause the construction standard system to adjust and update constantly through the structure of the system, due to there is dynamics in feature, extent, quality requirements and technology development of the subjects of regulation. This discrete change is one of the most important reasons for the complexity system.

118.2.1.1 The Dynamics in the Area of Construction Laws and Regulations

Along with the development of economy and the field of construction, the laws and regulations of construction field must adapt to the development demand of construction activities. Specially, regulations about safety of people's life and property require the elements of the standard system to adjust accordingly.

118.2.1.2 The Development of Information and Communication Platform

The development of the Internet makes the information, energy and material exchange of construction standardization work in different way. It also brings out higher request on the speed of standard update and the standard system optimization. The platform makes the standard update cycle shorten greatly, and adds the complexity level of the system.

118.2.1.3 The Dynamics of Technology Environment Development

Technological innovation is transforming the economy at an accelerating pace along with the arrival of knowledge-based economy. As the main carrier of the technology transfer, construction standard need to update more rapidly in order to satisfy the request of technical progress. The more the standard system includes or relates discipline knowledge and technical type, the more complex of construction technology requirement is, and the projects need more and more high technology

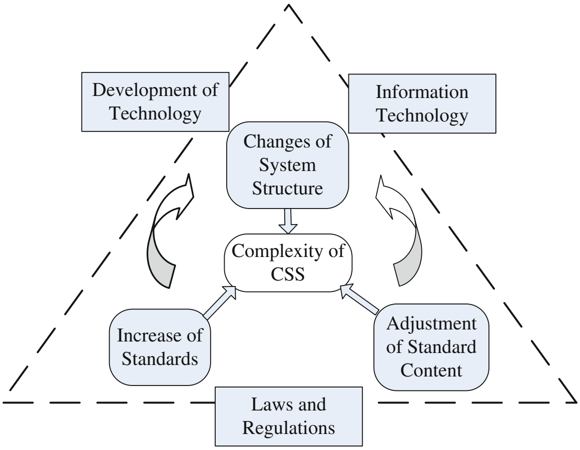

Fig. 118.3 External complexity factors of construction standard system

equipment, new materials and knowledge. These requirements enhance the complexity of standard system during the standard update.

The dynamic change of external factor of construction standard system is the origin of system adjustment. The dynamic of system causes the unsteadiness of the system. The disturbance of external elements is one of reasons of the complex system, as shown in Fig. 118.3.

118.2.2 Internal Complexity Factor

The internal complexity of construction standard system is caused by the complexity of standard system structure, the quantity of participating subject giant, the different objects of the system and the complexity of the feedback information, as shown in Fig. 118.4.

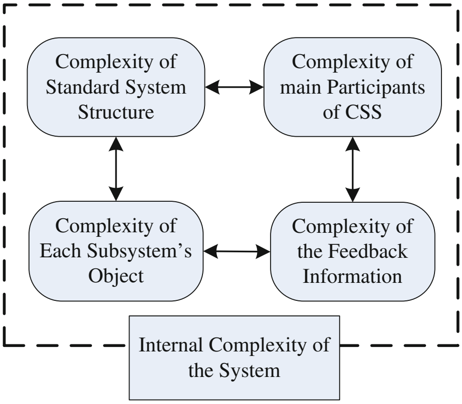

Fig. 118.4 Internal complexity factors of construction standard system

118.2.2.1 The Complexity of Standard System Structure

Construction standard system is constituted by a number of elements and subsystem. Each subsystem can be described by many sub elements, such as housing building standard system, urban construction standard system. Generally, the more levels system has, the more complexity system will get. There are many factors increase the internal complexity of the system, such as the interconnect interact between different levels and sub elements, the complex link between technology index, subjects and basic terminology. The standard system optimization is a dynamic process, and the update of each subsystem also shows dynamic characteristic.

118.2.2.2 The Complexity of Main Participants of Construction Standard System

The range of construction activities is very wide, and it not only contains the civil engineering and equipment installation, but also contains the materials, cost, infrastructure and other professional fields. These participants of the system influence each other in space–time, due to the establishment of system need the cooperation of participants. The establishment of construction standard system needs to cross multiple professional. The cross of the professional between transverse and longitudinal is very complicated, for example, the housing building subsystem needs the building design, structure, and foundation professional to combine in their respective stage. Each elements of the subsystem enters or exits the system in their own life cycle. So the complexity of the standard system embodies how to coordinate different professional standards in their different life cycle organically, thereby give full play to the function of the system, and reduce the conflict and contradiction between different standards.

118.2.2.3 The Complexity of Each Subsystem's Object

Construction standard system can be divided into 18 majors by different fields. Each major of the system has different subsystem object. The combination of the standards in each subsystem can evolve new system with different objects. The diversification and the pertinence of the system's function causes the complexity of construction standard standard system, finally complexity of the system reflects the complexity of each subsystem's aim.

118.2.2.4 Complexity of the Feedback Information

The feedback information of the construction standard system comes from owner, design institute, builder, supplier of the materials and the supervision units, and it also comes from different project stage, such as feasible research, design, bid inviting and construction process. The management process also generates large quantity of feedback information, such as quality control, investment control, progress control and the contract management. The feedback information from different units enhances the complexity of the information search during the system optimization process. The feedback information from related units may have contradiction, and the benefit may have consistency sometimes. The dependency and relevancy of feedback information from different related units, process, and environment can enhance the difficulty of the information collection and analysis of the information demanders.

118.2.2.5 The Analysis of Complex Adaptive Character of Construction Standard System

The research on the construction standard system is stuck in early stage of system science, which means the concept of elements, subsystem and the structure. The standards in system is completely passive, the purpose of their existence is to realize some task or function of the system, and these standards have no their own objects and orientations. The system can't "grow" or "evolve" in the environmental interactions, and it only can make fixed reaction according to the fixed mode even though there's some communication with external environment. The elements of the construction standard system can be regarded as an active and adaptive agent with their own purpose and initiative by using the theory of complex adaptive system.

Holland provided four characteristics of the study on the adaptive and evolutionary process about the concept of "agent": aggregation, nonlinearity, flows and diversity. He also gave three mechanisms: tag, internal, building blocks (Holland 1995; Jin and Qi 2010).

The constitutors of the construction standard system can analyze the demand of standard function, forecast the development direction of technology and take action according to the predetermined object. The constitutors can form an aggregate of organization in some particular field by "adhere", and this aggregate becomes the organization of standardization finally. The new aggregate develops in the environment, which has huge demand for the aggregate. The whole process can be considered as the motion of a subsystem. This aggregation relationship doesn't mean that every organization can adhere together. These organizations that comply with subsystem development goals, be helpful for standardization field, have the professional relativity can have this kind of aggregation relationship. This common object, conditions and rules of the choice are endowed with a cognizable form, which is called "tag".

"Nonlinearity" and "flows" are two characteristics of construction standard system. There is the exchange current of information, function and benefit between standards, subsystems, levels and standardization activities as previously mentioned. Moreover, the unblocked degree and turnover frequency of the "flows" are in a high level due to the complexity of the system. The elements and their characteristics are constantly changing, which is caused by the existence of the flows of information, function and benefit under the repeated interactions with the system. The changes don't follow the simple, passive, unidirectional causality and linear relationship, but are the active adaptive relationship. The previous experience can affect the future activities, and the changes are the complexity relationship of interaction and mutual entanglement actually.

The diversity of construction standard system is very common, such as the diversity of system dimensionality, objects of standardization and standard form. The primary reason is the diversity and instability of system, which is caused by the nonlinear function between internal system and the environment.

The constituters of construction standard system have the ability of foreseeing environment change and adjusting their own behavior. The constituters have the unique internal mechanism and decision model during the process of environment adapting and stress reaction. The way of reaction is judged by the internal mechanism. The whole process can be called "internal" for the system.

As a complexity system, the construction standard system is formed by the different combination way of many simple parts, which is defined as "building blocks". The complexity of the system doesn't depend on the number or size of the building blocks, but depends on the recombination of the original building blocks. In many cases, the old internal is often considered as the building blocks to generate new internal by the recombination.

118.3 The Analysis of Emergent Property Mechanism of Construction Standard Complexity System

The elements form the system according to some way, and it will produce the specific attribute, characteristics, behavior, function, which the whole system has but the parts don't have. The system theory calls this emergent property (Miao 2006). The most important thing to describe the construction standard system by using the system theory is to grasp the whole emergence of the system.

118.3.1 The Qualitative Description of Construction Standard System

There are a large number of elements involved in construction standard system, and the relationships between them are very complicated. On one hand the participants can't understand it deeply. On the other hand, the research on system can't be extended to the analysis of the whole system operation process, due to the dynamic of the system. The cognition and analysis on system should pick up the core influence variables from the huge number and multifarious qualitative

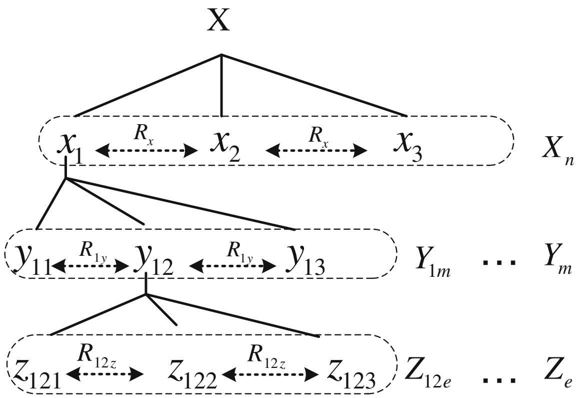

Fig. 118.5 The structure of abstract construction standard system

aspects, and get the related functional factors (Bo et al. 2002; Farley and Lin 1990; Berndsen and Daniels 1994).

According to the description of the complexity system, the paper uses the mathematical expression to describe a construction standard system with tertiary structure qualitatively:

The definition: the system X means a whole formed by n relational elements $x_1, x_2, \ldots, x_n$, measured as $X = \{X_n, R_x\}$, and $X_n = \{x_i | i = 1, 2, \ldots, n;\ n \geq 2\}$. R_x is the relation of these elements, called the soft structure of the system (Miao 2005). Meet the following conditions:

(1) $\exists$ a subsystem $Y = \{Y_m, R_y\}$, $Y \subset X_n$, $Y_m = \sum_{i=1}^{n} Y_{im}$, and $x_i = \{Y_{im}, R_{iy}\}$

$Y_{im} = \{y_{ij} | j = 1, 2, \ldots, m;\ m \geq 2\}$. Again the tertiary of the subsystem: $Z = \{Z_e, R_z\}$, $Z \subset Y_m$, $Z_e = \sum_{i=1}^{n}\sum_{j=1}^{m} Z_{ije}$, $Z_{ije} = \{z_{ijk} | k = 1, 2, \ldots, e;\ e \geq 2\}$, $y_{ij} = \{Z_{ije}, R_{ijz}\}$ The structure is shown in Fig. 118.5:

(2) $Z_m = AX_n^T$, in there $A = \begin{pmatrix} a_{11} & \cdots & a_{1n} \\ \vdots & \ddots & \vdots \\ a_{m1} & \cdots & a_{mn} \end{pmatrix}_{M \times N}$ $X_n = [x_i^l], (l = 1, 2, \ldots, L)$, and $L \geq 2$.

(3) $X_n \cap Y_m \neq \varnothing$, if the x_2 in X_n relates to the y_3 in Y_m, $X_n \cap Y_m = [x_2, y_3]$

The above expression means that the construction standard system also has the hierarchical, nonlinear and coupling characteristic.

118.3.2 The Emergent Property Mechanism of Construction Standard System

The emergent property of construction standard system comes from the elements, structure and the environment to the system. The effect of elements, scale, structure and environment make the whole emergent property of the system (Bo et al. 2002).

(1) The construction standard system is formed by the laws, regulations, standards and other elements, so the origin of the whole emergent property comes from each element. The emergent of system is restrained by the characteristic of the element, and that means the random combination of these elements can't form the system. (2) There's the relationship between the emergent and the scale of the system. The scale of the system is the essential condition of the complexity, and it's hard to emerge the complexity of a system from simplicity without enough elements. (3) The level and the characteristic of each element is the material base of the whole emergent property, and they only provide the objective possibility for generating the emergent. The interaction, mutual inspire, restraining and complement with each other between the different ways of every elements can generate the whole emergent, which is called structure effect, and it is the core source of the whole emergent property. (4) The external environment provides the necessary resources and constraint condition for the generating process of emergent. The construction standard system can get the resources from interaction with the external environment. The resources can help the system exploit system space, form the system boundary and establish the channel for exchanging material, energy and information with the construction activities. It also can make the system adapt new environment, enhance the anti-jamming capability. These exchanging results generate the emergent property of the system finally.

According to definition of complexity system and the mechanism of emergent property, we can deduce the emergent, which the system has but the elements don't have, mechanism abstractly.

According to the mathematical definition of the construction standard complexity system, system $X = \{X_n, R_x\}$, $X_n = \{x_i | i = 1, 2, \ldots, n;\ n \geq 2\}$ is the subsystem of X, R_x is the correlation set of elements $x_1, x_2, \ldots, x_n, x_i = \{X_i, R_i\}$, and x_i is in the $\bigcup_{i=1}^{n} X_i = X_n$.

The emergent of the system is reflected in $\bigcup_{i=1}^{n} x_i \subset X$, because $\bigcup_{i=1}^{n} X_i = X_n$, when $\bigcup_{i=1}^{n} R_i \subset R_x$, $\bigcup_{i=1}^{n} x_i \subset X$ is true.

Because:

(1) $\bigcup_{i=1}^{n} R_i \neq R_x$

Prove: suppose $\bigcup_{i=1}^{n} R_i = R_x$, only $R_x = \varnothing$ and $R_i = \varnothing$, or $R_x \neq \varnothing$ and $R_i = 0$. That means there's no soft structure between two subsystems, and it's inconsistent with definition of construction system: $X = \{X_n, R_x\}$, so usually have: $\bigcup_{i=1}^{n} R_i \neq R_x$

(2) $\bigcup_{i=1}^{n} R_i \supset R_x$ is not correct

Prove: because x_i is the subsystem of arbitrary system X, $x_i \subset X$is true for arbitrary system x_i, so $\bigcup_{i=1}^{n} R_i \supset R_x$

It's knowable that because of $\bigcup_{i=1}^{n} X_i = X_n$, $\bigcup_{i=1}^{n} R_i \subset R_x$, $\bigcup_{i=1}^{n} x_i \subset X$ finally.

Through the process of argumentation, the system has the function that the parts don't have, and this function comes from the soft structure of the system, which means the structure relationship of the parts.

118.4 Conclusion

The complexity system theory applies a new thinking and a rationale to the establishment of the construction standard system. The complexity of the standard system is caused by the internal and the external factor. External factor contains the dynamic of laws and technology environment, and the development of information technology. The internal factor contains the level of system, participants of the system, feedback information and complexity of the subsystem objects. This paper uses the theory of CAS, describes the complexity of the standard system. The construction standards form the system according to some objects base on the theory of emergent property. The system has the function and the characteristic which the parts or the total of part don't have.

Acknowledgments Foundation item: Project of the national twelfth-five year research program of China (2012BAJ19B03)

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Chapter 119
Location Selection of Coal Bunker Based on Particle Swarm Optimization Algorithm

Qing-an Cui and Jing-jing Shen

Abstract Center location selection of coal bunker is an important and practical problem in coal mine production. Because of the complex relationship between influence variables and optimization goal, it is frequent to reach a local optimization point rather than the global one by using linear programming. This paper combines nonlinear programming model and the algorithm of particle swarm optimization (PSO) to optimize the location selection of coal bunker in the coal mine transportation system. Firstly the coal bunker' center location selection problem is formalized and thereby the nonlinear programming model is constructed by minimizing the entire cost of the system. Secondly, the optimization model is solved by using the PSO algorithm and therefore the global optimization is reached. Finally the method mentioned above is verified by a typical coal bunker location selection example.

Keywords Coal bunker · Location selection · Nonlinear programming · Particle swarm optimization

119.1 Introduction

Coal bunker usually contains bottom coal bunker, district coal bunker, section coal bunker, ground bunker, tunneling bunker (Wang 1983). As the main cavern (Zhang 2010), coal bunker has an important role in the process of coal

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E. Qi et al. (eds.), *The 19th International Conference on Industrial Engineering and Engineering Management*, DOI: 10.1007/978-3-642-38391-5_119,

transportation. With the development of mechanization and production concentration levels of the transportation system in the coal industry, the importance of locating coal bunker is more and more significant in the transportation system. As the coal underground needs to be transported and carried through the system to the ground, one of the effective methods is to transport the coal mine underground to some special coal bunkers firstly, then to carry the coal to the ground in concentration, it is not only saves transportation cost, but also does improve transportation efficiency. The theme of this article is to study how to select location establishment of coal bunker, thus making the total cost of transportation least. It is important and difficult to research the location problem of coal bunker in the underground transportation system; the study of domestic existing literature is a little less, mostly focuses on coal construction and maintenance. For example, Zhen and Wang (Hua 2008) use particle swarm algorithm to research the problems of selecting monitoring stations in safety monitoring and underground transportation optimization system, and optimist coal layout to reduce the transportation fees, thus to enhance the transportation efficiency; Wei and Ma (Ma et al. 2012) introduce the construction technique of large deep coal bunker, and emphatically expounds key operation of protection system, and puts forward the corresponding measures for quality assurance to direct the similar project construction of coal. It is also a very practical application problem. On one hand, the selection of coal center is in relation to security of an underground transportation system; on the other hand, it links to the cost and efficiency of transportation. Therefore, it has the important practical significance to research the selection of coal bunker in this paper.

At present, it has won successful applications in the research of coal transportation problem based on genetic algorithm (Wu and Shi 2004), ant colony algorithm (Zhou 2006), simulated annealing algorithm (Qin and Shi 2007) and linear programming (Wang 2011). As the location selection of coal bunker in logistics system belongs to the discrete and combinatorial optimization problem, and has the properties of NP hard problem (An 2007). As it is not easy to realize the global optimization with linear programming, the value is mostly for local optimization, not enough to reflect the complex relationship between variables, but it is not for the nonlinear programming. Whereas, in the current stage, it doesn't have the most suitable algorithm that can ensure it gets the optimal solutions, and only can approximate to achieve optimal solutions in large probability. Therefore, according to this problem, this paper combines nonlinear programming model with the particle swarm optimization algorithm to optimize coal bunker in the transportation system.

Firstly, this paper introduces the basic principle of particle swarm optimization algorithm, then describes the location of coal bunker underground, and combines nonlinear programming model with particle swarm optimization algorithm to modeling and optimize it, and finally gets the optimization results.

119.2 Methodology

Particle Swarm Optimization (Kennedy and Eberhart 1995), which is known as PSO, put forward based on simulating birds' feeding behavior by Kennedy and Eberhart in 1995. It has characteristics of strong robustness (Niknam et al. 2009), it is bionics optimization algorithm that can handle complex optimization problem, and is a random search method reference to natural selection and biological particle swarm mechanism (Wang et al. 2009).

In the particle swarm optimization algorithm, each solution of optimization problem links to a particle (Ciurana et al. 2009), every particle has its position and speed, and then search for the optimal value according to the individual extremism P_{gest} and global extremism g_{gest} in the space.

The basic steps of particle updating are proposed to be summarized as follows (Wang and Li 2011):

(1) For each particle that selected as $x_i = (x_{i1}, x_{i2}, \ldots x_{id})$, the initial value is given with random method and initial flight rate as $v_i = (v_{i1}, v_{i2}, \ldots v_{id})$.
(2) Particles are flying in the search space, the flight rate of each step updates according to formula:

$$v_{id} = \omega * v_{id} + \phi_1 * rnd_1(p_{id} - x_{id}) + \phi_2 * rnd_2(p_{id} - x_{id}) \tag{119.1}$$

Among them, ω is for inertial weight, generally its init value is 0.9, and can be decreased to 0.4 with the linear increasing of iteration number (Huang 2011), which allows it to focus on global search firstly, and fast convergence in a certain area. ϕ_1, ϕ_2 are learning factors and normal numbers, and usually the value is 2, $rnd_1()$, $rnd_2()$ are random functions, the values range in (0, 1). P_{id} is for particles' best position on the history, P_{gd} is for the position of particle which has best fitness in all particles.

(3) Calculate the next step of the particle's location with the rate of current particle, namely

$$x_{id} = x_{id} + v_{id} \tag{119.2}$$

(4) Return to the second step to repeat calculating, until it reaches the limit value set or the evaluated number of function values is greater than that of the biggest function set.

119.2.1 Solving the Location of Coal Bunker Based on Particle Swarm Optimization Algorithm

Hypothesis that there exist n working surfaces in a range of underground, each working point is set as $q_1, q_2, \ldots, q_n$ respectively, and the coal production capacity of corresponding unit time is for $m_1, m_2, \ldots, m_n$ respectively. m_i is called as the productive capacity of working point q_i, considering the actual problem, the coal bunker only can be built on a particular point, or in a place edge of G. At present, the core problem is how to find point q, thus make the total cost as $F(q)$ minimum.

The coal bunker set belongs to the problem of cost minimum, namely that solving the minimization problem of transportation to minimize the cost. This paper selects a certain number of working points as resource points, and chooses a certain number of alternative points as the coal bunkers from alternative ones. In order to set a model easily, it makes the following assumptions: (Liu and Zhu 2005)

(1) The cost of resource point to point of the optional coal bunker is a linear function;
(2) The capacity of the coal bunker must meet requirements;
(3) Select coal bunker only in a certain range.
Here, the amount of resource points is called as m, the set is as $N = \{1, 2, \ldots, m\}$; the total number of alternative locations is remembered as $q, M = \{1, 2, \ldots, q\}$ is the set; A_j is for the total supply of each resource point j; M_k is the max capacity for alternative point $k(k \in M)$; C_{jk} is charge for unit transportation between candidate location and resource point $j(j \in N)$; l_{jk} is for transportation distance between optional point k and resource point j; F_k is the fixed expenses (including the cost of basic investment and fix management) of candidate location k on its construction; x_{jk} is the coal production in alternative point k from resource point j; C_k is Management cost of unit circulation in alternative point k; W_k is the decision variable whether optional point k is selected to be coal bunker. D_k is for the minimum demand of optional point k.The single objective optimization model on coal location is shown below:

$$F = \min \sum_{k=1}^{q} \left(\sum_{j=1}^{m} C_{jk} l_{jk} X_{jk} + \sum_{j=1}^{m} C_k X_{jk} + F_k \right) \tag{119.3}$$

Constraint conditions are as follows:

$$\sum_{k=1}^{m} X_{jk} \le A_j \tag{119.4}$$

$$\sum_{j=1}^{m} X_{jk} \le M_k \tag{119.5}$$

$$\sum_{j=1}^{m} X_{jk} \geq D_k \tag{119.6}$$

Among them, Formulas (119.4) is said that the total coal materials from resources j to the alternative points are not more than supply capacity; Formulas (119.5) is said that the total supply from the points of all coal resource to coal bunker k is not more than its maximum capacity; Formulas (119.6) is said that supply amount from the points of all coal resource is not less than its demand.

119.2.2 Building Model of Coal Bunker Location Based on Particle Swarm Optimization Algorithm

The main problem of coal bunker location in logistics system is to build some certain coal bunkers from candidate ones under the supply of a series of resource points. In other words, to optimize which coal bunker will be distributed from these resource points.

Therefore, particle position can be structured as following steps: For m resource points, q candidates of coal bunker, the current position of particle k is $X_k = \{x_{1k}, x_{2k}, \ldots, x_{mk}\}$, $x_{jk}(j = 1, 2, \ldots, m)$ is that transport coal resource to j, therefore, x_{jk} values interval in $[1,\ q]$. Select the adapt function as following form:

$$f_k = \sum_{j=1}^{m} C_{jk} l_{jk} X_{jk} + \sum_{j=1}^{m} C_k X_{jk} + F_k W_k \tag{119.7}$$

f_k is the adapt value of particle k, and the best adapt value of global is as:

$$g_{best} = \min\{f_k\} \tag{119.8}$$

P_{best} is the position owing the best adapt value that particle k has experienced, P_{best} is obtained by the following formulas :

$$P_{best}(t+1) = \begin{cases} P_{best}(t), & if\, f(X_k(t+1)) \geq f(P_{best}(t)) \\ X_k(t+1), & if\, f(X_k(t+1)) < f(P_{best}(t)) \end{cases} \tag{119.9}$$

Implementation procedure of algorithm is as follows:

(1) Initialization. Set the random position of particle swarm x_k, speed v_k and the maximum iterating times T, the initial particle randomly generates in the feasible domain of solution space;
(2) Calculate the adopt value of each particle according to formulas (119.7);
(3) For each particle, compare the adaptive value with the one on the best position P_{best} has experienced, thus to update the current best particle position according to (119.9);

(4) For each particle, compare the value on the best position P_{best} has experienced with the one on the global value g_{best}, thus to update the global best particle position;
(5) Update the value of the inertia weight w;
(6) The rate and position of the particles is iteration according to (1, 2);
(7) Update f_{best}, if it reaches maximum iterating times T, the cycle is over, and output optimal particle, its best position g_{best} and the value of optimal fitness; otherwise the cycle is not over, and return to step (2) to continue to operating.

119.3 Results

In order to validate the feasibility and effectiveness of particle swarm optimization algorithm in solving the coal bunker setting, use the following example to analysis and test.

Hypothesis that there are three resource points in coal underground logistics system, the supplements of resource are D_1, D_2, D_3, the values respectively are 60, 70, 80. Coal bunker's alternative points own four ones, the fixed cost, maximum capacity and minimum demands are shown in Table 119.1. Various rates are shown in Tables 119.2, 119.3 and 119.4.

Through using particle swarm optimization algorithm, the best choice for coal bunker and the results of coal transport distribution are shown such as in Table 119.5.

From the data in Table 119.5 and Fig 119.1, it can see that particle swarm optimization algorithm can quickly and effectively be used to get optimal solution or approximate optimal solution of the problem of coal bunker location, and it also has reference value to solve the similar problem about optimization.

Table 119.1 Alternative points of coal bunker

Alternative points	L_1	L_2	L_3	L_4
Fixed costs	90	80	110	70
Maximum capacity	40	30	60	20
Minimum demands	30	25	55	10

Table 119.2 Unit goods rate from resource point *j* to coal bunker's alternative point *k*

k				
j	1	2	3	4
1	7	8	13	13
2	10	10	9	8
3	11	8	11	9

Table 119.3 Unit distance from resource point *j* to coal bunker's alternative point *k*

k				
j	1	2	3	4
1	3	5	5	4
2	4	3	4	3
3	5	4	31	5

Table 119.4 Management fee rate of unit circulation in coal Bunker's alternative points

Alternative points	L_1	L_2	L_3	L_4
Management fee rate of unit circulation	80	90	95	85

Table 119.5 The quantity of goods from resource point *j* to coal bunker's alternative point *k*

k				
j	1	2	3	4
1	30	0	0	0
2	0	25	0	10
3	0	0	55	0

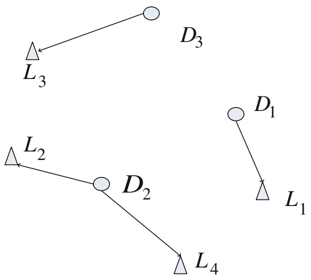

Fig. 199.1 Distribution relationship of coal bunker between resource points and alternative points

119.4 Conclusion

This paper solves the problem of coal bunker selection in underground logistics system on the case study based on Particle Swarm Optimization, and establishes the corresponding nonlinear model, thus to realize the cost minimization. The case shows that this method can be effectively applied in single target problem of location selection about coal bunker, thus to provide a new kind of optimization algorithm for coal bunker selection in coal underground logistics system.

Acknowledgments This paper is sponsored by Education Natural Science Foundation of Henan Province (No.2111A410003).

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Chapter 120
Mechanism of Firm's Response to Innovation Policy in Industrial Cluster: Based on Echo Model

Yong-an Zhang and Chen-guang Li

Abstract This paper presents a study of the behavior in firms receiving the government's policy support. It is emphasized that firm's attitude is an important factor to policy planning. Resource-based theory is also adapted to firm's response to the innovation policy of industrial cluster. In the perspective of complex adaptive system, policy responding has suffered from the influence of some factors such as comprehension, firm's scale, entrepreneur, benefit, innovative capability, demands for R&D and neighbor firms. Based on echo model, the paper discusses the mechanism of cluster firm's response to innovation policy. Furthermore, it describes the important role of various factors play in the process of policy responding and trigger condition. Finally, the behavior matching modes and self—adaptive responding flow have been analyzed. Findings show that the fundamental of firm's response to policy is resource—depending and self—organizing evolution ensures policy responding better and better.

Keywords Echo model · Industrial cluster · Innovation policy · Policy responding

120.1 Introduction

The industrial cluster (cluster) has a tremendous role in promoting the development of all sectors of society on the regional economy (de Oliveira Wilk and Fensterseifer 2003). It is no doubt about the positive role of regional innovation policy promotes enterprise technology research and innovation. Specially, in the

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E. Qi et al. (eds.), *The 19th International Conference on Industrial Engineering and Engineering Management*, DOI: 10.1007/978-3-642-38391-5_120,

industrial cluster, innovation policies conducts firms overcome the drawback of limited resource and innovation bottleneck by reciprocal investment and resource redistribution. However, asymmetry of policy information, longer return cycle, higher cost and standards of accreditation lead to the innovation policy responding effect is not very good. In recent years, scholars acknowledge that system theory is very helpful to policy studies about innovation policy towards societal challenges, rather than economic growth objectives only (Weber and Rohracher 2012). Moreover, due to the participation and influence of governments, S&T institutes, enterprises and other agents, policy issues are increasingly complex (Kern 2012). The implementation effect of innovation policy depends on two agents—governance and firms. On the one hand, government should be make a fair, reasonable, humane support policies based on firm's actual R&D requirement. On another, firms should respond positively after clear the policies provide foundational support (as money, materials, human-resource, etc.) and create a favorable environment by timely analyzing the policies' purpose and meaning. A new approach has being demand pressingly. From the macro point of view, we have to consider the mechanism of policy acting on innovative performance. And from the micro, the innovative performance is related with entrepreneurial attitude to the policy. The complex adaptive system (Holland 1995) and its echo model could research the issue from macro and micro aspect better. That is the reason the paper choose CAS theory. Firstly, we generalize the framework of innovation policy responding. Then, summarize the responding process. Finally, we find out key factors by literature analysis and build the Echo Model through advocating five mechanisms of firm responding innovation policy in Industrial cluster.

120.2 Research Framework

Using the echo model, researcher could solve the issue about mutual dissemination and absorption of firm's resource innovation by resource-based theory (Holland 1995). This paper sums up the echo model research framework as shown in Fig. 120.1. The model provides an analyze method of multi-agent interaction mechanisms for the government and industrial cluster's firms. The mechanism is divided into two segments naming control and tagging. The control segment includes selective response, resource acquisition, conversion, evolution and conditions of replication. The tagging segment is composed by offensive, defensive and adhesion.

For the process of policy response, the government realizes resource allocation by policy planning and implementing. Simultaneously, firms are responding to the policy for obtaining resource and engaging in innovation. These resources are usually divided into the information, funds, intellectual results, human resource and physical tools (Filippetti and Archibugi 2011). In this paper, innovation policy provides market information, funds, project items, human resource. The information includes guidance, specifications, market situation, technological advances,

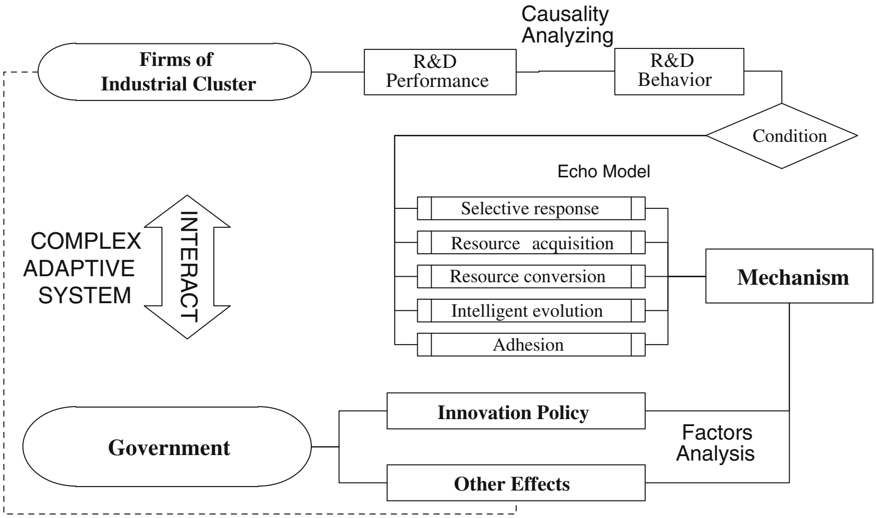

Fig. 120.1 Research framework

and R&D results. The funds are a collection of investment, subsidies, tax relief, etc. The projects provided by the government are stimulating cluster's firms R&D passion which has the form of major projects, fund projects, technology projects, and special projects. General, technology and R&D staff as human resource is supplying skill persons who are needed to Innovation R&D activities. Among them, the information and project providing by the government is an interactive resource which also could be shared. To be emphasized, the information only has the situation 'have' or 'None', and the remaining resource can be measured.

120.3 Response Mechanism Analysis Using Echo Model

After created echo model (Holland 1995) uses it to research group prisoner's dilemma and success to apply adaptive function in the process of multi-agent interaction for gaming. This paper will define agents as cluster's firms and government in the analysis of innovation policy response mechanism.

120.3.1 Key Factors

It is difficult to analyze the factors of innovation policy response directly (Coronado et al. 2008). And from the process of cluster's firms respond innovation policy perspective, a new thinking about key factors mining this paper proposed.

Based on the actual response to innovation policy, Scholars has been summarized seven key factors (such as shown in Table 120.1).

(1) *Cognition ability*: which is the ability to learn and understand, and the correct cognition of innovation policy is a prerequisite for cluster firm's response to the policy. Based on questionnaire survey, scholars believe that carefully

Table 120.1 Factors Affecting Firms Response to Innovation Policy

Factors	Literature analysis		
	Arguments	Variables	Scholars
1	Cognizing policy correctly is a precondition, and analyzing clause carefully and object clearly is crucial	Benefit qualification	Bessant (1982), Fichman (1997), Waarts(2002)
2	Larger firms often actively respond to policy, because they need to strengthen innovation capability, develop new market, and cooperate	Assets, employees, resources, liabilities	Souitaris (2002), Jeroen (2010), Paunov (2012)
3	Innovative entrepreneurs support innovation policy actively. An inert, questioning and inimical entrepreneurs hinder the policy implementation	RiskAppetite, firmaffiliation, location	Claver (1998), Horwitch and Mulloth (2010), Colwell (2010)
4	Direct invest and projects of policy affect firms' R&D and technology innovation which reduces cost and increases income. The expected return is key factor whether a firm responds policy	Funds, investment, cost, skillmennum, patent, profitability, tax relief	Simpson (1996), Huang (2007), Gilbert and Katz 2011
5	Innovation policy response willing depends on knowledge spillovers resource utilization, and innovation results promoting effect	Utilization and conversion rate of resource and knowledge, yield	Acs (1992), Mowery (2001), Audrets (2005), Grace and Shen (2010)
6	Policies effect meets the actual R&D requirement (including technical persons, R&D motivation and support), and firms responds policy depend on it could promote technology exchange and R&D activities	Direct invest of policy, R&D subsidy, staff welfare, R&D efficency, resource	Pavitt (1989), Breschi (2000), Palmberg (2004), Holmen (2007)
7	Policy implementation experience of cluster's inter-enterprise affects the response process, the cluster's firms will follow adjacent firms benefited	Cooperate willing, distance, information exchange frequency	Hadjimanolis (2001), Beneito (2003)

analyze and clearly understand the range of agents and limitations is very important.

(2) *Firm's size*: It limits innovation activities and capabilities, firms with different sizes have different attitude to policy response. Large scale firms tend to actively respond to innovation policy. And SMEs prefer subsidies and tax policy. The studies usually use the variables of assets, employees, resource, etc.
(3) *Entrepreneur's attitude*: It is a direct impact on whether a firm responds to policy. The studies usually use the variables of firms' diversification and position in the network of government and firms.
(4) *The results and income*: It is a key factor to firms' response policy. The studies usually use the variables of policy funding amount, project limits, innovation cost, Skillman incremental, patent and other results of incremental, new product profitability, tax relief and other income.
(5) *Innovation capability*: Policy can help to enhance firms' innovation capability is an influencing key factor of firms' response policy. The studies usually use the variables of yield, utilization and conversion rate of resource and knowledge.
(6) *R&D Requirement*: Innovation policy focuses on supporting firms' R&D innovation and R&D require meeting is also a factor of firms' response. The studies usually use the variables of direct invest of policy, R&D subsidy, staff welfare, R&D efficiency and resource.
(7) *Inter-Enterprise*: To measure the interaction between cluster firms and imitate innovation behaviors, cooperation and communication is so important. The studies usually use the variables of cooperate willing, distance and information exchange frequency.

120.3.2 Response Mechanism and Equations

The mechanisms of firm's response to innovation policy echo model is summarized, and each mechanism has its specific trigger conditions. In order to descript clearly, the model based on the classic Holland trigger rules to establish the matching pattern of the policy supply and firm's needs. The echo model chromosome structure contains five mechanisms as shown in Fig. 120.2.

(1) *Selection*: Cluster firm's response to innovation policy is a continuous 'stimulate-react' process, which according condition matching to ensure firm's attitude (Nybakk and Hansen 2008). Entrepreneur is the main factor of response. With resource-based theory, we think, the expected resource providing of policy influences entrepreneur whether respond the policy. On the one hand, they expect the amount of resource responding will be more than other activities. On the other, they also hope the benefits from responding will satisfy next innovation activity. At the moment t in the process, for R_i, a firm

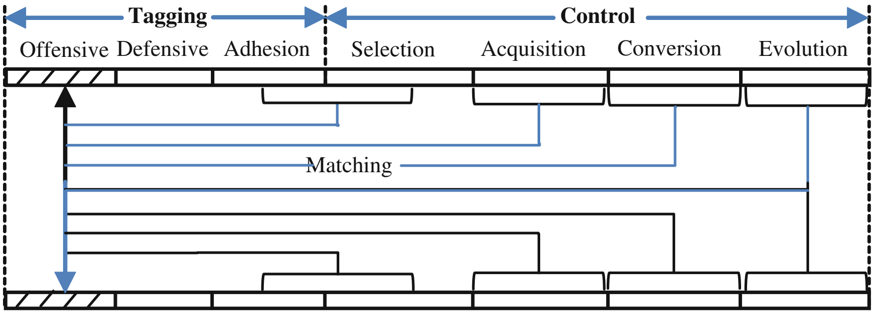

Fig. 120.2 Echo model chromosome of firm's response to innovation policy

has amount of resource $\overline{A}^t_{R_i}$, resource acquisition from response is $A^t_{R_i}$ and from others is $\triangle A^t_{R_i}$, resource of innovation use is $\tilde{A}^t_{R_i}$, Innovation policy should trigger two conditions as in

$$\begin{array}{c} D_1^t = \frac{A^t_{R_i}}{\triangle A^t_{R_i}} > 1, \\ D_2^t = \frac{A^t_{R_i} + \bar{A}^{t-1}_{R_i} - \tilde{A}^{t-1}_{R_i}}{\tilde{A}^t_{R_i}} > 1 \end{array} \tag{120.1}$$

Firms will select to respond the policy, as in

$$D_1^t \cdot D_2^t = \frac{A^t_{R_i}}{\triangle A^t_{R_i}} \cdot \frac{A^t_{R_i} + \bar{A}^{t-1}_{R_i} - \tilde{A}^{t-1}_{R_i}}{\tilde{A}^t_{R_i}} > 1 \tag{120.2}$$

It is emphasized that resource is not only cluster firm's innovation guarantee but the key point of response to policy. Compare to get income, resource acquisition meeting innovation require is the prime purpose of firm response to policy. So government needs to enhance resource supply in policy planning.

(2) *Acquisition*: Cluster firm's response to innovation policy is related to government resource supply. The resource which firms select themselves contains information (*R1*), funds (*R2*), projects (*R3*) and human resource (*R4*) (Kang and Park 2012). At the moment t in the process, a firm has resource $\bar{A}^t$ and consumes $\tilde{A}^t$. When $\bar{A}^t_{R_i} - \tilde{A}^t_{R_i} < \tilde{A}^{t+1}_{R_i}$, it will decide to respond to policy. Furthermore, because there is competition and cooperation relation between firms in cluster, so resource could disseminate from one firm to another. The $\triangle A^t_{R_i}$ denotes resource acquisition from other firms. If we do not consider the policy's effect, a firm maximum requires $\bar{A}^t_{R_i} - \tilde{A}^t_{R_i} + \triangle A^t_{R_i}$ at the $t+1$ moment. According to gaming theory, the government only needs to provide resource more than $t+1$ moment above mentioned, the firm will respond to innovation policy. The amount of resource is acquired from response as in

$$A_{R_i}^t = (1-\lambda)[\min(\tilde{A}_{R_i}^t, \bar{A}_{R_i}^t - \tilde{A}_{R_i}^t + \triangle A_{R_i}^t)] \tag{120.3}$$

Where, λdenotes the unexpected shrinkage of resource in the responding process ($0 \le \lambda < 1$).

(3) *Conversion*: In the process of resource converses to innovative results and income, different firm has different technology capability influencing conversion ratio. The trend of innovative results is Logistic curve (Rodríguez-Pose 1999). Traditional research shows that innovation results as in

$$Y = \alpha X - C \tag{120.4}$$

where, αdenotes technology results conversional coefficient, C denotes innovative cost. It is classic that income converted is relationship with resource, innovative capability and cost. However, the process is not a continuous and no technology effect in formula (120.4). So we reference Gilbert and Katz's standpoint to improve the formula (Gilbert and Katz 2011). We assume the policy responding process referred to n type's resource and conversional time t becomes shorter and shorter gradually with experience unceasing accumulating as in $1 - e^{-nht}$, parameter $h > 0$. Then, every innovative profit $I(T)$ converted from resource through technology T as in

$$\begin{aligned} I(T) &= \max_n \left\{ \alpha \int_0^{\infty} \left[nhI(T+1)e^{-(nh+r)t} dt - nc \right] \right\} \\ &= \max_n \left\{ \alpha \frac{nhI(T+1)}{nh+r} - nc \right\} \end{aligned} \tag{120.5}$$

Where, r denotes a changing parameter of resource convert to profits by technology. To all of firms, if $\alpha \le 0$, no response activity because of no profits. So $I > 0$ and $\alpha > 0$ is the condition of firms responding to innovation policy.

(4) *Evolution*: Firms as the agents who could realize evolution by experience accumulating from the study process of response. There are three kinds of evolution patterns based on firm's size. The first is passive evolution, which describes some firms depend on innovation policy intensively. Because they need the subsidy of policy to operate, so they have to respond policy. The process is a passive response, but after response their experience is accumulate to a database. And different responding patterns to different policy. The second is imitating evolution, which describes some firms depend on innovation policy generally. In this style, response process is decided by entrepreneurs who always follow large scale firms' experience in the cluster. The third is activity evolution, which describes some firms could select to respond policy or not themselves. Firms with this style often have their policy analysis sector which charges for statistic analyzing, evaluating the policy and establishing indicators of response. Firms also need to give government a feedback. The

evolution process is often from pattern 1–3. P_e denotes the probability of policy response experience as in

$$P_e = p\begin{cases} 0 < p < 0.4 & \text{first} \\ 0.4 < p < 0.7 & \text{second} \\ 0.7 < p < 1 & \text{third} \end{cases}$$

The probability of experience growing is random, which describes firms responding process is complex adaptive.

(5) *Adhesion*: By firm's experience accumulating, there are two connection styles. One names inertia connection, which describes some firms respond to innovation policy sustained through experience judging. Another is one time connection which describes some firms attempt to respond policy. The advantages of inertia connection are directly response without energy consuming and reduce the cost (Horwitch and Mulloth 2010). But some reason as qualification makes firm hasn't response and opportunity cost increasing. The selection of connection style is related to resource acquisition, conversion and the mechanism of selection. We assume that innovation policy j is responded by a firm, its sustained cost C''_{jk}, attempt cost C'_{jk}, and $C''_{jk} < C'_{jk}$. The intensity of inertia and attempt connection separately is μ''_{jk} and μ'_{jk} ($\mu''_{jk} + \mu'_{jk} = 1$). If unresponsive time t'at t time slice in the actual response process and $C''_{jk} \cdot t > C'_{jk} \cdot t'$. Then, reduce μ''_{jk} while increase μ'_{jk}. When the intensity equals 1, the process is stop. On the contrary, reduce μ'_{jk} while increase μ''_{jk}. If it appears inertia connection continuously, firms and policy is adhesion.

120.3.3 Analysis of the Response Process

In the industrial cluster firms interaction is so frequency, the process of a firm responding to innovation policy needs to consider other firms' influences and experience accumulation. The response may looks like a 'stimulate-react' and gaming activity with multiple variables of seven key factors affecting as shown in Fig. 120.3.

The matching mechanisms of policy response are a multi-agents process. The matching driver reflects the needs meeting of each other. And, the judgment of the trigger conditions should be based on agents' situation changes.

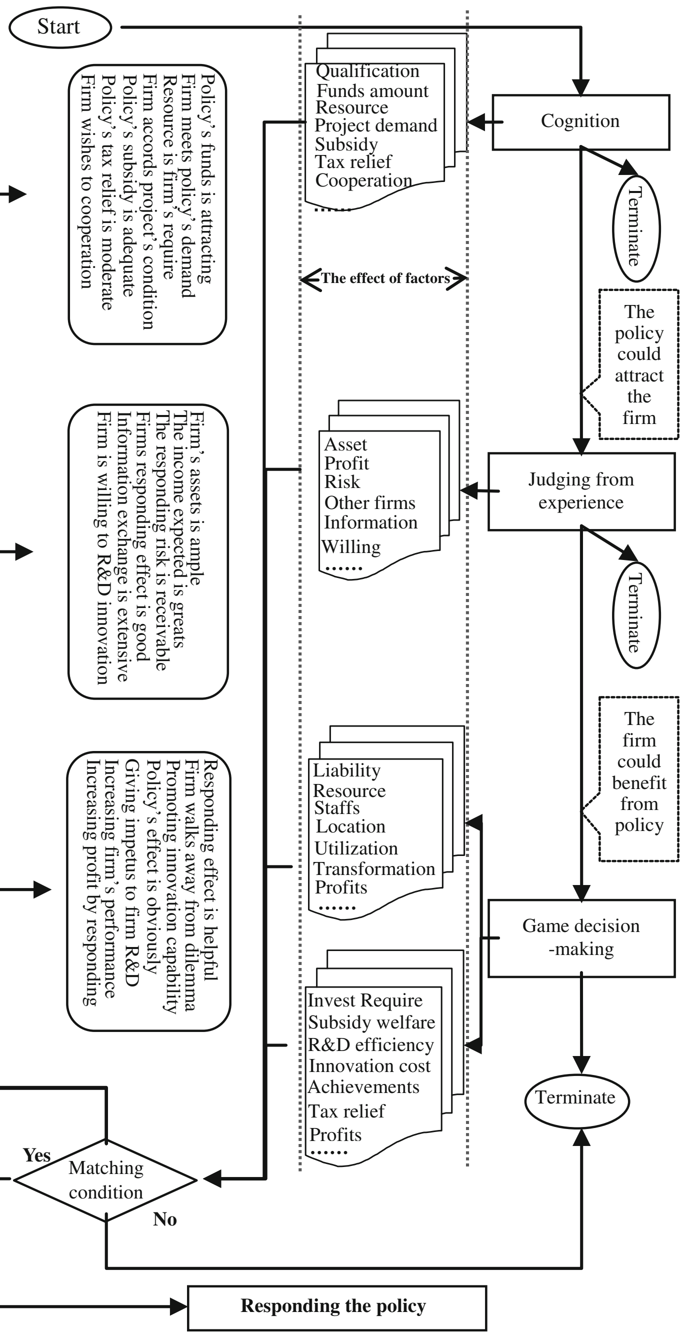

Fig. 120.3 Innovation policy response process

120.4 Conclusion

This study attempts to use echo model research on the response to innovation policy. It puts forward research frame based on CAS theory and establishes Echo model by response mechanisms analyzing. It is emphasized that firms in cluster pay attention to policy resource supplying. And other firms' experience also influences the policy response. Cluster firms response is a continuous 'stimulate-react' and gaming process. As experience accumulating, self-organizing evolution makes firms' policy cognitive capability and resource utilization increase gradually. This mechanism is important guarantee for benign response. On the one hand, government should focus on firms' requirement of innovation while cluster development planning. It is best to let firms participate in policy-making for ensuring the process to be impartial, opening and fair. Because of firms self-adaptive, the requirement of resource could be controlled within a certain range to achieve a balanced. It is not conducive to innovation with more and more resource, so government should seek a reasonable resource range of policy allocating in order to avoid the resource surplus. The other hand, the firm should avoid to blind pursuit benefit of policies and encourage staffs to analyze policy. Meanwhile, policy response could be incorporated into the innovative planning. Firms should respond to policy according their capability, and acknowledge the pros and cons of policy. The study also has some significance to government administration.

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Chapter 121
Modeling and Simulation of Troubleshooting Process for Automobile Based on Petri Net and Flexsim

Wei-zhen Liao, Kai-hu Hou, Yu-jie Zheng and Xiao-ling He

Abstract In this paper, Yunnan Y Automotive Company is taken as a research subject. Firstly, the troubleshooting methods from shallower to the deeper were summarized to find the origin of the defects quickly and efficiently. Then, the model of troubleshooting method was built by Petri net. What is more, the model was corresponded to single-queue and multiserver model and the optimal value of C corresponding to the optimal number of the quality engineer was calculated adopting marginal solving method. Finally, the results of calculation were simulated and verified using the simulation software Flexsim. Results indicate the troubleshooting method can detect the fault source efficiently.

Keywords Fault source · M/M/C queuing model · Modeling and simulation · Petri net · Troubleshooting

121.1 Introduction

Domestic studies on automotive failure: among the literatures, some scholars (Song and Yao 2009) used thousands of car failure data about auto after-sales service, from the perspective of statistical theory analysis to establish the reliability of theoretical models; some scholars (Luo and Zhu 2005) used a new pattern of support vector machine identification method to analysis and forecast short-term after-sales failure data, it was more reliable; in addition, reasoning

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E. Qi et al. (eds.), *The 19th International Conference on Industrial Engineering and Engineering Management*, DOI: 10.1007/978-3-642-38391-5_121,

method which was widely used in the automotive fault diagnosis expert system is fault tree and fuzzy set theory (Kong and Dong 2001; Ji 2003; Su 2011). In conclusion, most of the literature on the automotive failure analysis is simply about the after-sales data, although the created model has a certain reference value, but there is a strong lag; the fault tree, fuzzy set analysis methods can not be a good handling with fuzzy and concurrency of car fault feature extraction; in addition, these literature did not have simulation, their reliability needs to be elegant.

To make a breakthrough of three aspects which are mentioned above, this paper focuses on the process of cars production, to identify a process-oriented and experience-oriented approach that can gradually find fault source; combines with Petri Net and Flexsim to finish the modeling and simulation, handling with fuzzy, parallelism and concurrency of cars fault; using queuing theory to make quantitative analysis is more reliable.

121.2 About Petri Nets

Petri Net is a system model that uses P-element to represent the state, uses T-element to represent the changes and associates resources (material, information) flowing. Overall, it contains the state (Place), change (Transition), and flow.

So its mathematical definition (Su 2011) is a triple $N = (P, T; F)$

$P = \{p_1, p_2,\ldots,p_n\}$ is Place set, n is the number of the Place;
$T = \{t_1, t_2,\ldots,t_m\}$ is Transition set, m is the number of Transition;
F is a Set of ordered pair that consists of a P-element ana a T-element. And it meets $F \subseteq (P \times T) \cup (T \times P)$.

The characteristics of Petri Nets are mainly reflected in two aspects: first, it is realizability, the Petri Net systems must ensure that each Transition meets the laws of nature, so it can be achieved; the most prominent feature of Petri Nets is suitable for description and analysis of asynchronous concurrent systems on the various levels of abstraction.

121.3 Car Troubleshooting Method

In order to solve quality problems, the old and the new seven tools of quality management have been widely used in all aspects of business operations. These methods in the practical application have their respective strengths and focus, but they do not meet the authors' requirements: to identify the sources of the failure efficiently, step by step, from easy to difficult (Fig. 121.1 and Table 121.1).

According to the production of cars, combined with the experience of the staffs of the Yunnan Y Automotive Company, a new troubleshooting method is born.

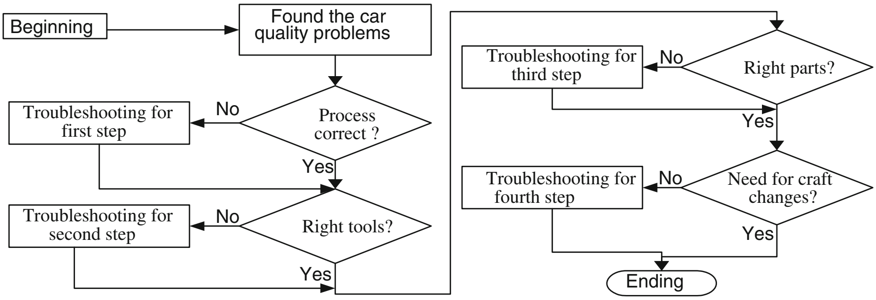

Fig. 121.1 Diagram for troubleshooting process

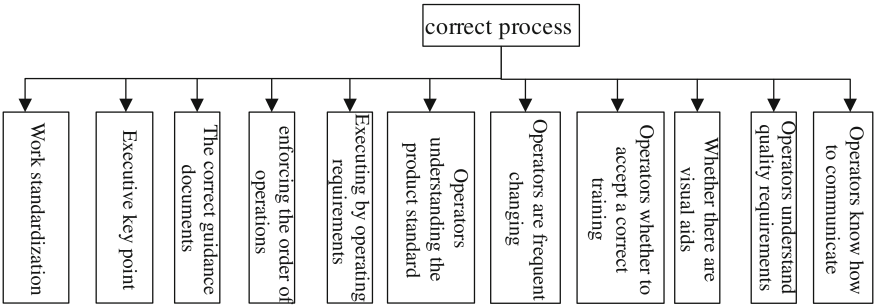

Fig. 121.2 Problems need to be shooting in the first step

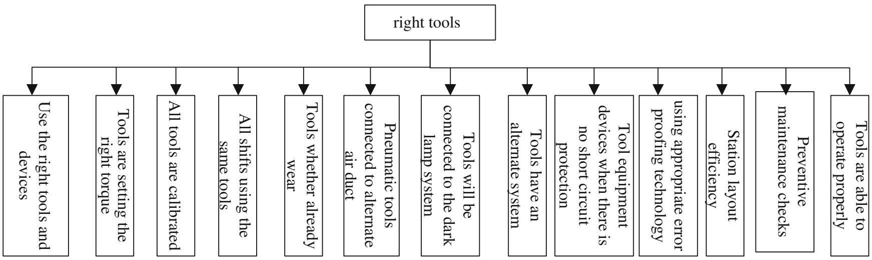

Fig. 121.3 Problems need to be shooting in the second step

It is the most effective method to determine the defect source of a standardized framework. It is used to promote the problem-solving. It can be decomposed into the following four steps: step 1—the correct process; step 2—the right tools; step 3—the right parts; step 4—the need for craft changes.

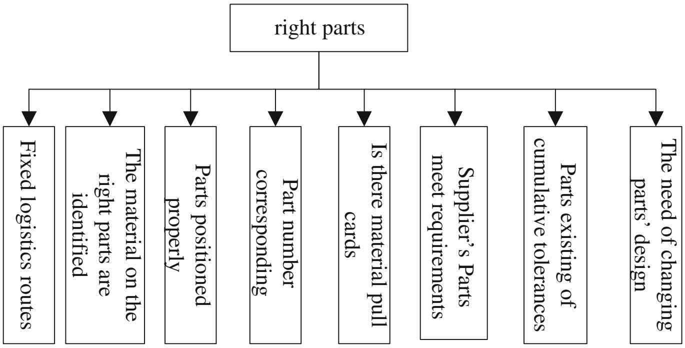

Fig. 121.4 Problems need to be shooting in the third step

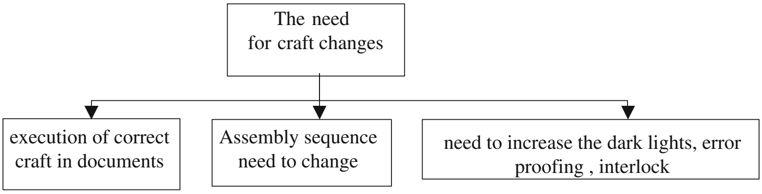

Fig. 121.5 Problems need to be shooting in the fourth step

121.4 Modeling and Analysis Combine with Petri Nets for Automotive Troubleshooting Process

121.4.1 Modeling with Petri Nets

Figure 121.6 is built models with basic Petri Net (Ren and Hao 2010; Su and Shen 2007; Xue et al. 2006). From Fig. 121.6, we know, nodes of the system are too much and model is too huge (Bourjij et al. 1993). In order to better express the logic relationship, so we references to the thought of Colored Petri Net (Wu and Yang 2007): through introduction of color transition and replacement reduces the complexity of system Petri Network model, making model intuitive and simple. modeling by using CPN-tools (Vinter et al. 2003) simplified as Fig. 121.7.

From Fig. 121.7, readers can stick out a mile to the entire car troubleshooting process; connection with Fig. 121.6, readers can get detailed reference, also can grasp from the overall and specific well for the whole troubleshooting process.

Table 121.1 The meaning of place and transition in Fig. 121.6

	Meaning
Place elements	
p_1	Appear car quality problems
p_{11}, p_{13}, …, p_{119}	No error state by searching 10 problems in Fig. 121.2
p_{12}, p_{14}, …, p_{120}	Error state by searching 10 problems in Fig. 121.2
p_2	The car still have failure after the first step
p_{21}, p_{23}, …, p_{215}	No error state by searching 8 problems in Fig. 121.3
p_{22}, p_{24}, …, p_{216}	Error state by searching 8 problems in Fig. 121.3
p_3	The car still have failure after the second step
p_{31}, p_{33}, …, p_{325}	No error state by searching 13 problems in Fig. 121.4
p_{32}, p_{34}, …, p_{326}	Error state by searching 13 problems in Fig. 121.4
p_4	The car still have failure after the third step
p_{41}, p_{43}, p_{45}	No error state by searching 3 problems in Fig. 121.5
p_{42}, p_{44}, p_{46}	Error state by searching 3 problems in Fig. 121.5
p_5	The car trouble shooting, returned to normal
Transition elements	
t_{11}, t_{12}, …, t_{110}	Search the corresponding 10 problems in Fig. 121.2 one by one
t_{21},t_{22}, …, t_{210}	Solve the problem of the first step
t_3	Check if the car can run normally
t_{41}, t_{42}, …, t_{48}	Search the corresponding 8 problems in Fig. 121.3 one by one
t_{51}, t_{52}, …, t_{58}	Solve the problem of the second step
t_5	Check if the car can run normally
t_{61}, t_{62}, …, t_{613}	Search the corresponding 13 problems in Fig. 121.4 one by one
t_{71},t_{72}, …, t_{713}	Solve the problem of the third step
t_8	Check if the car can run normally
t_{91}, t_{92}, t_{93}	Search the corresponding 3 problems in Fig. 121.5 one by one
t_{101}, t_{102}, t_{103}	Solve the problem of the fourth step
t_{10}	Start the car to show normal

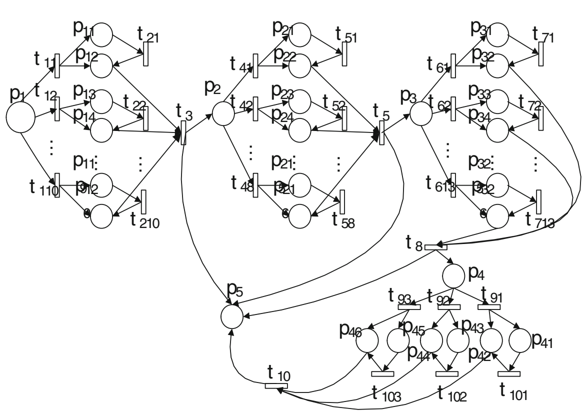

Fig. 121.6 Modeling of automotive troubleshooting based on Petri Net

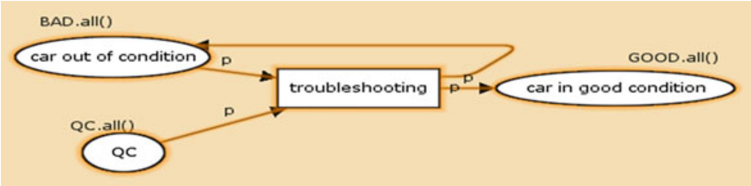

Fig. 121.7 Modeling of automotive troubleshooting based on Colored Petri Net

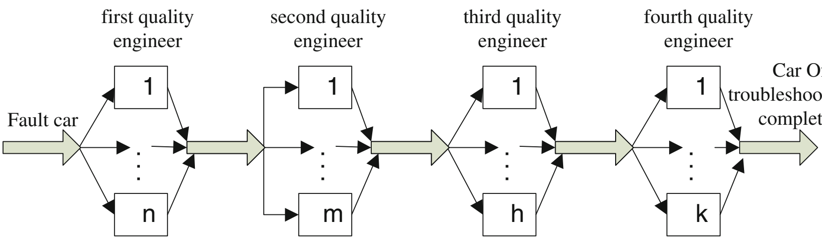

Fig. 121.8 Queuing model of car troubleshooting

121.4.2 With the Queue Theory Knowledge to Determine the Optimal Parameters of the Model (Service Desk C)

In Petri Nets model, if regarding problems that every step need to search as object (customers) waiting for service, the quality engineer as the service desk, and more than one quality engineer can work simultaneously, then the whole process can be simplified into the following multi-server single queue tandem queuing system model:

Assuming that the arrival of customers (fault cars) obey the Poisson, the quality engineer‘s checking time obeys negative exponential distribution, makes each step independent, then this model is the M/M/C queuing model. In the situation that the probability of cost and fault car basically turns to stabilized, to determine the optimal number of service desk can reduce costs and maximize the benefits. Seeking the optimal number of service desk is obtained in Fig. 121.8 n, m, h, k.

To improve the reliability and accuracy of the calculation, using the following references (Ai et al. 2007) to seek the method of M/M/C model optimal service desk number C.

In steady-state case, the expectations of the unit time full cost (service costs and waiting costs):

$$z = c_s' \cdot c + c_w \cdot L \tag{121.1}$$

where c is the number of service desk; c_s' is the unit time cost of each desk; c_w is the unit time costs of each customer stay in the system; L is the system’s customer average number L_s or the queue's customer average L_q, the service desk number setting up has the deep impact on it. Because c_s' and c_w can get the statistics through the actual situation, so (121.1) is the function $z(c)$ about c, the purpose is through getting the optimal solution c^* makes $z(c)$ minimize.

c^* is an integer, using the marginal analysis method:

$$\begin{cases} z(c^*) \le z(c^* - 1) \\ z(c^*) \le z(c^* + 1) \end{cases} \tag{121.2}$$

Substituting 'z' of formula (121.1) into formula (121.2), then

$$\begin{cases} c_s' \cdot c^* + c_w \cdot L(c^*) \le c_s' \cdot (c^* - 1) + c_w \cdot L(c^* - 1) \\ c_s' \cdot c^* + c_w \cdot L(c^*) \le c_s' \cdot (c^* + 1) + c_w \cdot L(c^* + 1) \end{cases} \tag{121.3}$$

Simplify formula (121.3), then

$$L(c^*) - L(c^* + 1) \le {c_s'}/{c_w} \le L(c^* - 1) - L(c^*) \tag{121.4}$$

According to the related analysis to thousands of cars failure data of Yunnan Y Automotive Company collected at the scene, the car failure source in the four steps of the searching, which belongs to the first step is about 25 %, the second step is about 40 %, about 30 % is the third step, the last step is only 5 %. Due to the influence of external factors, every step's average service time is different: 240, 300, 300, 600 s, and obey exponential distribution.

Yunnan Y Automotive Company's internal data shows that: the costs of each searching incurred due to delays in other processes about 8 Yuan, the services costs to each time set an quality engineer (salaries and equipment wear and tear) for about 37 Yuan per hour.

121.4.2.1 The Determination of the Numbers of the Optimal Service Desks in the First Step

According to the statistics, in the first step, the fault cars arrived time obeys the average arrival rate of 26 times per hour to the Poisson distribution; service time is negative exponential distribution which average service rate is 15 times per hour.

So, $c_s' = 37$ Yuan/quality engineer, $c_w = 8$ Yuan/time, $\lambda = 26$, $\mu = 15$, $\lambda/\mu = 1.73$, assuming the number of quality engineers to c, makes c respectively as 1, 2, 3, 4, 5. According to the $W_q \cdot \mu$ value of multi-server desks (Ai et al. 2007), with linear interpolation algorithm to find the corresponding value of $W_q \cdot \mu$, as shown in the Table 121.2.

Substituted L_s into the formula (121.4), obtained the following data in Table 121.3 by the formula (121.1):

From Table 121.3, 128.09 Yuan is the lowest total cost, the corresponding c equals to 3, so the result coming out is the lowest cost that needs to set three quality engineers.

Table 121.2 Average number of customers (L) in the system

c	1	2	3	4	5
$\lambda/c\mu$	1.730	0.865	0.577	0.433	0.346
$W_q \cdot \mu$	–	3.393	0.235	0.054	0.012
$L_s = \frac{\lambda}{\mu}\left(W_q \cdot \mu + 1\right)$	–	7.600	2.136	1.823	1.751

Table 121.3 Data calculated by marginal analysis

The number of quality engineers c	The number of car waiting to search $L_s(c)$	$L(c) - L(c+1) \sim L(c) - L(c-1)$	The total costs (every hour) $z(c)$
1	∞	∞	∞
2	7.6000	5.4640–∞	134.80
3	2.1360	0.313–5.4640	128.09
4	1.8230	0.116–0.313	162.58
5	1.7510	–	199.01

121.4.2.2 The Determination of the Numbers of the Optimal Service Desks in the Second Step

Easy to know that fault cars reached in the second step still obey to Poisson distribution (Winston 2004), if N is Poisson random variables, then $E(N) = \operatorname{var} N = \lambda$. So the fault cars from the first step into the second step reduce 25 %, then $\lambda = 26 \times 75\,\% = 19.5 \approx 20$, service time also obeys negative exponential distribution, $\mu = 12$ times per hour.

It can be gained the smallest total cost is 109.30 yuan, corresponding to the optimal service desks c = 2, this step sets two quality engineers is best.

121.4.2.3 The Determination of the Numbers of the Optimal Service Desks in the Third and the Fourth Step

Similarly, it is known that the fault cars reached in the last two steps obey Poisson distribution with $\lambda = 26 \times 35\% = 9.1$, $\lambda = 1.3$ respectively; service time also obeys index distribution, Service rate are $\mu = 12$, $\mu = 6$ times per hour. Because of the average arrival rate λ less than service rate μ, so the last two steps only need to set up 1 quality engineer.

According to the above theoretical calculation result, it is known that first step should set three quality engineers, the second step shall set up two quality engineers, the last two steps shall just set one quality engineer that can make the benefit of the system to achieve optimal.

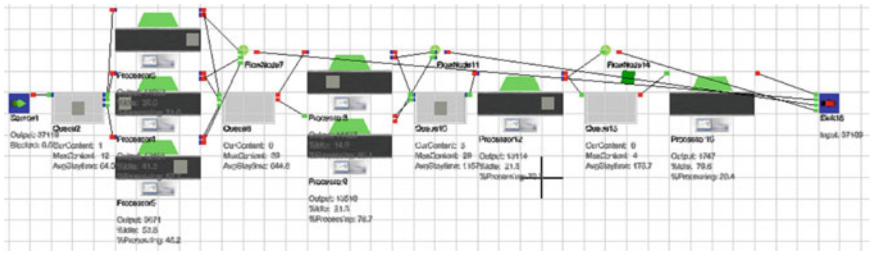

Fig. 121.9 Modeling plan

121.5 Flexsim Simulation Analysis

121.5.1 Modeling and Parameter Settings

According to the previous section, fault car's arrival interval time is about 138 s, average service time is exponentially distributed, their means, respectively, as 240, 300, 300, and 600 s (Chen et al. 2007). Using Flexsim to modeling, the plan is shown in the Fig. 121.9.

As shown in Fig. 121.9: using a Source as fault car's generator; four Queues to achieve car's cache; Processor represents quality engineer, there are different proportion of car finished troubleshooting inflow to Sink, so uses three Flow Node to provide path, achieve the shunting of the first three steps.

121.5.2 Analysis of Simulation Data

121.5.2.1 Confirm the Simulation Time

According to the work schedules of Yunnan Y Automotive Company, the company belongs to the mode of two shifts 1 day, 8-hour one shift, two for 16 h, so the length of simulation time is 16 h.

121.5.2.2 Confirm the Simulation Method

Using independent replications (Lin 2003) to simulate, namely, use of different random variables and select independent starting state to simulate R times.

121.5.2.3 Confirm the Simulation Times of Established Interval

Utilization of different random variables, after R simulations, generated R observed values (average values $\hat{\theta}_r$), using the R observed values to conduct point estimation values is as follows:

$$\hat{\theta} = \frac{1}{R}\sum_{r=1}^{R}\hat{\theta}_r \tag{121.5}$$

The sample standard deviation:

$$S^2 = \sum_{r=1}^{R}\frac{(\hat{\theta}_r - \hat{\theta})^2}{R-1} \tag{121.6}$$

The estimate value $\hat{\theta}$:

$$\hat{\sigma}^2(\hat{\theta}) = \frac{S^2}{R} = \frac{1}{(R-1)R}\sum_{r=1}^{R}\left(\hat{\theta}_r - \hat{\theta}\right)^2 \tag{121.7}$$

In order to confirm the optimal times of simulation, assuming that a parameter's interval estimation within the scope of a particular, half-length interval is less than a certain value ε, we need to simulate at least R times to meet the required half interval length. Just starts our first R_0 simulations, general 4–5 times. Through formula (121.6) obtains standard deviation S_0, when the half-length interval less than ε, can be expressed as follows:

$$h.l. = t_{\alpha/2,R-1}\hat{\sigma}(\hat{\theta}) \leq \varepsilon \tag{121.8}$$

Formula (121.8) substituted the formula (121.7), then:

$$R \geq \left(\frac{t_{\alpha/2,R-1}S_0}{\varepsilon}\right) \tag{121.9}$$

Owing to $t_{\alpha/2,R-1} \geq z_{\alpha/2}$ ($z_{\alpha/2}$ is the $\alpha/2$ quantile of the standard normal distribution), so R meets the following minimum integer, and $R \geq R_0$, then:

$$R \geq \left(\frac{z_{\alpha/2}S_0}{\varepsilon}\right)^2 \tag{121.10}$$

Utilization of formula (121.5) to find out the point estimation value of each Processor in 5 different random variables simulation is shown in Table 121.4. It is clear that each Processor's utilization remains relatively low, so the three Processors of the first step should be reduced to two, then analysis the simulation. The data obtained from simulation analysis is shown in Table 121.5:

Five simulations is shown in Table 121.5, the data gained from Table 121.5 substituted the formula (121.6) to (121.10), followed by count $\hat{\sigma}^2(\hat{\theta})$, S_0^2, $(\frac{z_{0.025}S_0}{\varepsilon})^2$.

Table 121.4 Simulation data of first model

Times	Processor						
	1	2	3	4	5	6	7
1 (%)	77.70	65.50	55.74	88.72	83.39	71.33	16.93
2 (%)	72.02	58.28	47.33	80.79	73.68	82.70	21.47
3 (%)	72.04	61.21	45.20	77.87	69.90	72.37	22.05
4 (%)	69.53	60.00	47.78	79.66	71.15	77.03	20.40
5 (%)	70.64	62.62	54.54	80.83	71.91	81.58	11.21
Mean	72.39	61.52	50.12	81.57	74.01	77.00	18.41

Table 121.5 Simulation data of second model

Times	Processor					
	1	2	3	4	5	6
1 (%)	89.66	81.84	78.49	68.69	70.84	21.86
2 (%)	99.28	98.25	82.59	81.25	90.40	23.22
3 (%)	91.05	86.26	84.17	77.84	70.32	22.06
4 (%)	90.47	86.47	79.69	70.79	73.27	21.29
5 (%)	79.83	71.00	78.31	69.92	70.23	25.33
Means (%)	90.06	84.76	80.65	73.70	75.01	22.75

Table 121.6 Simulation times had been determined

$\hat{\sigma}^2(\hat{\theta})\,(\times E-03)$	0.96	1.93	0.14	0.61	1.51	0.05
$S_0^2\,(\times E-03)$	4.77	9.63	0.68	3.05	7.56	0.26
$\left(\frac{z_{0.025}S_0}{\varepsilon}\right)^2$	7.34	14.8	1.05	4.69	11.6	0.40
Simulation times R	8	15	5	5	12	5

Ultimately to determine how many times need to be simulated if 95 % processor busy rates of the confidence interval between ±0.05. The result is shown in Table 121.6:

In the whole model, the highest simulation times determine the final simulation times. From Table 121.6, knowing that should simulate more than 12 times, if we takes 15 times, 10 more times need to be simulated to insure that processors' busy rates could be drawn between the confidence interval ±0.05. The resulting data of the entire simulation process is shown in Table 121.7.

Confidence intervals can know from Table 121.7, half-length interval of 95 % confidence interval for all processors is less than 0.05. Finally it is turned out to be confidence in the 95 %: busy rates of Processor1 will fall in the interval 0.8843 ± 0.0425; busy rates of Processor2 will fall in the interval 0.8321 ± 0.0363; busy rates of Processor3 will fall in the interval 0.8126 ± 0.0375; busy rates of Processor4 will fall in the interval 0.7387 ± 0.0421; busy rates of Processor5 will

Table 121.7 Data analysis of the whole simulation process

Value	Processor					
	1	2	3	4	5	6
Mean	88.43	83.21	81.26	73.87	72.58	21.35
Standard deviation	0.0549	0.0797	0.0392	0.0544	0.0739	0.0447
Confidence interval	±0.0425	±0.0363	±0.0375	±0.0421	±0.0407	±0.0428

fall in the interval 0.7258 ± 0.0407; busy rates of Processor6 will fall in the interval 0.2135 ± 0.0428.

Combined with the calculation of third section and results of two different models' simulation, in the first step two quality engineers are more reasonable; the efficiency of Processor6 is still low, to further improve the efficiency and benefits of system, should train the technology-packed quality engineers. The problems of the last two steps will be finished by one quality engineer.

121.6 Conclusion

Automotive troubleshooting method that is described in this paper is a more universal method to find out the fault source. It is from simple to complex, is trending to standardization procedures to solve problems.

Modeling with Petri Net and Colored Petri Net, from global and local troubleshooting on cars have a good control and master; effectively solve the parallel reasoning of the car fault detection system; reduce the complexity of the fuzzy inference reasoning method.

And collecting data in real-time from car production process, the use of queuing theory related knowledge obtains the optimal number of quality engineers.

Modeling and Simulation with Flexsim have great reference value for reasonable arrangements to quality inspectors. Using of the troubleshooting method makes all activities of the enterprises with strong timeliness.

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Chapter 122
Modeling and Simulation of Wartime Casualty Surgical Treatment

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Abstract The objective of this paper is to model and simulate the wartime casualty surgical treatment with a discrete simulation tool (Simio) based on treatment process analysis and medical data. Firstly, the surgical treatment process is analyzed. Then, a 3D visual simulation mode is built with Simio. Seven scenarios about different casualty arrival rates are used to test the surgical capability of the field hospital of the PLA. The results show that two hundred casualties may reach the maximum throughput in the field hospital equipped with one operation table. The modeling and simulation of wartime casualty surgical treatment contributes to obtaining the system performance indicators, and simulation model developed can support medical resources estimation and allocation optimization.

Keywords Casualty · Modeling · Simulation · Wartime

122.1 Introduction

Warfare has changed significantly in modern time. Range and accuracy of the lethal modern weapon systems are far more effective than ever, and the army has transformed into modular units that are smaller, more deployable and flexible.

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E. Qi et al. (eds.), *The 19th International Conference on Industrial Engineering and Engineering Management*, DOI: 10.1007/978-3-642-38391-5_122,

The field characteristics of dispersion, rapid military operations, increased mobility, rapid task organization, and extended lines of communications make the battlefield more lethal than ever. These directly impact the medical service. The medical facility must adjust to these impacts (Nuhut and Sabuncuoglu 2002). As known to all, the operating room (OR) is the most demanding department in field hospital of the PLA. The process of the operating room directly influences the treatment efficiency of the medical treatment facility. Since the OR treatment process is dynamic and contains many stochastic elements, simulation is used in this research to model and analyze the related problems.

The objective of this paper is to model and simulate the wartime casualty surgical treatment. Firstly, the surgical treatment process is analyzed. Then, a 3D visual simulation mode is created with Simio, a quite new simulation platform. Seven scenarios about different casualty arrival rates are used to test the surgical capability of the medical aid station. The results show that two hundred casualties may reach the maximum throughput in the field hospital equipped with one operation table. The modeling and simulation of wartime casualty surgical treatment contributes to obtaining the system performance indictors, and simulation model developed can support medical resources estimation and allocation optimization.

122.2 Casualty Surgical Treatment Process

Casualties are treated at medical facilities organized into a series of echelons in wartime. The facilities at the forward echelons have the greatest mobility but least surgical capability (Fleet marine force manual (FMFM) 1990). Each facility establishes some treatment areas and treats casualties based on treatment range, rules and capability, which are defined by treatment rules of the army. The field hospital, equipped with necessary operation resources, has the surgical capability. The casualty surgical treatment process in the field hospital is shown in Fig. 122.1.

When casualties arrive at the facility, they are distributed to different treatment areas after triage. The casualties, who immediately need operation disposition, are sent to preoperative room, and the others, to the areas of Lab, X-ray, serious or minor injury treatment, etc. In addition, some casualties flow between these areas and could then get to the preoperative room. When the personnel and equipment

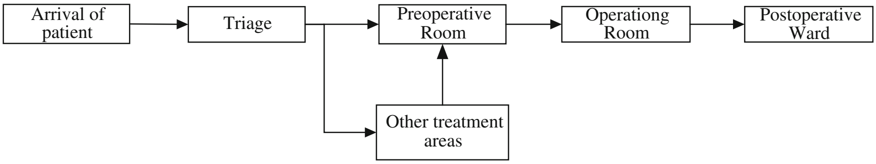


Fig. 122.1 Flowchart of patient movement in the field hospital

required to treat the casualty are available, the casualties are delivered to OR and then flow to postoperative ward.

In the OR, the casualties would receive operation disposition based on their traumatic conditions. The treatment process in the OR could be considered as a series of treatment tasks connected with each other, which could then be named operation treatment task sequence (Zhang and Wu 2011a). There are 2 types of treatment tasks according to the relative order between each other:

(1) Sequential tasks are those performed one after another.
(2) Concurrent tasks are those completed simultaneously.

The operation treatment task sequence is shown in Fig. 122.2. This task sequence is obtained by literature investigation and expert consultation.

So, a casualty surgical treatment process could be considered as this casualty flowing through the above operation treatment task sequence and all casualty surgical treatment processes actually make up this sequence.

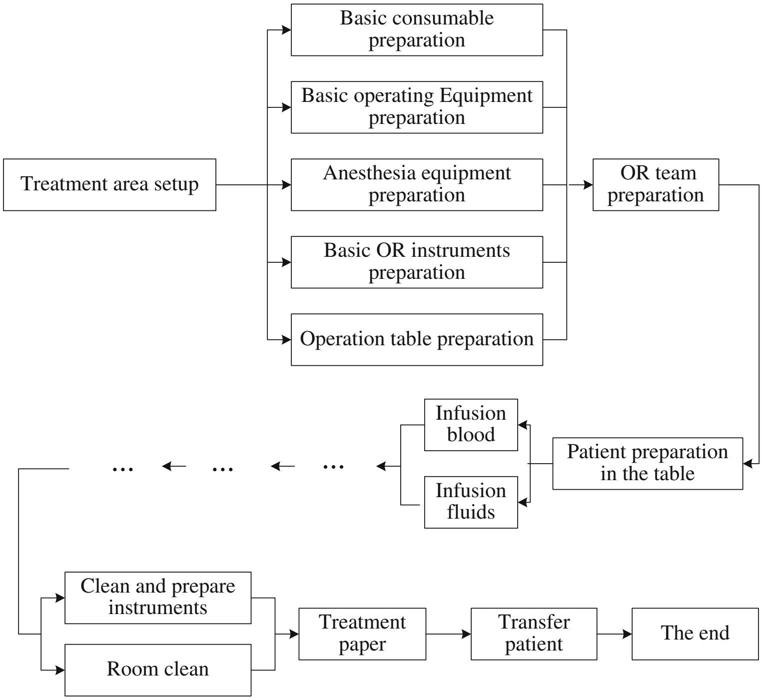


Fig. 122.2 Treatment task sequence of an operating room

122.3 Modeling and Simulation

122.3.1 Simulation Scenario

The simulation scenarios provided are a typical medical support context in which a field hospital of the PLA provides emergency treatment to the casualties involved according to the treatment rules defined by the PLA. In the baseline mode, each patient arrives randomly with an exponential time between arrivals with a mean of 14 min. They would receive first aid treatment within 10 min after injury and then be evacuated to the regiment aid station and get to the preoperative room randomly following an uniform distribution with parameters 0.5–3.5 h. This time internal is defined by the treatment rules of the PLA. There is 1 operation table equipped with necessary medical personnel and resources in the OR. In order to test the OR capability, the casualty arrival rate would successively increase by 25 % in other scenarios.

122.3.2 Modeling and Simulation Tool

Selection of a proper modeling and simulation tool is critical to the outcome of data needed for analysis. In this paper, Simio is selected as the modeling and simulation platform for its various advantages. Simio is a quite new simulation tool, which has functions of visual, interactive, and interpretative modeling. Using Simio, modeling is based on describing system's objects and evolution of system behavior by interaction of these objects. Its graphics and extended capabilities are able to help the researchers easily model the system and determine how an existing or a proposed system will perform. In addition, Simio provides the most advanced real-time 3D technology, which strengthens the interaction of simulation (Zhang and Wu 2011b; Pegden 2008; Dennis Pegden 2009).

122.3.3 Evaluation Measures for Modeling and Simulation

The main focus of modeling and simulation is to valuate the system's surgical treatment capability. For the system, the average casualty wait length and time for operation, operation time, and mortality rate must be accepted by the treatment rules. Since the model developed is a baseline model, and only the casualty arrival rate is changed in other scenarios, the same metrics to measure the performance of system would be used. This allows us to collect similar data in each of the simulations and compare data obtained from several runs of the simulation. Once the data are collected, statistical analysis is performed and the results are used in the analysis of different allocation of the operation room.

122.3.4 Medical Parameters

122.3.4.1 Casualty Types and Generation

The casualty types in this simulation research mostly come from the U.S. army Deployable Medical System (DEPMEDS) PC Code and are adjusted by the subject experts of the PLA. These PC codes occur during deployment and combat operations and range from snake bites, to severe hearing impairment, to more serious injuries (James et al. 2005; Deployable Medical System (DEPMEDS) 2003). The casualties needing operation treatments involve in 87 PC codes. In the simulation, casualties are randomly generated based on an exponential distribution. The casualty cumulative probability distribution obtained from historical accounts of ground operations and adjusted by factors such as recent of operation and medical advances is used for simulation model to indentify a certain PC Code for each injury event.

122.3.4.2 Casualty Survival Probability

The wartime casualty survival probability data are obtained by expert questionnaires. After preliminary analysis, casualties are identified and designated as having either a high (H), medium (M), or low (L) risk of mortality according to the severity of life-threatening. In addition, the casualty survival probability data are fitted by the Weibull survival function with MATLAB. Then the survival functions based on types of medical treatment facility and treatment delays are obtained (Zhang and Wu 2011; Mitchell et al. 2004).

In a certain medical treatment facility, the casualty survival model based on a treatment delay would be obtained by the functions known. A certain type of casualty starts treatment at $c_{0,}$ and this time point is between c_1 and c_2 ($c_1 < c_0 < c_2$), then the casualty survival model based on c_0 treatment delay is:

$$\begin{aligned} S(t)_{c0} &= \Pr[T > t] \\ &= ((c_0 - c_1))\left(\exp\left(-(t/a_1)^\wedge b_1\right)\right) \\ &\quad + ((c_2 - c_0)/(c_2 - c_1))\left(\exp\left(-(t/a_1)^\wedge b_2\right)\right) \end{aligned} \tag{122.1}$$

Using this model and the function parameters fitted, a certain type of casualties' survival probability at any point and time during their treatment processes could be obtained.

122.3.4.3 Casualty Treatment Data

The casualty treatment process is a continuous one composed of a series of treatment tasks required to treat that specific type of casualty. Each type of casualty is linked to a set of treatment tasks, and each treatment task is linked to the resources required to accomplish that task. These tasks could be connected together based on their relative order and compose a casualty treatment sequence. Actually, each casualty treatment task sequence is a subset of the OR treatment task sequence. When this casualty arrives at the operating room, he/she would flow through the OR treatment task sequence. The treatment task sequences are mostly obtained from the U.S. army treate file. The treatment time, personnel and necessary equipment and supplies are obtained by consulting with experts and researching books.

122.3.5 Modeling Process

122.3.5.1 Modeling Casualty Treatment Task Sequence

The treatment process could also be considered as a series of treatment tasks connected by a series of junctions. A new junction object from scratch and a treatment task object sub-classed and redesigned from the standard Time Path object are developed with Simio (Jeffrey and Roberts 2011; Dennis Pegden 2009). Linking the junction and treatment task objects together and setting the object properties, the casualty treatment task sequence is developed as shown in Fig. 122.3.

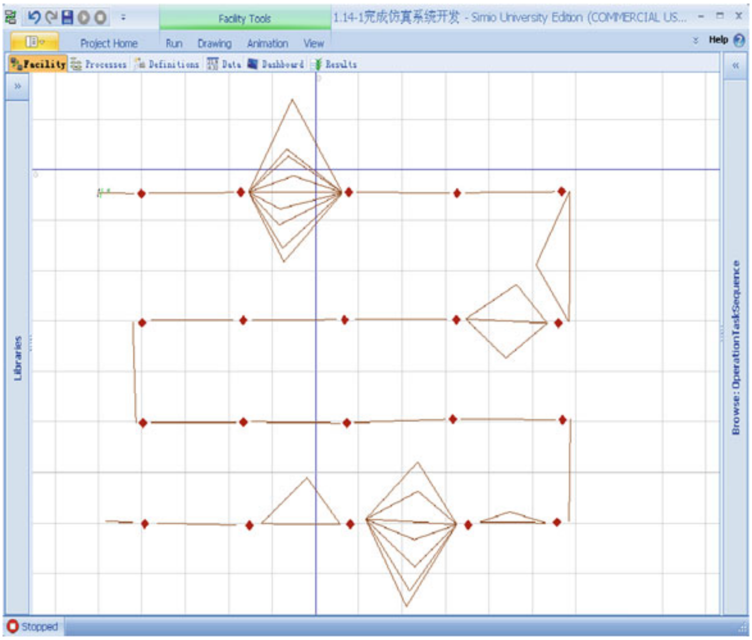


Fig. 122.3 Casualty treatment task sequence in Simio

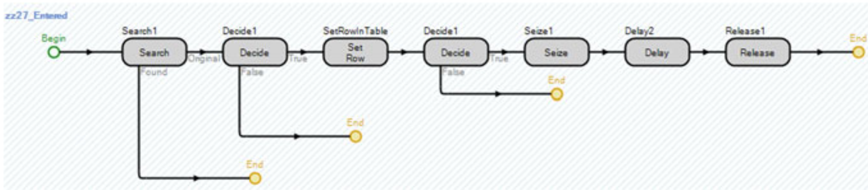


Fig. 122.4 Typical treatment task logic

122.3.5.2 Modeling Resources Consumed by Casualty Treatment Task

The medical personnel are modeled with Worker object, medical equipment with Resource object, and time consumed by the task with triangle distributions got by consulting with subject experts. The logic of each treatment task is designed using the graphical process flows. Figure 122.4 depicts typical treatment task logic. When a casualty flows to this task process, the Search and Decide steps are used to decide whether this task is required by the casualty from a casualty treatment task data table which would be described below. The Set Row and the next Decide steps are used to link the task to the required resources in the table. Then, the Seize, Delay and Released step are used together to model the resources to be seized, delayed and released (Simio user's manual 2009; Dennis 2009).

122.3.5.3 Modeling Casualty Survival Situation

There are four types of risk of mortality and five types of internal of treatment delay. Each type of mortality risk and internal of treatment delay is distinguished by the Decide step. The survival model is used following the next Decide step to determine the casualty survival situation. If the casualty is still alive, he/she would then flow the next treatment process. These logics are shown in Fig. 122.5.

122.3.5.4 Setting Simulation Data

In addition to entering data directly into the modeling objects, a casualty table, including casualty types, composition of proportions, litter conditions, treatment chances and priorities, is defined to set all casualties' basic information, and a treatment task table, including casualty types, task types, task time and treatment probabilities, is defined to set all casualties' treatment information, which is shown in Fig. 122.6.

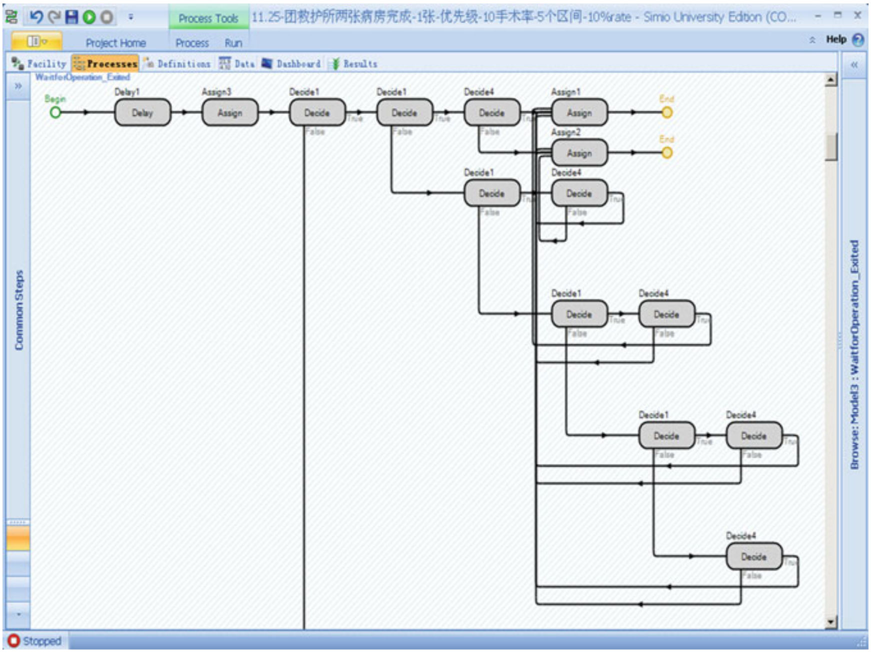


Fig. 122.5 Casualty survival situation modeling logic

122.3.5.5 Achieving Simulation Results

Though Simio platform has powerful statistical functions and makes most statistical data automatically, the surgical system still needs some special data statistics. So, some statistic elements are created to record the treatment data in Simio, as shown in Fig. 122.7.

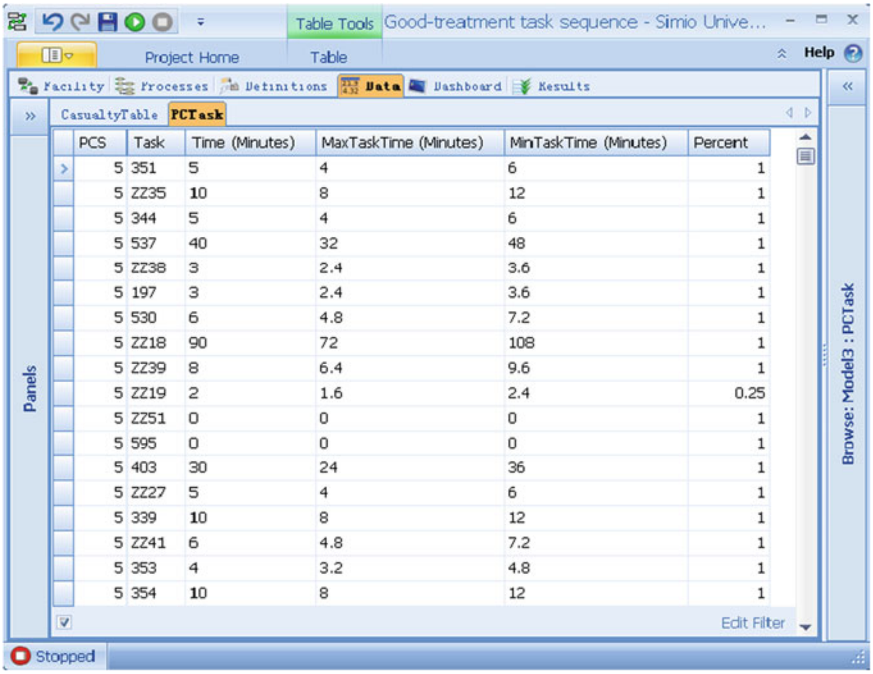
In addition, some process logics, accompanied with statistical elements, are created to trace the simulation data.

122.3.5.6 Visual Simulation Model of Casualty Treatment

The 3D casualty, medical personnel, equipment, and operating room objects are developed by 3D modeling software and imported to create the realistic 3D casualty treatment model with Simio, which is shown in Fig. 122.8 (Dennis 2009).

122.3.6 Results and Discussion

Seven scenarios about different casualty arrival rates are built in the experiment window within Simio. The simulation time lasts for 34 h, and the first 10 h is not



PCS	Task	Time (Minutes)	MaxTaskTime (Minutes)	MinTaskTime (Minutes)	Percent
5	351	5	4	6	1
5	ZZ35	10	8	12	1
5	344	5	4	6	1
5	537	40	32	48	1
5	ZZ38	3	2.4	3.6	1
5	197	3	2.4	3.6	1
5	530	6	4.8	7.2	1
5	ZZ18	90	72	108	1
5	ZZ39	8	6.4	9.6	1
5	ZZ19	2	1.6	2.4	0.25
5	ZZ51	0	0	0	1
5	595	0	0	0	1
5	403	30	24	36	1
5	ZZ27	5	4	6	1
5	339	10	8	12	1
5	ZZ41	6	4.8	7.2	1
5	353	4	3.2	4.8	1
5	354	10	8	12	1

Fig. 122.6 Casualty treatment data tabe

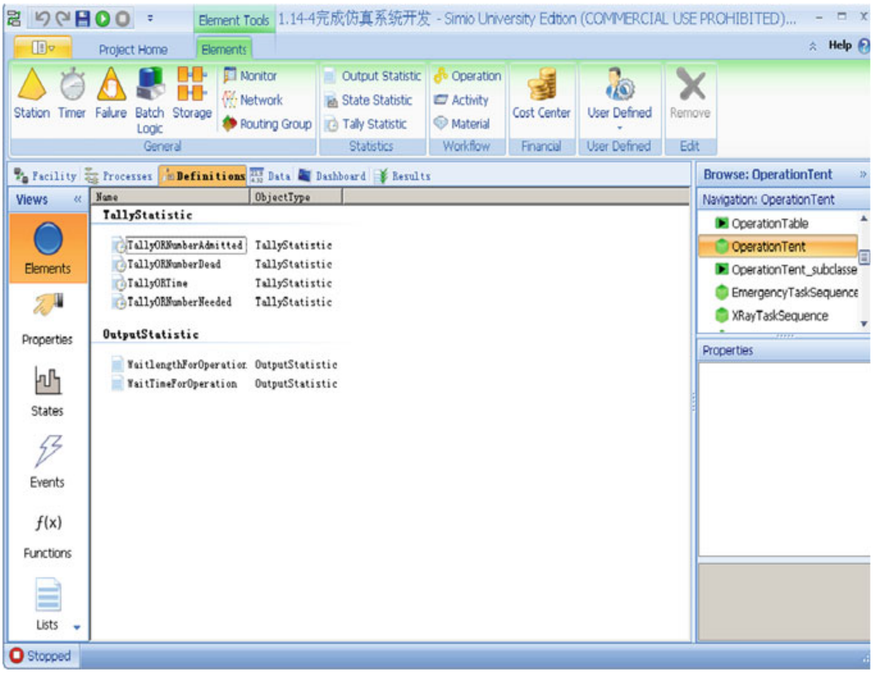


Fig. 122.7 Statistic elements created to record simulation data in Simio

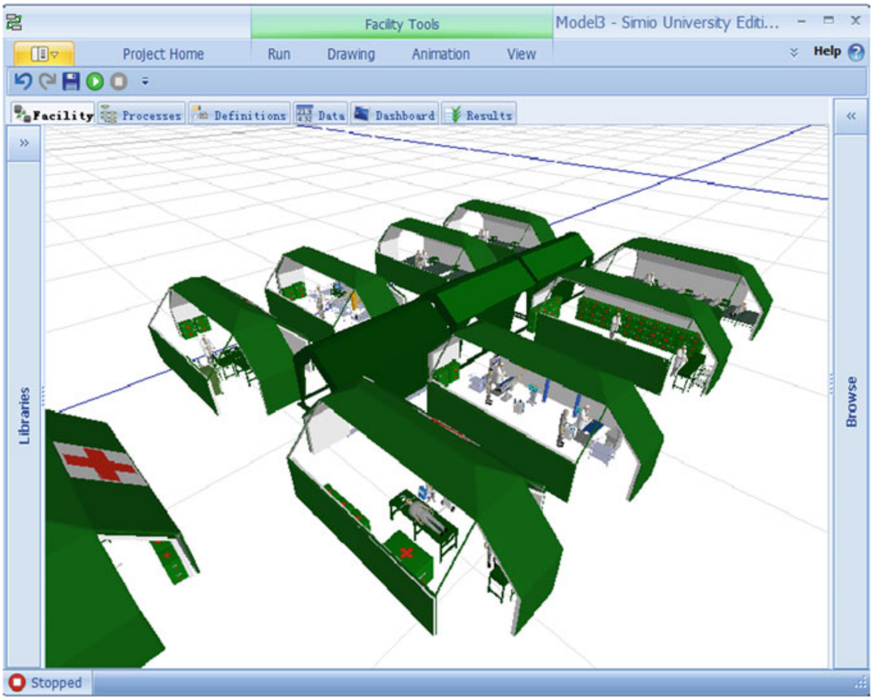


Fig. 122.8 Simio model with animation 3D

used for collecting data. The scenario 1 is the baseline model, and the arrival rate is increased by 25 % after each scenario. We take 100 replications for each scenario and the results are within the 95 % confidence interval.

All the important performance indicators of the system are obtained. Parts of mean value of average data are shown in Table 122.1.

Two hundred casualties have long been considered as the maximum throughput in the field hospital researched in this paper. Though, long time has passed, the performance indicators still reflect this situation. As shown in Table 122.1, the

Table 122.1 Performance indicators of the field hospital with one operation table

Scenario	Casualty arrival number	Mortality rate (%)	Operation number	Wait length for operation	Wait time for operation (h)	Operation time (h)
1	103.46	1.42	8.40	0.25	0.53	1.23
2	128.21	1.48	10.50	0.46	0.74	1.24
3	160.89	1.99	12.94	0.89	1.20	1.20
4	201.07	1.89	14.83	1.37	1.48	1.21
5	249.97	2.60	16.78	2.81	2.25	1.23
6	314.26	3.03	18.26	4.97	3.06	1.25
7	392.91	3.15	18.41	9.48	3.59	1.29

average casualty arrival number is 201.07 ± 2.72 in scenario 4. In this situation, after consulting with subject experts, we consider that the wait length and wait time for operation, and the mortality rate may reach the maximum, which could be borne by the casualties. In scenario 5, 6 or 7, more operation tables should be established.

122.4 Conclusion

The objective of this paper is to model and simulate the wartime casualty surgical treatment. Firstly, the surgical treatment process is analyzed. Then, a 3D visual simulation mode is built with Simio simulation platform. Seven scenarios about different casualty arrival rates are used to test the surgical capability of the medical aid station. The results show that two hundred casualties may reach the maximum throughput in the field hospital equipped with one operation table. The modeling and simulation of wartime casualty surgical treatment contributes to obtaining the system performance indictors, and simulation model developed can support medical resources estimation and allocation optimization.

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Chapter 123
Modeling of Shipboard Aircraft Operational Support Process Based on Hierarchical Timed Colored Petri-Net

Ting Wang, Bo-ping Xiao, Lin Ma and Yan-kun Tian

Abstract The operational support of shipboard aircraft is a complicated process, reasonable planning of aviation support resources and reduce the operational support time plays a vital role of the tasks persistent of the aviation support system. The paper introduces the basic principles of Petri nets, points out the defects of the basic Petri net in the operational support process modeling and puts forward a simulation model of shipboard aircraft operational support process based on Hierarchical Timed Colored Petri-Net. The approach simplifies the hierarchical modeling, make up for the lack of a Petri net time performance analysis, and distinguish the different operational support resources. The operational support process of shipboard aircraft and the modeling method based on HTCPN has been given in this paper. It shows the application of Petri net in the analysis and evaluation of the shipboard aircraft and is important to optimize the shipboard aircraft operational support process.

Keywords Aviation support system · HTCPN · Petri-Net · Operational support · Shipboard aircraft

123.1 Introduction

The aircraft carrier is the combat platform at sea with the most powerful combat effectiveness in the world now. It plays a significant role due to its unique characteristics like integrating the sea and air routes, combining ships and planes, controlling the air and sea and rapid deployment. The main reason for aircraft carrier becomes an important force in naval battle and land combat is its unique

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E. Qi et al. (eds.), *The 19th International Conference on Industrial Engineering and Engineering Management*, DOI: 10.1007/978-3-642-38391-5_123,

weapon equipment—shipboard aircraft. The shipboard aircraft is the power of the aircraft carrier. The operation and management of aircraft carrier is very complex, starting and recycling need a series of procedures like the lifting, guiding, arranging, refueling, loading ammunition, landing, catapulting, and blocking, which are implemented by the aviation security system. Therefore, the rational planning of aviation security resources and reducing the security time of using aircraft carrier play vital roles in the sustainability of the aviation security system task.

The security process of using the carrier aircraft is the typical discrete system. The process modeling methods commonly used for simulation modeling in discrete system are: CPM/PERT methods, IDEF3 method, Petri network method, activity-based random network method. The concepts of the place, transition and arc in the Petri network correspond to the activities, states, and rules in the security process of equipment. Applying Petri network can better show the use and maintenance process of the equipment. But the basic Petri network is difficult to describe a variety of security resources, unable to model the security task execution time, moreover, the system is complex, the model is large, hence it is easy to become chaotic. As the air security system have more security resources, higher requirements of the task duration, and complex and variable security tasks, the Timed Colored Petri network concept is introduced, which models the security process of applying shipboard aircraft, and lays foundation for building comprehensive security model of complex equipment and systematic analysis.

123.2 Basic Principle of Petri-Net Modeling

Petri network is put forward by German scholar C. A. Petri in 1962 as a process modeling and analysis tool. It is a tool for describing the graphical and mathematical processes, which provides a powerful means for studying complex systems with parallel, asynchronous, distributed and stochastic characteristics. After four decades' development, the Petri network has been widely used in various fields to simulate, analysis and control of the system such as the design, artificial neural networks, network performance analysis in parallel program and so on.

123.2.1 Basic Elements of Petri Network

The basic elements of the PDM workflow model include Store house, Transition, Token and directional arc (Sun et al. 2011).

(1) Store house: Represents the conditions that is, promoting factors of processes, and is shown by a circle "○". When the conditions are met, the corresponding end nodes of directional arc with this store house as the starting point will be

activated. The introduction of store house is used to strictly distinguish the abilities and the real implementation of the activities.

(2) Transition: represents the tasks, which is the activities in the PDM workflow, and is shown by a box "□". For example, document countersignature and the design change. However, when an activity is not completed within the set time, the system will deliver the timeout warning to the operating users, and the process will be suspended. In order to better describe the PDM workflow, transition of zero delay-instantaneous transition as auxiliary structure is added in the model. To make the model easy to be understood, this paper will apply "□" to represent the transition of zero delay.

(3) Token: represents the resources and data that can be used, which is a sign that a certain condition is met, and is shown by the black spots in the circle. When the process is moving forward, the token will transfer from one store house to another.

(4) The directional arc: it is used to connect store house and transition, representing the order of the implementation of activities. When the starting node of the directional arc is finished, the system will conduct process navigation according to the definition of the directional arc and the follow-up activities will be activated.

(5) Routing: routing means the sequencing description of activities and connection through the process of business implementation, and the various activities are associated through routing. There are four basic routing structures in PDM workflow: sequential routing, parallel routing, conditional routing, and cycle route. In order to describe some basic routings in the workflow model, several corresponding structured components are constructed in a functional network, i.e.: serial component, parallel component, condition selecting component and cycle component.

(a) Serial component

Serial relationships define the activities performed in a fixed order. For example, in the shipboard aircraft transporting process, the carrier aircraft must be transported from the hangar to a lift, and then transported by the lift to the deck, which is just as shown in Fig. 123.1.

(b) Parallel component

If several tasks can be executed simultaneously or in any order, it can be called as the parallel relationship. It mainly applies two basic workflow primitives: And-Split and And-Join. For instance, in the deck support process, when the shipboard aircraft gets to the support point, a variety of deck support activities, such as refueling and charging. If these activities have no relations, they can be seen as different branches of the whole process. The implementation of the

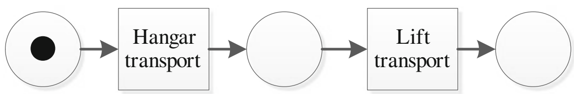

Fig. 123.1 Serial component

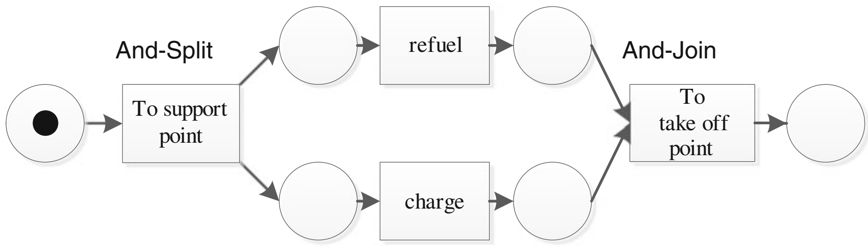

Fig. 123.2 Parallel component

two activities is not in chronological order, the "take off" activity will not be triggered only when the two activities are completed. It is just shown as in Fig. 123.2.

(c) Condition selecting component
Corresponding to conditional routing, it is used to define the split activities with mutual restraint and exclusive relations between each other. This kind of split activity often conducts the "single choice" or "multiple choices" based on the specific implementation situation. The condition selecting component also requires two basic work-flow primitives: OR-Split and OR-Join. The relationships of condition selection can be divided into two kinds: one is the implicit or split selection, that is, it is not known in advance that the trigger order of the activities determines which split is triggered; and the other is the explicit or split selection, that is, determine which branch is triggered according to the activity property before split. The operational support process mainly adopts explicit or split selection logic. In the refueling process, do pressure refueling or gravity refueling will be determined according to the aircraft model. After refueling is completed, move to the next step as shown in Fig. 123.3.

(d) Cycle component
Cycle component is used to characterize the repeated execution of a task. In this component, an explicit or OR-Split is used. For example, in the tractor repair process, if the repair is successful, go to the next step, that is used for aircraft transporting. If the repair is unsuccessful, continue to repair, until

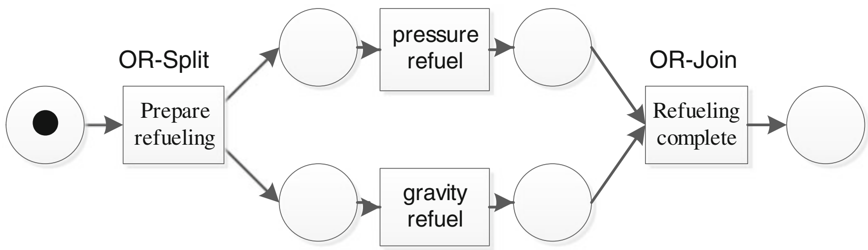

Fig. 123.3 Condition selecting component

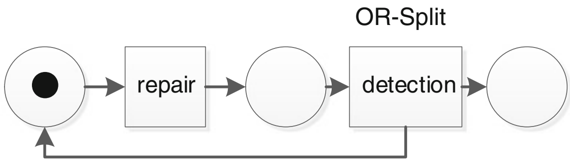

Fig. 123.4 Cycle component

available. Here does not consider the tractor maintenance grading and repair strategies, only discuss the maintenance activities as a unity. It is shown as in Fig. 123.4.

123.2.2 HTCPN Model

Hierarchical timed colored Petri net (HTCPN) not only extends the color of the model and the execution time of activities, but also hierarchical modeling operational support processes, which combine data structures and hierarchical decomposition (Zheng et al. 2011).

Aviation support system is very complicated; the model created with traditional Petri net will be a huge scale and have a large amount of notes. This will not only make the process of modeling complex, but also make the analysis of the model characteristics difficult. Therefore the hierarchy Petri network models can be introduced, that is, use corresponding subnet in a large model to replace the transition needs to refine. The transition that contains the subnet is represented by the double box ‘⧈’. The design process of hierarchy Petri network model can be divided into two stages. First: define tasks at the top of the entire workflow structure; second: to determine the details of tasks description in the lower level (Zhao et al. 2009).

In the basic Petri network model, the transition is only with the feature of “transient”, which means its trigger is not time-consuming. When studying the operational support process, time is the parameter must be considered, as many analysis quantitative indicators like maintainability and support are described in time value, such as MTTR. HTCPN brings in the concept of time and the modeling task execution time, hence they can be simulated to obtain the time performance of shipboard aircraft using the support HTCPN model, and estimate the support time of aviation support system and the utilization rate of the support resources so as to provide the basis for the optimization of applying the support process.

In the work of the equipment support, contents like support equipment and support personnel must be considered. HTCPN defines the color of the places and enhance the arc expression ability so as to uniformly model different support resources and avoid utilizing the large and complex support models (Yang et al. 2010; He et al. 2010).

123.3 The Support Process Analysis of Shipboard Aircraft's Aviation Support System

Aviation support system is constituted by a variety of subsystems, components, parts and equipment assembly, and it is designed to provide the overall of carrying, taking off and landing, maintenance and supplies for shipboard aircraft. It includes lifts, catapults, tractors, jet bias board, the Fresnel lens, arresting wires, island-type superstructure, flight deck and hangar, etc. The system can be divided into command, transporting, deck support, landing, catapult, and other subsystems (Yao et al. 2009; Wang et al. 2005).

The aviation support system studied in this paper is composed of the transportation system, deck support system, taking off system and landing system (Zhang 2010) (Fig. 123.5).

The transportation system includes shipboard aircraft's tractors and lifts as well as weapons' tractors and lifts. To guarantee the plane transportation of shipboard aircraft on the hangar deck, the hangar is equipped with the tractors of the shipboard aircraft. To guarantee the shipboard aircraft's lifting transportation between the hangar and flight deck, the shipboard aircraft's lifts are set. To guarantee the plane transportation of weapons between the hangar deck and flight deck, the weapons' tractors and lifts are set.

The deck support system is mainly for the detection and maintenance services of shipboard aircraft, including preparation before start, inspection after the task, and preparation for another start. The main equipment contains supply facilities of air power, compressed air, nitrogen, air oil and fuel and weapons mounting equipment.

Landing system mainly ensures the safe landing of the shipboard aircraft. In order to complete the safe landing of the shipboard aircraft, the landing system is equipped with facilities like optical landing aid device, arresting wires and arresting nets.

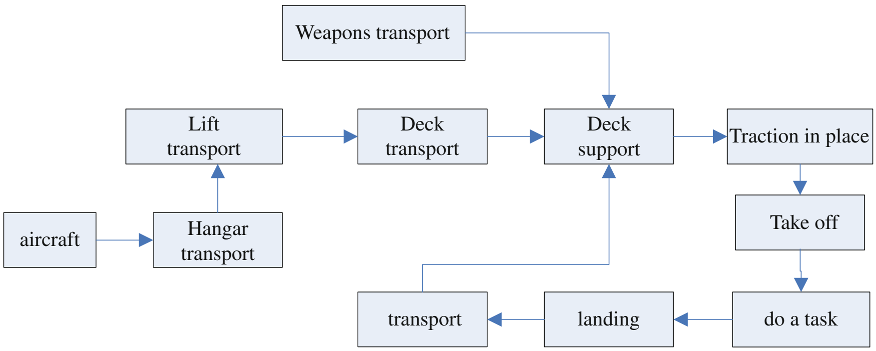

Fig. 123.5 The operational support process of shipboard aircraft

Take-off system mainly includes the facilities such as catapults, jet bias boards. The main task is to provide sufficient power to make the shipboard aircraft take off smoothly in a shorter distance.

The task of the aviation support system is triggered by the shipboard aircraft's task, and the number of shipboard aircrafts can be flexibly set according to the task.

123.4 Petri Network Modeling for the Aviation Support System

HTCPN modeling is used to establish support modeling for applying shipboard aircraft as shown in Fig. 123.6. This model fully reflects the characteristics of hierarchical modeling, simply and clearly shows that working processes of aviation support system, and lays the foundation for further analysis and evaluation of the operational support processes (Song 2008).

123.4.1 The Top-level Model of the Aviation Support System

The operational support process of shipboard aircraft from the hangar to the take-off point first needs to transport shipboard aircraft from hangar to deck support point, meanwhile, the ammunition must be transported from ammunition depot to the deck support point, and then conduct deck support for the shipboard aircraft so as to complete deck support and tract the shipboard aircraft to take-off point. This process can be divided into four relatively independent modules, and the operational support process is sub-divided according to hierarchical Petri network theory (Fig. 123.7).

In the figure, the black token means shipboard aircraft, and the red token represents ammunition. It should be noted that the token in the figure is only for more vividly expressing the relationship between support resources and major equipment, not for showing the number of tokens. During the actual modeling process, the amount of preset resources can be simulated and the allocation of resources can be balanced through analyzing the simulation results.

123.4.2 Transportation Process Modeling

The transportation of shipboard aircraft can be divided into three stages. The first stage is the transportation of shipboard aircraft in the hangar, which is the time transporting shipboard aircraft from the hangar to the lift; the second stage is the time transporting shipboard aircraft from the hangar to the deck, that is, the transportation process of the lifts; the third stage is the transporting time of the deck 1.

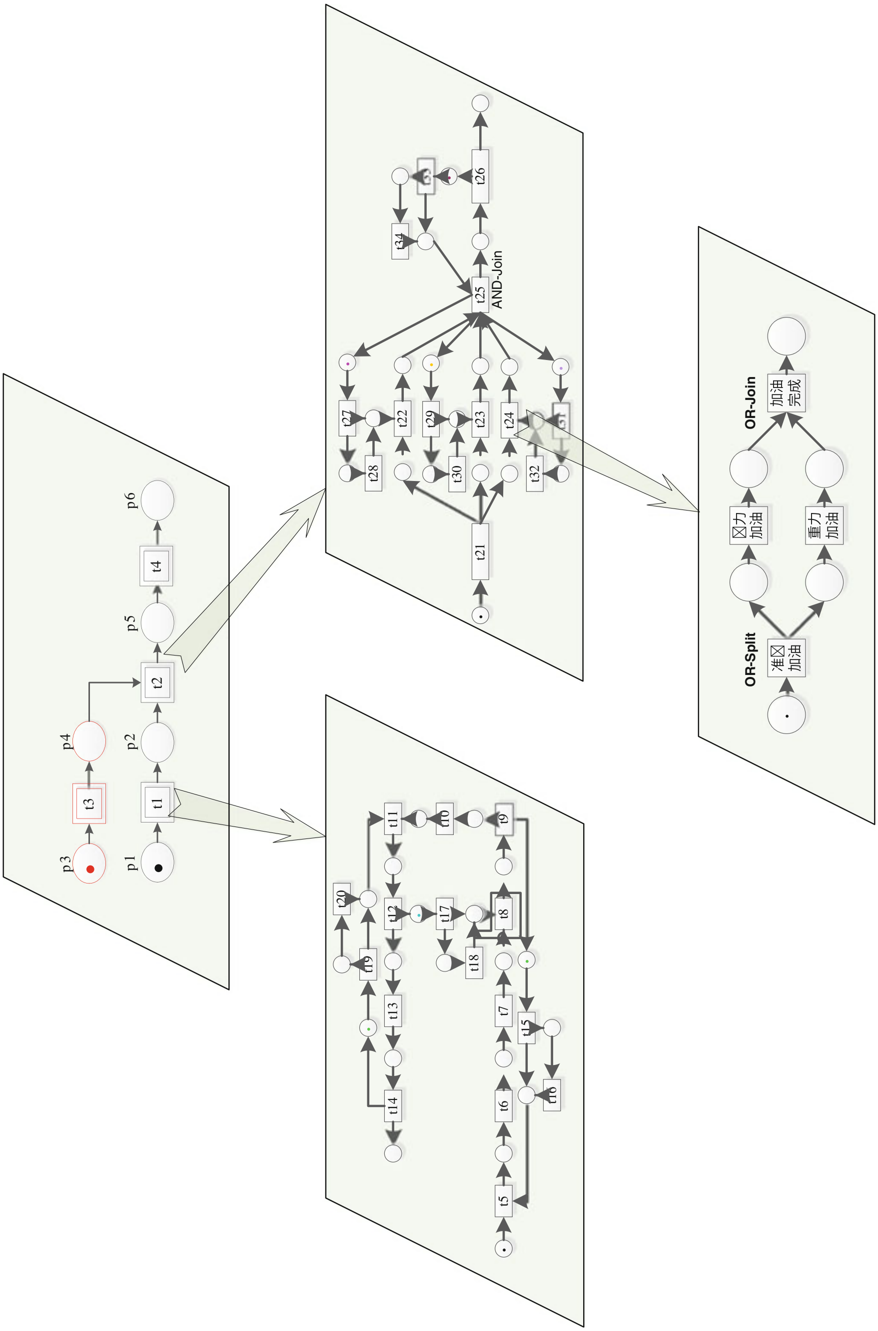

Fig. 123.6 The petri-net model of aviation support system

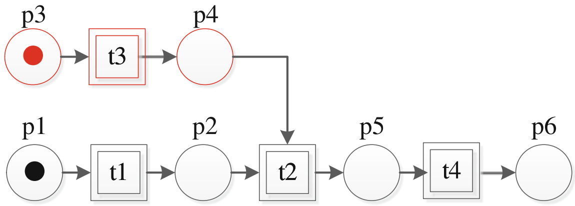

Fig. 123.7 The top-level model of the aviation support system. *t1*: transport shipboard aircraft from hangar to shipboard support point. *t2*: shipboard support. *t3*: Weapons transport. *t4*: tract the shipboard aircraft to take-off point

The transporting time here means the time from the lift to the protection time to time, excluding from the protection point to the take-off time, and to protect the support point excluding the time from the support point to the landing point and from the landing point to the support point. The number of shipboard aircraft's tractors in hangar, the number of lifts, the number of shipboard aircraft's lifts on the deck and the number of shipboard aircrafts need transporting directly affect the transporting time. The more the tractors and lifts are, the less time needed is. However, due to space and weight constraints, unlimited increase in the number of tractors and lifts is impossible. Considering from the other aspect, it will also cause a waste of resources. Therefore, in order to meet the conditions required, a reasonable number must be determined.

The model of transportation process is shown as Fig. 123.8.

The model also takes the failure of support equipment into account, and incorporates the support equipment maintenance activities into the shipboard aircraft's transporting sub-module in dominant or branch ways. The green token in the figure means the hangar tractor and deck tractor while the blue token represents lift. It should be noted that in order to more clearly show the utilization of support resources, this paper only uses a token to show the support device, but in the actual situation there should be more standby support equipment.

Ammunition transporting process is similar to transporting process of shipboard aircraft, and hence it will not be repeated here. It should be noted that the quantity of the weapons delivery should be measured by weight, which can be split. The transporting of the shipboard aircraft is as a whole, which cannot be split. This should be considered when conducting simulation.

123.4.3 Deck Support Process Modeling

The deck support system includes jet fuel system, aviation power system, air supply system, and deck support facilities. The major functions include pressure refueling and gravity refueling for shipboard aircraft; responsible for the support of the preparation before deck and shipboard aircraft flight, and aviation power

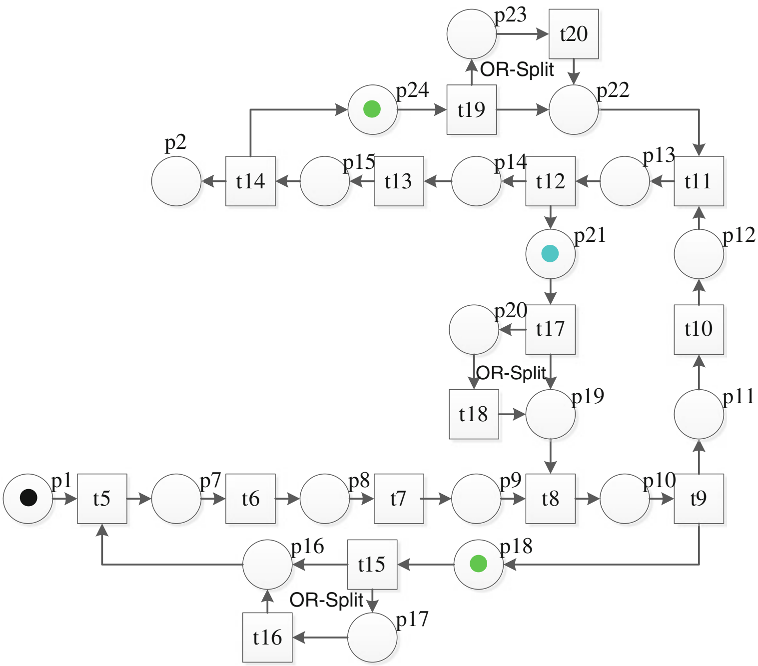

Fig. 123.8 The model of transportation process. *t5*: tie the aircraft to the hangar tractor. *t6*: untie the aircraft from the hangar. *t7*: transport by the tractor. *t8*: tie to the lift. *t9*: untie the hangar tractor. *t10*: transport by the lift. *t11*: tie to the deck tractor. *t12*: untie the lift. *t13*: transport by the deck tractor. *t14*: untie the deck tractor. *t15*: check the hangar tractor. *t16*: repair the hangar tractor. *t17*: check the lift. *t18*: repair the lift. *t19*: check the deck tractor. *t20*: repair the deck tractor

supply before the second start; power supply for the maintenance of flight deck and shipboard aircraft in the hangar; aviation power supply for guaranteeing the ship aviation maintenance, and related cabin maintenance; guaranteeing the flight deck utilizes aviation power to start the shipboard aircraft; guaranteeing the centralized storage, management and charge/discharge maintenance for aviation batteries,. In addition, it is also responsible for preparation before flight, maintenance of the required gas including filling oxygen and nitrogen to the shipboard aircraft, guaranteeing the gas filling for the shipboard aircraft's wheels and making sure the cooling of electronic equipment in shipboard aircraft when the power is on. Guarantee the routine maintenance of the deck support equipment and the wash, hydraulic maintenance, safe ground and the snow removal of the flight deck.

Suppose all the processes can be conducted at the same time except filling oxygen, and every support site is equipped with the same set of jet fuel system, the deck support model can be established as shown in Fig. 123.9.

123.5 Simulation and Analysis

Petri network has powerful analytical techniques and means. Analysis of workflow's behavior, status, and performance can be solved through the nature of Petri network (such as accessibility, safety, livability, etc.); moreover, the analysis techniques of Petri network can be used to calculate various performance indicators of the model, such as response time, latency time and share.

CPN-Tools is a Petri network modeling and simulation platform developed by the Petri network Research Center for the University of Aarhus, Denmark. It is featured with fast simulation speed and powerful network grammar checker. It supports for Linux and Windows operating system, supports hierarchical modeling and analysis of Timed Colored Petri network and supports secondary development. After modeling by Petri network, the features of the system can be analyzed to check the characteristics of the actual system. CPN-Tools support the state equation analysis and time simulation. By assigning the corresponding model's transition, arc, and the place, it can be clearly learnt the overall situation of the

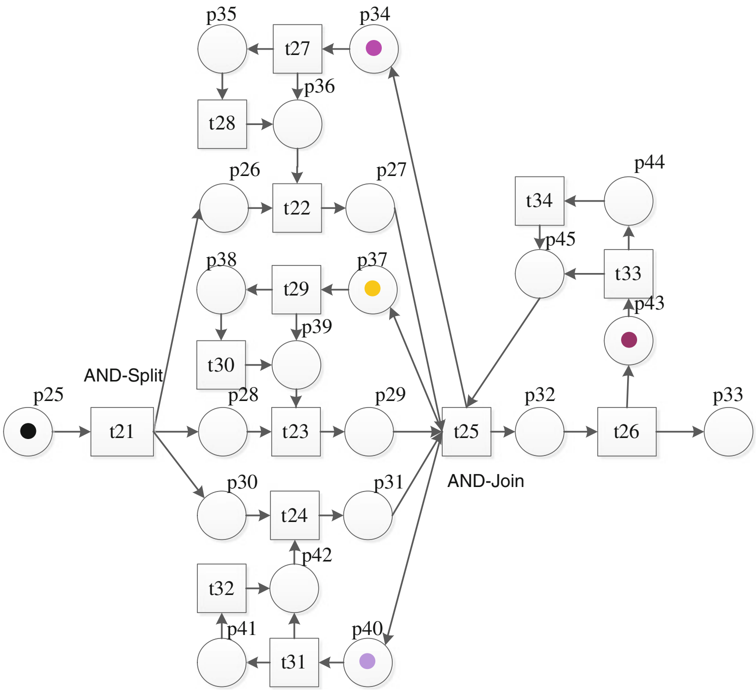

Fig. 123.9 The model of deck support process. *t21*: repair the deck support. *t22*: refuel. *t23*: charge. *t24*: load ammunition. *t25*: oxygenate. *t26*: complete deck support. *t27*: check the refuel equipment. *t28*: repair the refueling equipment. *t29*: check the charging equipment. *t30*: repair the charging equipment. *t31*: check the loading equipment. *t32*:repair the loading equipment. *t33*: check the oxygenating equipment. *t34*:repair the oxygenating equipment

operational support, parameters like the average support delay time and the support resources' utilization can be obtained, and the operational support time of the shipboard aircraft can be analyzed according to the simulation results so as to achieve the optimization of support resources (Song et al. 2007).

123.6 Conclusion

Based on the operational support feature of shipboard aircraft, this paper utilizes the hierarchical Timed Colored Petri Network (HTCPN) to establish the process model of shipboard aircraft to achieve a simple hierarchical modeling, which makes up for the shortage of time performance analysis of Petri network, achieves the distinction for support resources, provides a reference for the research of the support process of aviation support system, and plays a significant role in the tasks persistence of aviation support system.

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Chapter 124
Modeling and Simulation of a Just-in-Time Flexible Manufacturing System Using Petri Nets

Yue Cui and Yan-hong Wang

Abstract The modeling and simulation issues of the flexible manufacturing system under Just-in-Time environment is addressed in this paper. A typical flexible manufacturing system has been used as the study case, and its Petri nets model with Kanban has been presented. Since bottleneck or hunger resources in the manufacturing system usually have bad influence on the production process, more attentions were paid to the bottleneck identification and digestion in support of the proposed modeling and simulation mechanism in this paper. The machine utilization, under the premise of meeting custom needs just-in-time, is used as the main measure, while the trigger priority and the kanban numbers are two main adjusted artifices. Therewith, a large number of numerical simulations are investigated and detail discussions are proposed further. The simulation results show that the proposed Petri nets based modeling technique, as while as the bottleneck identification and digestion strategies, are feasible and effective.

Keywords FMS · JIT · Modeling · Petri nets · Simulation

124.1 Introduction

FMS is a manufacturing mode that combines computer information control system and material automatic storage and transportation system (Du 2010). JIT approach to production was originated by Toyota in 1970s in their car assembly plants and the core content is eliminating manufacturing wastes by producing only the right amount and combination of parts at the right place at the right time (Araz et al. 2006; Zhang et al. 2012). The advantage of JIT flexible manufacturing system is

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E. Qi et al. (eds.), *The 19th International Conference on Industrial Engineering and Engineering Management*, DOI: 10.1007/978-3-642-38391-5_124,

not only embodies the JIT ideology but also enhances the flexibility of production systems. However, flexible manufacturing system is an extremely complex discrete event dynamic system; it is difficult to be described with traditional mathematical models.

Petri nets with its perfect mathematical theory as the foundation, has strong modeling capabilities to describe the parallel, synchronous, conflict relations and plays an important role in the system modeling and simulation. It has also been applied in the modeling of flexible manufacturing systems (Colombo et al. 1997; Mao and Han 2010). On the other hand, with the manufacturing system has become increasingly complex, especially under today's challenge environments, the auxiliary analysis software becomes a prerequisite for the application of Petri nets. ExSpect (Voorhoeve 1998), the Executable Specification Tool, is a powerful modeling and analysis of language and software tools based on timed colored Petri nets. It is widely used in transportation systems, workflow modeling and maintenance support system (Qu et al. 2009; van der Aalst and Waltmans 1991; Vanit-Anunchai 2010; University of Aarhus 2005).

This paper addresses the modeling and simulation issues of the flexible manufacturing system under Just-in-Time environment basing Petri nets and ExSpect, a common simulation software platform. A typical flexible manufacturing system has been used as the study case, and its Petri nets model with Kanban has been built. Since bottleneck or hunger resources in the production process are commonly occurred cases, and they often have bad influence on the production process of JIT flexible manufacturing system (Zhang and Wu 2009), more attentions were paid on the bottleneck identification and digestion in support of the proposed model and simulation mechanism. The machine utilization, under the premise of meeting custom needs just-in-time, is the main measure of the problem, while the trigger priority and the kanban numbers are two main adjusted artifices. At the end of the paper, a large number of numerical simulations are investigated to verify the effective of the proposed model and detail discussions are proposed further.

124.2 Petri Nets Model of the Single-Kanban System

One of the major elements of JIT philosophy is the kanban system (Al-Tahat et al. 2009). The kanban system is an information system which controls the production quantities in every process. Figure 124.1 shows a Petri nets model of the single-kanban system (Di Mascolo et al. 1991) and describes the production process of three adjacent processing units. In a single kanban system, a production line could be divided into several stages and there are a fixed number of kanbans at every stage. The production of a part cannot start until a kanban indicates that this part is needed by the following downstream station (Matzka et al. 2012).

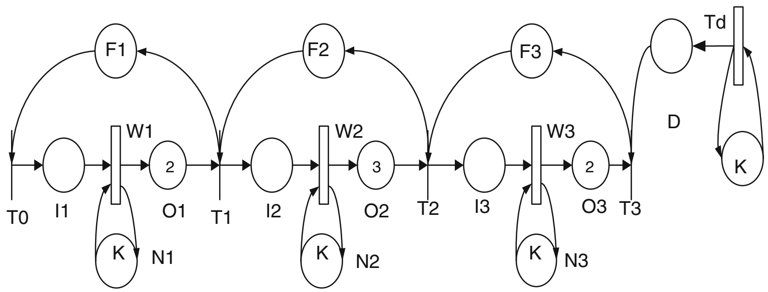


Fig. 124.1 Petri nets model of the single-kanban system

124.3 Modeling of JIT Flexible Manufacturing System

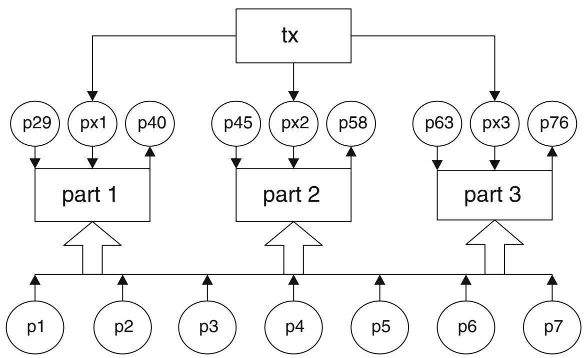
124.3.1 A JIT Flexible Manufacturing System Case

This paper takes a typical JIT flexible manufacturing system given in (Raju et al. 1997) as a case for addressing the modeling and simulation problem. The JIT flexible manufacturing system consists of five machining centers (from M1 to M5) and a load/unloads station (LUS), and they were connected by automatic guided vehicles (AGV) network. It caters to a variety of part types. In this paper, three part types are processed in this JIT flexible manufacturing system.

124.3.2 Petri Net Model of JIT Flexible Manufacturing System

The proposed JIT flexible manufacturing system modeling strategy adopted a hierarchical modeling methodology. First, The Petri net model of each part type is made separately. Then, these three models are linked by merging the common

Fig. 124.2 The JIT flexible manufacturing system model



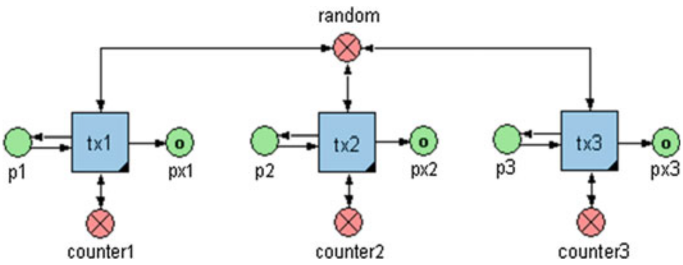


Fig. 124.3 User demands subsystem model

resource places to yield the system net. The interpretations of places and transitions are given in (Raju et al. 1997). Figure 124.2 shows the model.

Here main elements in the system are defined as:

px1, px2, px3: num, //Input requirements

p29, p45, p63: num, //Input of raw materials

p40, p58, p76: num, //Output products

p1, p2, p3, p4, p5: num, //Machines

p6: num, //Fixture

p7: num, //AGV

This Petri net model contains four sub-system, they are named as tx, part1, part2 and part3, respectively representing user demands subsystem, part1 processing subsystem, part2 processing subsystem and part3 processing subsystem. Among them, tx randomly generates user demands. A Poisson arrival pattern with a different mean arrival time for each part variety is considered in the present study. Each part has 10 demands as example in this paper, as an example for the system modeling, the tx model shown in Fig. 124.3.

This paper takes part1 as an example to introduce the processing subsystem, its model shown in Fig. 124.4. Being a demand-driven system, the functioning of the JIT flexible manufacturing system starts with the arrival of a demand. When a demand arrives, the system directly delivered the part to the user from output buffer. Then, the system begins to produce the same number of semi-finished or finished products to compensate for output buffer.

124.4 Simulation and Results

This paper use ExSpect as the simulation platform for our JIT flexible manufacturing system to illustrate the performance of the proposed modeling mechanism. Since bottleneck or hunger resources in the production process are commonly occurred cases, and they often have bad influence on the production process of JIT flexible manufacturing system, more attentions were paid on the bottleneck identification and digestion in support of the proposed model and simulation mechanism. The machine utilization, under the premise of meeting custom needs

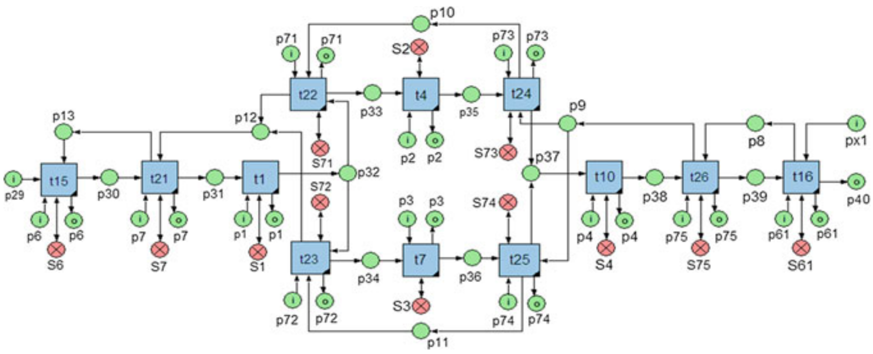


Fig. 124.4 The processing subsystem model for Part1

just-in-time, is the main measure of the problem, while the trigger priority and the kanban numbers are two main adjusted artifices. The simulation is running by the concurrent execution of the system net. A large number of simulations have been done, and the results data are recorded.

124.4.1 Initial Settings

The initial conditions of the system include the number of resources place token is one, the number of output buffer token is one, kanban number is zero, raw material is infinite and the average arrival time of the three part type demands are 10, 12 and 15 s respectively.

Simulation data include that the processing time of three parts, the difference of takt time, the total time, the machines utilization and the machines average utilization.

124.4.2 Simulation Results

Among them, takt time is an important factor in simulation. In order to produce only what the customers need just-in-time, the supplier has to adapt his production quantity to the customers' orders and produce to the takt time. The takt time is used to synchronize the pace of production with the pace of sales.

Takt time = Available working time per day/Customer demand rate per day (Matzka et al. 2012).

The difference of takt time is the difference between largest takt time of the part type and minimum takt time of the part type. The difference is smaller, the synchronization is better. However, because of bottleneck resources and hunger resources in the production process often impact the synchronization of

Table 124.1 Simulation Data

Performance Index	Simulation					
	1	2	3	4	5	6
P40 (s)	6052	5077	3872	3655	3670	3620
P58 (s)	3167	2517	3562	3170	3410	4200
P76 (s)	3797	3407	3142	3440	3470	3390
Difference of takt time	288.5	249	73	48.5	26	81
Total time	6632	5457	4892	4960	5290	5515
P1 (%)	61.37	69.27	83.20	94.35	94.52	91.21
P2 (%)	46.97	81.82	96.48	86.69	76.08	95.19
P3 (%)	33.47	51.31	52.33	76.81	93.01	81.41
P4 (%)	84.74	96.11	93.93	91.94	90.08	87.04
P5 (%)	49.00	73.30	91.99	90.73	85.07	90.66
P6 (%)	27.14	32.99	36.79	38.10	37.43	37.53
P7 (%)	78.71	47.42	52.59	54.39	53.36	52.63
Average utilization	55.11	74.36	83.59	88.10	87.75	89.10

production, it must eliminate bottlenecks and hunger issues. So this paper gives the definitions of bottleneck resources and hunger resources. Bottleneck resources refer to the machine resources that utilization exceed 10 % of the machines average utilization, and hunger resources refer to the machine resources that utilization below 10 % of the machines average utilization.

Simulation results were shown in Table 124.1 and the detail analysis were given bellow.

(1) Simulation 1. The simulation is run in the initial conditions; data show that the difference of takt time is too large; it means that the production synchronization is too weak. By comparing machines utilization and machines average utilization, it can obtain hunger resource is P3, bottleneck resources are P4 and P7 respectively.
(2) Simulation 2. In JIT flexible manufacturing system, resources are divided into two classes: fixed resources (P1–P5) and variable resources (P6, P7). Because of the former is the machine resource with high cost, it is not allowed to increase arbitrarily the number of resources. While the latter resource cost is low, it allowed be added properly its resources quantity. This paper adds one token in P7 for eliminating the influence of the bottleneck P7. The simulation results show the difference of takt time is decreased and bottleneck P7 is eliminated, it means that the production synchronization is improved. But there are still bottleneck resource P4 and hunger resource P3.
(3) Simulation 3. In JIT flexible manufacturing system, priority is divided into two kinds: resources priority and processing subsystem priority. Application simulation 1 utilization to set resources priority, (P1–P7): 0.61, 0.47, 0.33, 0.85, 0.49, 0.27, and 0.79. Through respectively calculating the ratio of three parts production time and the total time to set three processing subsystem priority, they are 0.91, 0.48, and 0.57. Resources priority can be set in the corresponding transitions, processing subsystem priority is set in all

transitions. When two kinds of priority will be set in the same transition, they should be added together. The priority is greater, the transition to be inspired more early. Results show that the difference of takt time are decreased, utilization are increased. But there are still bottleneck resources P2, P4, and hunger resource P3.

(4) Simulation 4. Increasing one kanban of P3, results show that synchronization continues to strengthen. By analyzing the data, it can obtain bottleneck affect has been eliminated, but there are still hunger resource P3.
(5) Simulation 5. Increase two kanbans of P3, results show that the synchronization is best, hunger resource P3 has been eliminated, but hunger resource P2 is appeared again.
(6) Simulation 6. The above conditions remain unchanged, increase one kanban of P2, results show that synchronization has been weakened, but the basic elimination of bottlenecks and hunger problem.

Through simulation and analysis of the simulation data, the bottleneck resources and hunger resources can be identified. Via adjust the number of kanban and the system priority, the system can effectively solve the bottleneck and the hunger problems, and optimize the performance indicators.

124.5 Conclusion

The main trend of the system simulation is the integration of modeling and simulation. Petri nets give a convenient method for the flexible manufacturing system modeling and simulation. This paper presents our modeling and simulation mechanism of the flexible manufacturing system under Just-in-Time environment.

By virtue of strong modeling capabilities of timed Petri nets, the model of the JIT flexible manufacturing system can describe the complex production process completely. In support of ExSpect environment, through simulation and data analysis, it can identify bottleneck resources and hunger resources. By setting the system priority and the number of kanban, the bottlenecks or hunger facilities are settled, and performance of the system is thereby improved by ameliorating the machine utilization and takt time in manufacturing processes. Therefore, the manufacturing process can run as a smooth and orderly mode with the premise of meeting custom needs in just-in-time manner.

Acknowledgments This research work is partly supported by the Scientific Research Fund given by the Liaoning Education Department (LS2010112).

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Chapter 125
Numerical Simulation of External-Compression Supersonic Inlet Flow Fields

Ping Wang, Hong-wei Wang, Si-dong Wei, Xue-shan Liu, Qing-guo Zhang and Xin Hua

Abstract In this paper, Method of CFD is used to simulate 2D flow fields for a certain external-compression supersonic inlet. It describes the methods of mesh generation, boundary conditions determination, convergence techniques of governing equation, and analyzes simulation result. The numerical results match well with the theory.

Keywords Convergence · Flow fields · Numerical simulation · Supersonic inlet

125.1 Introduction

The airplane inlet is an important component of aviation propulsion systems, its main functions are to transform kinetic energy of high-speed airflow into potential energy, and to provide necessary air to engine. The airplane inlet flow characteristics affect engine performance greatly. Inlet design and research are mainly based on wind tunnel experiments, aerodynamics and computational fluid dynamics (CFD). Hereinto, wind tunnel experiments need a long cycle, high cost, and there are many limits such as air flow temperature, pressure, speed, and model size. Currently, CFD method has become a popular aerodynamic analysis tools (Ju et al. 2005; Wang 2004; Zhang and Bai 2008; Zhu et al. 2002; Zhang and Wu 2008). CFD method is used in the paper to simulate 2D flow fields for a certain external-compression supersonic inlet; it describes the method of mesh generation,

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E. Qi et al. (eds.), *The 19th International Conference on Industrial Engineering and Engineering Management*, DOI: 10.1007/978-3-642-38391-5_125,

boundary conditions determination, convergence techniques of governing equation, and analyzes three kinds of operating mode of external-compression supersonic inlet.

125.2 Calculation Model and Mesh Generation

In this paper, the external-compression supersonic Inlet is with 3 wave system. Before entering the channel, supersonic flows get through two oblique shock waves and a normal shock wave, and then the flows reduce to subsonic flow, furthermore velocity drop, pressure increase in the diffuser, and ultimately achieve the requirements of the combustion chamber. Figure 125.1 shows 2D structure of inlet used for calculation and schematic of the shock wave system. The design operating mode of the inlet is as follows: flight altitude H = 11000 m, stream Mach number M = 2.6, attack angle $\alpha = 0$.

Mesh generation is the key issue for calculation of the inlet flow field, a reasonable grid make for the computational speed and accuracy. The inlet CFD model is defined with structured mesh. Wall functions are adopted for wall surface, initial grid is defined for $Y+ \approx 500$ and the number of fluid cells is 19,500. After adapted, final $Y+ \approx 150$ and the number of fluid cells are 20,675. The sensitivity to grid adaption has been investigated to reduce effect of mesh density. Results show that adaption of a solution grid with static pressure gradients <40 and $Y+ < 500$ does not significantly change the internal CFD results under the same type operating condition. The boundary conditions are given in Fig. 125.2. AGFE is defined as non-reflecting pressure boundary, ED pressure-outlet, ABCD and EH no-slip adiabatic wall. Many experiments and calculations (Ju et al. 2005; Wang 2004; Zhang and Bai 2008; Zhang and Wu 2008) have proved the reasonableness of the above choices

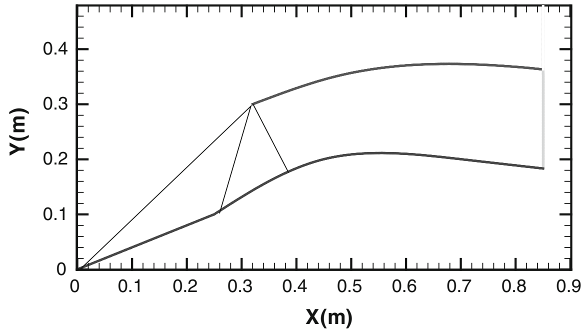

Fig. 125.1 Inlet structure and the shock wave system

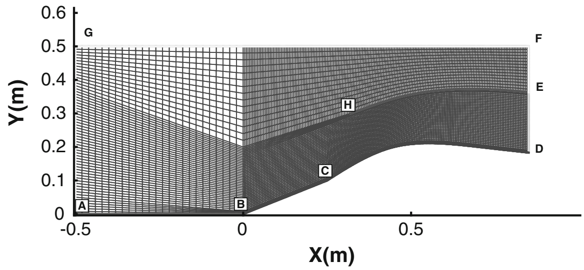

Fig. 125.2 Mesh and boundary conditions

125.3 Numerical Methods and Turbulence Model

Finite volume method is employed to solve N–S equation. Coupled implicit arithmetic with second order discretization and ideal gas properties is used to model the inlet. Combined with wall functions, RNG $k - \varepsilon$ turbulence model with eddy viscosity correction is adopted. The formula of standard RNG $k - \varepsilon$ model for solving the flow effective viscosity is described as:

$$\mu_{\text{eff}} = \mu + \mu_T. \tag{125.1}$$

where μ is molecular kinematics viscosity of the fluid and μ_T is RNG model turbulent viscosity calculated. The formula of RNG $k - \varepsilon$ model with eddy viscosity correction for solving the flow effective viscosity is described as:

$$\mu_{\text{eff}} = \left(\sqrt{\mu} + \sqrt{\mu_T}\right)^2 \tag{125.2}$$

125.4 Convergence Techniques

The numerical calculation of supersonic inlet is not easy to convergence, which is the generally accepted view (Wang 2004; Zhang and Wu 2008). The main reason is supersonic flow inside inlet while subsonic flow outside inlet, and there exists interaction between pressure gradient and viscosity in flow field, accompanied with shock waves, to get a stable normal shock wave flow field, iteration is much slower than the whole supersonic flow field. For the non-convergence problems, this paper has tried two methods and compared them. The one is to select first order upwind discretization scheme until convergence, then select the QUICK scheme, and the other is a direct QUICK scheme calculation until convergence, the results show that the first method calculation uses 7 h in computer with 2 GHZ CPU, and the second method uses 32 h, besides, the calculation results are consistent. That is to say, we can adopt the first method when calculating other similar problems. During the calculation process, the residuals are difficult to down, order of magnitude is always maintained at 10^{-2}–10^{-3}, we can concern about the amount of change to determine convergence, such as exit flow turnover, total pressure recovery coefficient, etc., when the value changes in each iteration step become very small and no real meaning, that is convergent (Hu and Wang 2008; Huang and Wang 2007; Li 2009; Zhao and Zhou 2001; Zhou et al. 2009).

A reasonable initialization of flow field affects significantly the accuracy of results and convergence rate. Initialization method in this article is as follows: To begin with, full multigrid initialization (FMG initialization) is adopted, which is effective for the flow with great pressure or velocity gradient, and then, the calculation results of inlet design operating mode are used to extrapolates the flow field else, Numerous tests have been performed about the computational scheme in the case, and results show that calculation efficiency could be improved more than 5–8 times (Carlson 1994; Lakshmanan and Nagarajan 2010; Launder and Spalding 1974; Lee and Edwin 1981; Morgan 2004).

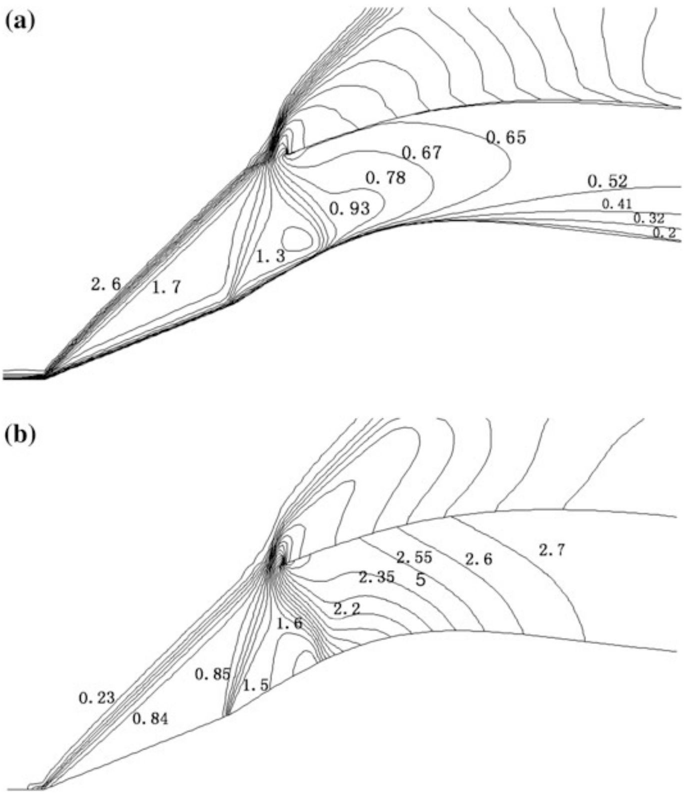

Fig. 125.3 Contours of the critical operating mode. **a** Contours of Mach number. **b** Contours of static pressure (Unit of pressure in atm)

125.5 Calculation Results

When the flight number M is constant, the flow status of inlet changes with the flow capacity of inlet export. The inlet flow fields including critical, supercritical and subcritical operating mode have been simulated with the Mach number of design operating mode. The boundary conditions of critical operating mode are as follow: flight altitude H = 11000 m, flow Mach number M = 2.6, angle of attack $\alpha = 0$, the export anti-pressure P = 2.78 atm. Figure 125.3 shows the calculation result.

Two oblique shock waves and a normal shock wave intersect just at the leading edge of outer walls in critical operating mode. After the first oblique shock wave, Mach number is reduced to 1.7, after the second oblique shock wave, it decreases to 1.3, the flows are still supersonic, after going through a normal shock wave M decreases 0.93, the flows become subsonic. Static pressure before and after every shock has a mutation, inside the pipeline flow pressure increases and velocity is reduced.

The intake conditions of supercritical and subcritical modes are the same as critical operating mode, the calculation results of critical operating mode are utilized to extrapolate the flow field else, Figs. 125.4 and 125.5 show the numerical results.

As shown in Fig. 125.4, the normal shock wave moved into channel in the supercritical operating mode, it is still supersonic flow in the initial segment, after normal shock wave flow pressure increases and velocity is reduced. As shown in

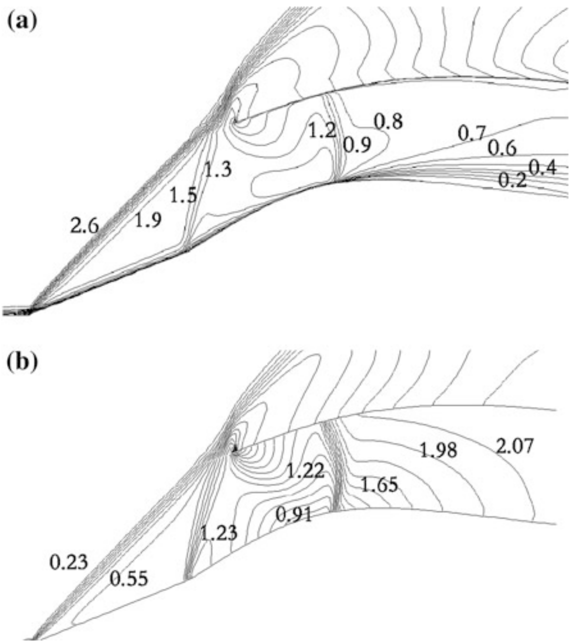

Fig. 125.4 Contours of the supercritical operating mode. **a** Contours of Mach number. **b** Contours of static pressure (Unit of pressure in atm)

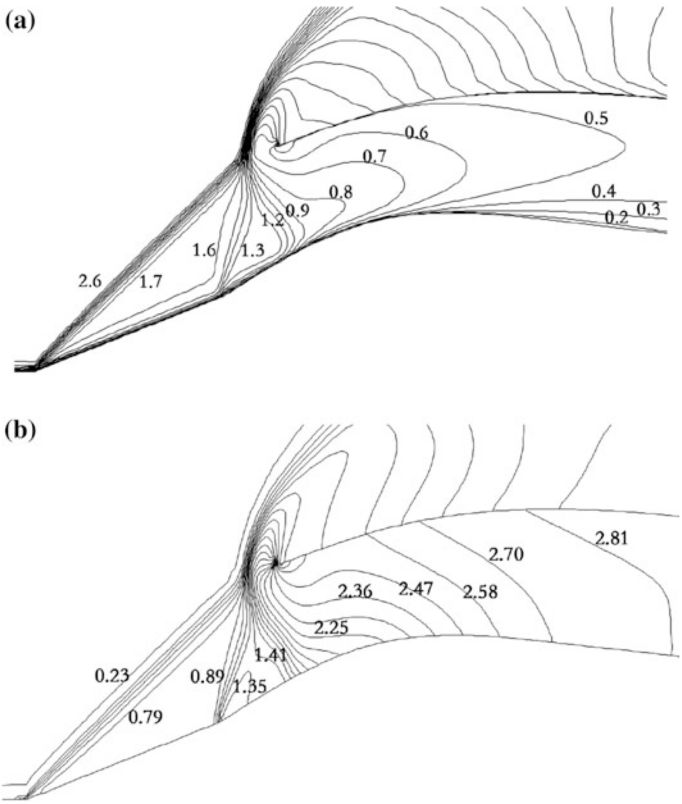

Fig. 125.5 Contours of the subcritical operating mode. **a** Contours of Mach number. **b** Contours of static pressure (Unit of pressure in atm)

Fig. 125.5, oblique shock waves and normal shock wave intersect before the entrance in the subcritical operating mode. Low-energy flow inpour into the channel so as to increase total pressure loss, serious cases may lead to an unstable operating mode. The total pressure recovery coefficients under the three modes are as follows: 0.849 in the critical operating mode, 0.741 in supercritical operating mode, and 0.827 in subcritical operating mode. As far as total pressure loss is concerned, the most favorable location of normal shock is just at the leading edge of entrance.

125.6 Conclusions

Finite volume method is employed to solve N–S equation. Combined with wall functions, RNG $k - \varepsilon$ turbulence model with eddy viscosity correction is adopted. Numerical techniques such as FMG initialization, extrapolation and reasonable calculation process can significantly improve efficiency. Numerical results of three operating mode show that the most favorable location of normal shock is just at the leading edge of entrance. Numerical results are consistent with the theory better, which indicate that the simulation method is reasonable, and it is valuable for inlet design and research.

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Chapter 126
Ontology-Based Multi-Enterprise Heterogeneous Model Fusion Method

Hong-xiu Wang

Abstract For the multi-enterprise collaborative modeling environment, the semantic conflicts of concept in the merger from the local model into the overall model or in the integration from the lower model into the upper model, the semantic-based multi-enterprise heterogeneous model fusion method is proposed. Moreover, the semantic similarity among the model instances is analyzed from the various levels, and based on the semantic similarity, a series of rules of the model merging are proposed, and then model integration is completed. Finally, the similarity matching tool is developed to realize based on semantic similarity analysis.

Keywords Heterogeneous · Model integration · Multi-enterprise model · Ontology

126.1 Introduction

In the collaborative enterprise modeling, the model is completed by more than one person in the project team; they will apply their own terms to create a model instance, resulting in the semantic conflict in the merger from the partial model to the overall model. The main problems are: the one on the same physical application of different terms to describe, the same terminology to describe different content, three different definitions of the granularity of the process, activity.

For this type of semantic heterogeneity, the related research work focus on building a unified dictionary based on meta-data (Castano et al. 2005; Missikof and Schiappelli 2003), but less involved in the essence of the information

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E. Qi et al. (eds.), *The 19th International Conference on Industrial Engineering and Engineering Management*, DOI: 10.1007/978-3-642-38391-5_126,

semantics, and can not fundamentally solve the problem (Cui et al. 2001; Mike et al. 1998). On the basis of the work on the research at home and abroad, proceed from solving the semantic heterogeneity of shared modeling the collaborative modeling, proposed an enterprise ontology-based concept of constraints to solve the consistency problem in enterprise modeling.

Ontology achieves the effective semantic understanding and communication between people or application systems (Horrocks et al. 2003; Pulido et al. 2006). In engineering applications, the ontology can support semantic interoperability. It provides the mechanism described in the explanation of the objective world. Semantic interoperability requirements of the data easier to understand, and can be easily defined mapping between the data of known and unknown (Athena 2004; Berre et al. 2007).

126.2 Multi-Model Fusion Method

126.2.1 Two Assumptions

Generally, the enterprise model is composed of multiple views, and its structure is complex. In order to achieve the integration of partial models, first of all assume that the two conditions have been met: First, the model is divided into view established; Second, during the merger have been identified belong to the same view of part of the model can be combined with a view of the upper model.

126.2.2 The Formal Definition of the Enterprise Model

According to the references (Vernadat 2002) on the definition of enterprise model and (Thiagarajan et al. 2006) on the definition of the business model, it is present that the business model formal definition is as follows:

Definition 1 Enterprise model EM = (E, R), where E is composed of a collection of elements for the model, R is the relationship between these elements in the model.

Modeling element E = {{Attribute}, {range}, {Subelem}}, Attribute is description of the properties of the element characteristics, range is range of the property, Subelem is set of elements of sub-concepts.

126.2.3 Similarity Definition

Definition 2 The formal definition of the similarity of two concepts x, y :
Sim(x,y)∈[0…1]
Sim(x,y) = 1→x = y: The two entities are equivalent
Sim(x,y) = 0 : The two entities do not intersect, unrelated
Sim(x,y) = Sim(y,x) : the symmetry

Matching relations between concepts, we can make a judgment according to their similarity.

In this paper, Sim, (c1, c2) expressed the similarity function between the two concepts c1 and c2.

Set a threshold t, when Sim (c1, c2) ≥ t, we believe that c1 and c2 is similar.

126.2.4 Analysis of Ontology-Based Model Semantic Similarity

Basis for the formal definition of the enterprise model, in order to calculate comprehensively, accurately the similarity between the concepts, Respectively, it is calculated based on the name, concept properties, the subset of concept. Finally, it is given the right value to merge the similarity.

(1) Calculation of concept name similarity. Assumptions two concepts A and B, the similarity of their names is calculated as:

$$sim_{name}(\mathrm{A}_{name}, \mathrm{B}_{name}) = \frac{N(\text{the longest substring between } \mathrm{A}_{name} \text{ and } \mathrm{B}_{name})}{(N(\mathrm{A}_{name}) + N(\mathrm{A}_{name}))} \tag{126.1}$$

If the concept has an alias, in addition does computing the concept name similarity, but also to calculating the similarity of the concept alias. Using the formula (126.1), the final name similarity is

$$Sim_{nameZ} = \sum_{j=1}^{m+1} \sum_{i=1}^{n+1} w_{ij} Sim_{name}(A_i, B_j)\ \mathrm{n,m} \geq 0 \tag{126.2}$$

Among them, $\sum_{j=1}^{m+1} \sum_{i=1}^{n+1} w_{ij} = 1$, n is the number of the alias of the concept A, m is the number of the alias of the concept B. When n = 0, m = 0, $Sim_{nameZ} = Sim_{name}$

(2) Calculation of similarity based on concept attributes

Based on the attributes, the theoretical basis for calculation of the conceptual similarity is: if the attributes of the two concepts are the same, then the two concepts are the same; if the two concepts have similar properties, these two concepts are similar. Each concept in the ontology is to be described and limited by a set of attributes. The attribute set definition is given in the following.

Definition 3 Let A = {$A_1[V_1]$, $A_2[V_2]$,…, An[Vn]}, A is a set of properties. A_i is the attribute name; V_i is the range of A_i. The definition is the set of attributes were classified into the attribute set level and the attribute value level. The calculation of similarity of the property is divided into two parts of the set of attributes and attributes values to conduct investigations. Let C1 and C2 are the concept associated attribute set of the objects o_1 and o_2. The similarity of the attribute set is:

$$Sim_{attrS} = \frac{1}{|dist(o_1, o_2) - 1|} \times \frac{|C_1 \cap C_2|}{|C_1 \cap C_2| + \alpha|C_1 - C_2| + (1 - \alpha)|C_2 - C_1|} \tag{126.3}$$

There may be different values in the instances of two objects in the common property. Therefore, the value of the similarities and differences in the common property need inspect. Let $A_i|C_1 \cap C_2|$. $A_i(o)[v]$ represents that the value of the instance o on attribute A_i is v, and the upper and lower bounds of the statistical range of the A_i values are expressed as Low(A_i), High(A_i). The similarity of the attribute value is:

$$Sim_{attrV} = \prod_{i=1}^{|C_1 \cap C_2|} \left(1 - \frac{|A_i(o_1)[v_1] - A_i(o_2)[v_2]|}{|Low(A_i) - High(A_i) + 1|}\right) \tag{126.4}$$

According to Ai specific data types, the specific meaning of its statistical range is different. For example, for the numerical data type, the difference between the maximum and minimum can be used in the actual value of the attribute. For Boolean data type, 0, 1 value is processed. For string type, if the attribute values of two instances are the same, similarity is 1, otherwise 0.

In the end, the similarity of two instances in the characteristics of the attribute set is the superposition of these two aspects. The formula is

$$Sim_{attribute} = Sim_{attrS} \times Sim_{attrV} \tag{126.5}$$

In addition, a concept may have multiple attributes and the effects and the extent described of each attribute on the concept are different. Therefore, if each attribute is involved, the amount of the calculation will be greatly increased. When the attribute similarity is calculated, the attributes need be classified, and focusing on the calculation of the business attributes.

(3) Calculation of similarity based on a set of concept

In the ontology, the meaning of a concept can consist of the meaning of its direct sub-concepts. The combination of all sub-concepts can describe the meaning of the concept. Thus, the similarity between the upper concepts can be obtained by calculating the similarity between the sub-concepts. This method is flexible and extensible. Let A, B for the two upper concept in the ontology, similarity between A and B using following formula:

$$Sim_{sub}(A,B) = \frac{\sum_{a_i \in A} \max_{b_j \in B} S(a_i, b_j) + \sum_{b_j \in B} \max_{a_i \in A} S(b_j, a_i)}{N(A) + N(B)} \tag{126.6}$$

N(A) indicates the number of sub-concepts of A, N(B) indicates the number of sub-concepts of B. S(a,b) is calculated by using the instance-based method, formulated as:

$$Sim(A,B) = \frac{P(A \cap B)}{P(A \cup B)} = \frac{P(A,B)}{P(A,B) + P(\overline{A},B) + P(A,\overline{B})} \tag{126.7}$$

which P(A,B) indicates the probability that this concept is sub-concepts both A and B when a concept randomly is selected from the ontology.

$$P(A,B) = {(N(U_1^{A,B}) + N(U_2^{A,B}))}\Big/{(N(U_1) + N(U_2))} \tag{126.8}$$

U_i indicates the set of underlying concepts in the ontology i, $N(U_i)$ indicates the number of the concepts in U_i. $N(U_1^{A,B})$ indicates the number of the concepts both belong A and B in the ontology 1. $N(U_2^{A,B})$ indicates he number of the concepts both belong A and B in the ontology 2. At this point, the similarity of A and B is obtained.

(4) Comprehensive computation of similarity

This three kinds of similarities are comprehensively computed, the formula of the final comprehensive similarity as follows:

$$Sim(A,B) = w_{name}Sim_{nameZ}(A,B) + w_{attribute}Sim_{attribute}(A,B) + w_{sub}Sim_{sub}(A,B)$$

which, $w_{name} + w_{attribute} + w_{sub} = 1$.

126.2.5 E Model Merging Rules Based on Semantic Similarity

Setting a threshold for the above four kinds of similarity, the threshold is usually determined by experts or analysts. When the calculated similarity is greater than the threshold, they are called name similarity, attribute similarity, subset similarity and comprehension similarity. Where, the model merging rules are defined based on these four similarity relations. According to these rules, and then the overall model is generated.

Rule 1: if the two model instances are comprehension similarities, the one is kept, another is deleted in the model merging.

Rule 2: if the two model instances are name similarities and the similarity is less than 1, but the attribute and the subset are not similar, two models are kept in the model merging.

Rule 3: if the name similarity of the two model instances is equal to 1, but the attribute and the subset are not similar, two models are kept in the model merging. At the same time, the name of a model is modified.

Rule 4: if two models are name similarity and attribute similarity, but their subsets are not similar, two models are kept in the model merging.

Rule 5: if two models are name similarity and subset similarity, but their attributes are not similar, two models are kept in the model merging.

Rule 6: if two models are attribute similarity and subset similarity, but their names are similar, one model is kept in the model merging.

Rule 7: if the two models are attribute similarity, but their names and subsets are not similar, two models are kept in the model merging.

Rule 8: if the two models are subset similarity, but their names and attributes are not similar, two models are kept in the model merging.

Rule 9: if the two models are not subset similarity, name similarity, attribute similarity, two models are kept in the model merging.

126.3 The Tool System of Model Knowledge Matching

The function of the system of model knowledge matching consists of ontology editing, database/owl transformation and concept matching. The ontology editing module has completed the editing and maintenance functions of ontology, establishing ontology tree and all knowledge stored in the database. Database/owl transformation module has completed to transformation the knowledge stored in

Fig. 126.1 Concept matching

the database into the standard expressed in OWL ontology. Concept matching module has completed to compute the similarity of the inputted concept.

According to the precious method of similarity calculation, when two concepts and the weight of each similarity input, the multi-layer similarities and the total matching are computed. Figure 126.1 show the matching result between "Quotation" and "Payment application form".

126.4 Conclusion

In this paper, the model merging method from the partial model to the whole model is studied. Moreover, the semantic similarity among the model instances is analyzed from the various levels, and based on the semantic similarity, a series of rules of the model merging are proposed, and then model integration is completed.

Finally, a prototype system of the model knowledge matching is developed. And a case is described to validate the modeling method proposed in this paper.

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Chapter 127
Outpatient Scheduling in Highly Constrained Environments: A Literature Review

Xiao-dan Wu, Mohammad T. Khasawneh, Juan Hao and Zhan-ting Gao

Abstract This paper provides a comprehensive survey of research on scheduling in outpatient services. An effective scheduling system has the goal of matching demand with capacity so that resources are better utilized, especially in highly constrained environments. This paper presents a general problem formulation and modeling considerations. It also provides taxonomy of methodologies used in the literature. The current literature fails to develop general guidelines that can be applied to design outpatient scheduling systems. Therefore, we identify future research directions that provide opportunities to expand the existing knowledge and close the gap between theory and practice. Our paper presents a literature review about four primary aspects: allocation of outpatient resources (R), outpatient appointment model (A), patient preferences (P), and research methodology for outpatient scheduling (M) under highly constrained environments. The models presented are focused on three outpatient appointment models (i.e., the traditional model, carve-out model, and advanced access model).

Keywords Allocation of outpatient resources · Highly constrained environments · Outpatient appointment model · Outpatient scheduling research methodology · Patient preferences

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E. Qi et al. (eds.), *The 19th International Conference on Industrial Engineering and Engineering Management*, DOI: 10.1007/978-3-642-38391-5_127,

127.1 Introduction

Nowadays appointment reservations can be made in advance in many health centers and outpatient clinics in an effort to improve the utilization of resources. However, the randomness of outpatient appointment models should be emphasized in scheduling under constrained conditions because of the uncertainty associated with patient demand, arrival patterns, and preferences. Typically, for some healthcare services, most appointment time-slots are prepared for those randomly arriving patients (i.e., walk-in patients) and only a small portion is available for scheduled patients. Under the condition of appointments in advance, for example, some patients may accept any time offered while others may ask to be treated at certain times that are convenient to them. Some may not mind the waiting time. Some patients may only choose to see their own doctor. Therefore, one of the primary areas of research can focus on how to arrange all patients and allocate available resources according to their changing preferences.

In 2008, Gupta and Denton (2008) talked about various challenges and opportunities facing appointment scheduling in healthcare. They introduced scheduling from three aspects, namely primary care, specialty clinics, and surgery appointments, with a focus on four factors: arrival process, service process, patients and provider preferences and incentives, and performance measures. In addition to providing specific application areas and research issues, another researcher (Erdogan and Denton 2009) presented a review on planning and scheduling problems that have been developed for three stages: preoperative stage, intra-operative stage, and postoperative stage. Furthermore, the authors also provide new insights for future areas of research. From the perspective of appointment scheduling, we introduce patient preferences and resource allocation in an overall outpatient scheduling methodology.

Our work presents a literature review about the above four aspects (i.e., RAPM) under highly constrained environments. The models in our paper are mainly about three outpatient appointment models (i.e., traditional model, carve-out model, and advanced access model) and several types of appointment systems. Patient preferences are divided into three aspects: assigned appointment time, appointment at convenient time for patient, and walk-ins. Outpatient resources include healthcare providers, staff, and equipment. Those scheduling models in the literature are either cost-oriented or revenue-oriented. Simulation, dynamic programming, and heuristic methods, etc., are the main methodologies used in outpatient scheduling.

This paper is organized as follows. In the first section, we introduce the topic and purpose of this research. Section 127.2 describes the relevant literatures. In Sect. 127.3, we introduce the various outpatient appointment models and compare them. Section 127.4 reviews patient preferences. The allocation of outpatient resources and research methodology of outpatient scheduling are discussed in Sects. 127.5 and 127.6, respectively. Finally, in Sect. 127.7, open challenges and possible future research directions are discussed. We also provide related literatures in the appendix.

127.2 Problem Definition and Formulation

The uncertainty in the service related variables represent the primary challenge in outpatient scheduling. Highly constrained environments determine the conditions which should be considered in the selection of outpatient appointment models, patient preferences, allocation of outpatient resources, and outpatient scheduling research methodology. With different appointment models, highly variable preferences of treatment time, and various scheduling methodologies, we can derive different optimal policies for making appointments. Under optimal conditions, those four highly constrained environments (Fig. 127.1) should be considered and all service related processes must be quantified. Early studies in the literature provide significant research about surgical scheduling, with outpatient cost and revenue as objective functions. However, to the best of the authors' knowledge, there is limited literature on the scheduling process under highly constrained environments. As stated earlier, there are a significant number of constraints in the outpatient scheduling process, such as patient preferences and allocation of outpatient resources.

Figure 127.1 shows that highly constrained environments mainly consist of four elements: outpatient appointment model, patient preferences, allocation of outpatient resources, and outpatient scheduling research methodology. Patients arrive to the system with the following distributions: uniform, empirical, and lognormal. Traditional model requires patients to accept any scheduled or service time provided to them. The work (Fries and Marathe 1981) considers patients' waiting

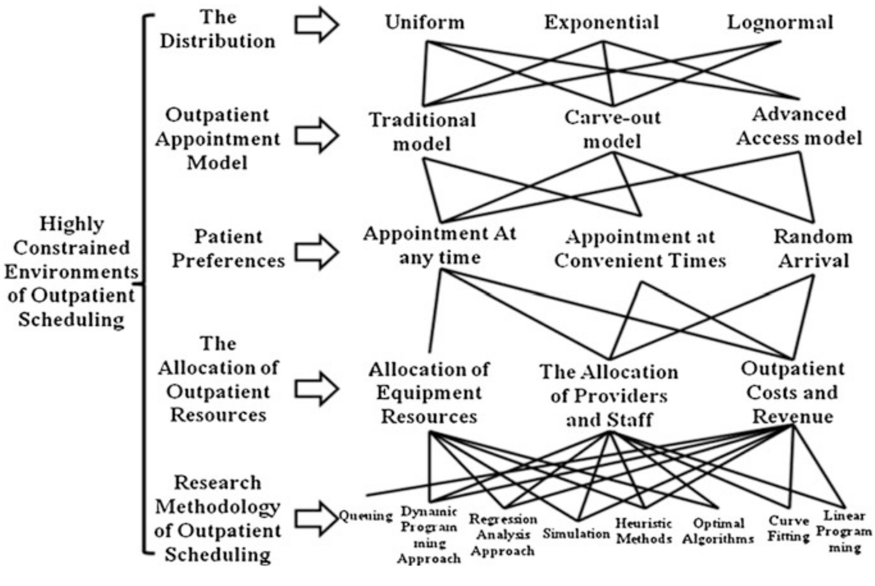


Fig. 127.1 Highly constrained environments of outpatient Scheduling

time, as well as the idle time and overtime of providers and staff as performance metrics or objective functions and utilizes dynamic programming and queuing models to maximize system capacity.

For instance, according to different outpatient appointment models, different patients' preferences may lead to different impact on the objective function under the same constraints. The distribution and utilization of outpatient resources can be analyzed as a function of different modes of capacity allocation considering the changing preferences of different patient groups. Finally, different results can be obtained when choosing different outpatient scheduling methodologies, with the ultimate goal being to find a better research methodology of outpatient scheduling, which further motivates the research presented in this paper.

127.3 Outpatient Appointment Model

There are several ways for determining the appropriate outpatient appointment model. When an appointment has been made, patients have to wait for a long time, and sometimes their treatments will be postponed. Thus, the patient may not be able to see their own doctor which could be the output of an inefficient outpatient appointment scheduling system. This could also result in poor communication between patients and doctors and could lead to unnecessary costs. Based on this fact, the paper attempts to select the appropriate outpatient appointment model. As stated earlier, there are generally three outpatient appointment models: traditional model, carve-out model, and advanced access model (Murray and Tantau 2000).

In the advanced access model, every doctor has available appointment slots, which improves the availability of outpatient services. When existing capacity is unable to meet patient demand, advanced access models become more advantageous. This model can better balance supply and demand. Though patients make diverse choices when making reservations, this method only takes into consideration reservations made in advance and walk-ins, which will reduce the variability in patient types. Moreover, the model can increase the effective utilization of resources, especially bottleneck resources, such as expensive equipment in outpatient clinics. Table 127.1 illustrates the daily capacity available on physicians' schedules in the three access models described in the paper, where TPA refers to the proportion of appointments; WU refers to walk-ins and the urgent; C-R refers to cost-revenue; and CP refers to capacity.

Table 127.1 Outpatient appointment model

Model	TPA (%)	WU	CP	C-R
TM	100	N	L	Higher-L
COM	>50	Y	H	H–H
AAM	<50	Y	Higher	L-Higher

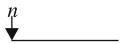
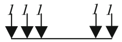
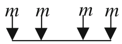
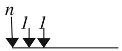
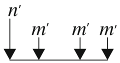
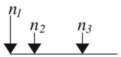
In the traditional model (TM) (Bowers and Mould 2005; Guo et al. 2004; Gupta and Wang 2007; Hassin and Mendel 2008; Huang 2008; LaGanga and Lawrence 2007; Murray and Tantau 2000; Muthuraman and Lawley 2008; Ogulata et al. 2009; Turkcan et al. 2010), the schedule is completely booked in advance; same-day urgent care is either ignored or added on top of existing appointments. In a carve-out model (COM) (Chakraborty et al. 2010; Chao et al. 2003; Fries and Marathe 1981; Gallucci et al. 2005; Green and Savin 2007; Kaandorp and Koole 2007; Patrick et al. 2008), appointment slots are either booked in advance or held for same-day urgent care; same-day non-urgent requests are satisfied in future time. In advanced access model (AAM) (Murray and Berwick 2003; Murray and Tantau 1999; Green et al. 2006; Kim and Giachetti 2006; Klassen and Rohleder 1996; Liu et al. 2010; Qu and Shi 2011), where practices focus on doing today's work today, there is true capacity. The majority of appointment slots are open for patients who call that day for routine, urgent, or preventive visits.

Our paper focuses on the overall process of scheduling, which stresses the proportion of scheduled patients. Table 127.2 emphasizes that every patient is assigned to a time block, and that the number of patients a doctor can serve in a certain period of time is fixed. The types of block appointment systems are shown in Table 127.2.

The work (Fries and Marathe 1981) shows that a multiple-block system is more feasible when the number of patients change. It was found that it is better to expand the size of the reservation model. The literature also gave the appropriate weight to patient's waiting time, doctor's idle time and overtime, in an effort to compare different booking systems using those performance metrics. The paper (Patrick et al. 2008) applied dynamic programming to schedule multi-priority patients in the diagnosis of resources. The size of patients in a multi-block appointment system is not carried out using a dynamic programming model. The study found that the impact of patients with different priority on outpatient costs is large.

The paper (Hassin and Mendel 2008) studied the patient no-show rate in the single-block system, and investigated the degree to which the model is influenced by outpatient costs and revenue. In the multiple-block system, the patient's waiting time cost, no-show costs, and service costs with no-show rate are examined. The study found that patient no-show cost has a smaller impact than the services cost on outpatient scheduling. Through the introduction of the above three studies (Fries and Marathe 1981; Hassin and Mendel 2008; Patrick et al. 2008), it can be clearly seen that the previous literature studied single-block and multiple-block systems, with the primary objective function being the overall cost, with variations in the outpatient factors considered.

Table 127.2 The type of appointment systems

Type	Representation	Explanation	References
Single-block		*n* patients arrive at same time	Hassin and Mendel (2008) and Kim and Giachetti (2006)
Individual-block/Fixed-interval		An initial-block of *1* patient	Green and Savin (2007) and LaGanga and Lawrence (2007)
Multiple-block/Fixed-interval		*m* patients individually at intervals equal to the mean service times of patients	Cayirli et al. (2006) and Patrick et al. (2008)
Single-block/Individual-block		*m* patients with intervals set equal to twice the mean service time, *m* >= 1	Green et al. (2006)
Single-block/Multiple-block		An initial-block of *n* patients, others call patients 1-at-a-time, *n* >= 1	Gupta and Wang (2007) and Kaandorp and Koole (2007)
Variable-sized multiple-block		An initial-block of n' patients, m'-at-a-time patients with intervals set equal to twice the mean service time, $n' > m'$	Chakraborty et al. (2010) and Fries and Marathe (1981)

127.4 Patient Preference

In recent years, extensive studies in the literature emphasized the importance of taking customer preferences into account using various choice models in different application areas. In particular, the discrete choice model has received major attention in economics, marketing, and operations literature, with significant research conducted to develop methods that simulate choice probabilities. Therefore, we will introduce the previously mentioned models including: Independent demand model (IDM), the multinomial logit model (MNL), the random utility-maximization model (RUM), and the Independent from irrelevant alternatives (IIA) (Gupta and Wang 2007). This way, our paper makes a simple introduction about the importance of patient preference in scheduling systems.

Patient preferences (PP) mainly include the following aspects. Some patients want to be treated at the exact day they make appointments (Bowers and Mould 2005; Chao et al. 2003; Fries and Marathe 1981; Green et al. 2006; Klassen and Rohleder 1996; Muthuraman and Lawley 2008; Ogulata et al. 2009; Turkcan et al. 2010), while others prefer their treatment to be performed when it is convenient since they do not mind waiting for some time (Chakraborty et al. 2010; Erdogan and Denton 2009; Green and Savin 2007; Guo et al. 2004; Hassin and Mendel 2008; LaGanga and Lawrence 2007; Liu et al. 2010). Some patients only prefer random arrivals (Gupta and Denton 2008; Gupta and Wang 2007; Kaandorp and Koole 2007; Qu and Shi 2011). PP adds to the complexity of the mathematical modeling process in which better optimized scheduling policies can be set and optimal number of patients of urgent reservations can be found to improve revenue (Gupta and Wang 2007).

In recent years, there have been few studies that focus on patient preferences in healthcare systems, unfortunately. The work (Talluri and Ryzin 2004) analyzed consumer choice model in revenue management, where they demonstrate that some patient preferences make the calculation of the optimization criteria simpler. The study (Zhang and Cooper 2005) considered a seat-allocation problem in which there are multiple flights between the same start and destination points. The paper (Gupta and Wang 2007) examined outpatient services with a Markov decision process model according to patient preferences with revenue being the objective function. When there is more than one doctor in the outpatient clinic, patient preferences differ, thereby making the optimization criteria even more complex.

It is observed that many of the published studies considered the situation when patients accept any appointment time offered to them. As expected, the dynamics of the scheduling system varies with different patient preferences. The paper (Patrick et al. 2008) divided outpatients into several priorities without considering patient preferences, wherein each patient is offered sometime to accept the CT scan appointment. The scheduling manager even has the right to reject patients or go overtime to complete the scan. However, in the literature, patients can choose to accept an offered time or select the appropriate time for them. The paper (Qu and Shi 2011) studied the effect that patients' preferences have on outpatient appointment scheduling in advanced access model using Markov chains.

127.5 The Allocation of Resources in Outpatient Clinics

Outpatient resources include many elements, such as providers, staff, and equipment. Furthermore, there might be a single department or multiple departments in outpatient clinics. The paper (Chao et al. 2003) proposed multi-block appointment and scheduling system based on patients' waiting time, provider's available appointment slots, and other factors. The focus was to determine a reasonable distribution of outpatient resources, which was not found to be proportional with other factors.

The paper summarizes the relevant literature regarding outpatient resources, including slack capacity (SC) (Chakraborty et al. 2010; Huang 2008), the penalty (P) (Chakraborty et al. 2010; Fries and Marathe 1981; Gupta and Wang 2007; Kim and Giachetti 2006; Liu et al. 2010; Patrick et al. 2008), cost (C) (Fries and Marathe 1981; Hassin and Mendel 2008; Kim and Giachetti 2006; Klassen and Rohleder 1996; Liu et al. 2010; Muthuraman and Lawley 2008; Patrick et al. 2008), providers and staff (PS) (Fries and Marathe 1981; Gupta and Denton 2008; Gupta and Wang 2007; Guo et al. 2004; Hassin and Mendel 2008; Huang 2008; Klassen and Rohleder 1996), revenue (R) (Bowers and Mould 2005; Chakraborty et al. 2010; Fries and Marathe 1981; Gupta and Denton 2008; Gupta and Wang 2007; Kim and Giachetti 2006; Liu et al. 2010; Muthuraman and Lawley 2008; Patrick et al. 2008), equipment resources (ER) (Bowers and Mould 2005; Guo et al. 2004; Gupta and Denton 2008; Patrick et al. 2008). While some studies focused on costs and revenue to evaluate the scheduling process, others considered slack capacity. In those studies (Huang 2008), slack capacity is said to be the idle time of staff or equipment, wherein idle time varies between departments. The paper (Chakraborty et al. 2010) studied both the idle time and overtime with consideration given to no-show rate and service time distribution based on outpatient services' revenue.

We can see in the paper that only four studies focus on outpatient equipment. The work (Guo et al. 2004) emphasized the efficiency of equipment under certain scheduling processes. The study (Bowers and Mould 2005) focused on the utilization of equipment shared by outpatient and inpatient clinics. The paper (Gupta and Denton 2008) mentioned the distribution problem of special facilities in outpatient clinics, and showed the efficiency when taking into consideration special patient conditions. The work (Patrick et al. 2008) mainly focused on the scheduling process of patients with different priorities. In equipment related research (Bowers and Mould 2005; Guo et al. 2004; Gupta and Denton 2008; Patrick et al. 2008), the evaluation should not be focused only on facility efficiency, but should also consider facility planning and department layout.

127.6 Outpatient Scheduling Research Methodology

There are numerous methodologies to solve this scheduling problem, with many using simulation (Bowers and Mould 2005; Cayirli and Viral 2003; Guo et al. 2004; Hassin and Mendel 2008; Huang 2008; Klassen and Rohleder 1996; Ogulata et al. 2009) and regression analysis (Gallucci et al. 2005; Hassin and Mendel 2008; Kim and Giachetti 2006; LaGanga and Lawrence 2007). Heuristic methods (Green et al. 2006; Gupta and Wang 2007; Liu et al. 2010) and the curve fitting approaches (Muthuraman and Lawley 2008; Qu and Shi 2011) are relatively rare. The variables can involve many aspects in the scheduling process. Revenue and cost are widely used as performance metrics, although other measures such as resource utilization have also been used. We know that genetic algorithms (Kaandorp and Koole 2007) and local search algorithms (Turkcan et al. 2010) are used only in two studies. However, we think that genetic algorithms can be a promising research tool.

The work (Fries and Marathe 1981) used dynamic programming to determine the optimal block sizes for the next period given that the number of patients remaining to be assigned is known. They present an approximate method to apply the dynamic results to generate a schedule for the static version.

The paper (Ogulata et al. 2009) used simulation to analyze different conditions, such as the percentage of unaccepted patients, treatment delay, number of patients waiting in queue, normal capacity usage ratio, and slack capacity usage ratio, which radiology patients need to schedule. Simulation has shown that in systems with high frequency, the percentage of unaccepted patients is mostly determined by maximum waiting parameter rather than slack capacity; the treatment delay is completely determined by the slack capacity; and the main factor that affects the treatment delay is maximum waiting time.

A study (Qu and Shi 2011) assessed the impact of patient preferences and providers/staff capacity using mathematical modeling. They included different patient choices which belong to the IIA method. The work (Gupta and Wang 2007) assumed patients choices were subject to IDM, MNL, RUM methods. Different models used linear programming to study outpatient revenue as a target and to find community cost according to bound heuristic methods.

The paper (Turkcan et al. 2010) proposed genetic algorithms to plan and schedule the entire chemotherapy cycle. The main factors are the height variation of the resource requirements, such as treatment time, nursing time, and pharmacy time, so that limited resources are fully utilized. The work (Liu et al. 2010) also used a dynamic heuristic method to study patients' no-show behavior. The simulation analysis shows that the method is more suitable when the number of patients exceed the outpatient clinic's actual capacity.

127.7 Open Challenges and Future Research

We mainly pay close attention to patient preferences and the allocation of resources in the outpatient scheduling process. In recent years, this emerged as one of the main challenges with significant potential for various research opportunities. Research to find an optimal outpatient scheduling process that is suitable for the Chinese healthcare system is relatively rare, and suitable scheduling rules for medical treatment, especially given the domestic characteristics, were not found. As stated earlier, most researchers consider cost and revenue as their goals. However, from the customer perspective, patients' waiting time is the most important issue to consider in an outpatient scheduling system.

Most of the literature discussed focuses on the uncertainty of patient preferences. Little efforts have been spent on managing the uncertainty in outpatient demands. For instance, current literature focuses on patients waiting times, when in fact the time spent in waiting lists may be more important from a healthcare outcomes perspective. Despite the rich literature considering the allocation and utilization of outpatient resources (e.g., idle time and providers and staff overtime, patient's waiting time) is still largely unexplored.

Due to different considerations, the optimal percentage of appointment timeslots in each category is not researched. The determination of optimal variable-sized multiple-blocks in appointment systems in this paper has been proposed. Also, most of the literature focused on using simulation and dynamic programming. Another research area that needs further study is optimal algorithms for outpatient resources allocation. This has the potential to incorporate multiple factors that impact patient satisfaction, such as the patient diagnostic process.

Acknowledgments This work is supported by Natural Science Foundation of Hebei (F2009000111) and Social Science Foundation of National Education Department (12YJC 630235).

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Chapter 128
Realization of 3D Reconstruction of CAD Model Based on Slicing Data

Ming Li and Quan-qing Li

Abstract This paper points out that the reverse engineering is the important technology to realize product innovation based on the prototype. It puts forward a new method to realize 3D reconstruction that takes slicing data of prototype as original data, under the commercial CAD modeling software environment, and briefly introduces the system developed by authors. The working process of this system is to read in the slicing data of the prototype, after pretreatment and feature recognition, to output feature data and realize 3D reconstruction under the SolidWorks environment, at last to construct the CAD solid model. It lays a good foundation for modifying the model so as to realize the product innovation. The innovation of this system lies in: according to slicing data, it can directly construct the CAD solid model. This paper also analyzes the key problems of the reconstruction process, and indicates that this technology has obvious advantages for mechanical manufacture filed.

Keywords 3D reconstruction · CAD model · Feature recognition · Reverse engineering

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E. Qi et al. (eds.), *The 19th International Conference on Industrial Engineering and Engineering Management*, DOI: 10.1007/978-3-642-38391-5_128,

128.1 Introduction

128.1.1 Basic Concept of Reverse Engineering

Reverse engineering is a science technology that is widely used in mechanical manufacture, modern-design-method, computer hardware, computer software and computer graphics. Reverse engineering is the important means of digestion and absorption, innovation for imported products (Honsni and Ferreira 1994; Daschbach et al. 1995; Puntambekar et al. 1994; Motavalli and Bidanda 1994; Chen and Lin 1997; Abella et al. 1994; Liu et al. 1998; Liu and Huang 1992). The essential difference between reverse engineering and copy technology is that the product model constructed by reverse engineering is CAD model. After acquire CAD model, it can be modified and re-designed in order to realize the innovation purpose. The working process of reverse engineering is shown in Fig. 128.1.

128.1.2 Key Technology of Reverse Engineering

It is known from Fig. 128.1, digitizing the part and constructing CAD model are the two key technology of reverse engineering (Luan et al. 2003).

Digitizing the part refers to adopt some measuring methods and equipments to acquire the geometry coordinate of the part. Presently the measuring methods that are used in industrial are coordinate measuring machines (CMM), laser beam scanning, industrial computed tomography and layer-layer cutting image. Using these methods can get every layers of slicing data of the prototype.

The method to construct CAD model that is commonly used in the reverse engineering technology at home and abroad is: to recognize the border to the slicing data automatically or manually; 3D dots are grouped according to the feature single principle; to carry on surface modeling to each group dots; the last is solid modeling (Chow et al. 2002; Huang et al. 2001). That is to link up each surface to form a complete part. The surface modeling theory and algorithm has basically ripe, but the research of oriented solid modeling of reverse engineering is still not reach the ideal practical level, therefore, in constructing CAD model is looking forward to have a breakthrough as soon as possible.

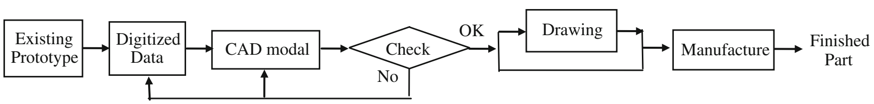


Fig. 128.1 The working process of reverse engineering

128.2 Functions of Reverse Engineering System Based on Slicing Data

Reverse engineering system based on slicing data, short for SdRe system is the reverse engineering system software of constructing products 3D model based on slicing data, which is developed by us. SdRe system includes three function modules: slicing data processing; feature recognition: 3D reconstruction.

128.2.1 Slicing Data Processing

The data obtained after digitizing the part is the bitmap image of all slicing layers of the part prototype. Processing these slicing images have two steps: filtering out noise and extracting borders. In image filtering technology, global filtering technology requires to know the signal or noise statistic model in advance, which for the slicing images is almost impossible, so the SdRe system uses the local filtering technology, which uses the local operators to do local treatment for the images in turn.

The SdRe system is with a filter function library including a lot of filter function. The user can select appropriate function for various image qualities and modify the filtering parameters, in order to get the best filtering result. Then the system extracts borders after filtering image, the image information is constructed as the ring chain that is composed of interconnected pixels. Aiming at the slicing data of object prototype in reverse engineering must be a ring of respective closed and mutually disjoint; the system has the effective arithmetic to extract borders for slicing data of object prototype in reverse engineering. While extracting borders the system's parameters can be modified by man–machine conversation to eliminate futility data like air holes and chips. Moreover, it can also distinguish between the convex feature and concave feature for extracted border. The concave means the solid surface materials to be removed, such as a hole, while the convex means the solid surface to possess materials, such as a cylinder. After extracting borders, the data become each closed ring composed of ordered dots, which is named data ring.

128.2.2 Feature Recognition

SdRe system uses feature model to construct CAD model, so the work of stage 2 is the feature recognition. Data ring after feature recognition is constructed the data that expresses object prototype feature, that is named feature ring. This is the core model of the system.

128.2.3 3D Solid Reconstruction

SdRe system selects the commercial CAD modeling software, such as SolidWorks, as system support software of 3D modeling. SolidWorks is 3D modeling software oriented computer. Its function is powerful, the cost is effective and it easily realize the interfaces with the programming language and other commonly used CAD software (Wen 2004). Moreover, on the support of commercial CAD modeling software, the 3D solid model that is reconstructed can be modified, it can output the part drawings and assembly drawings, as well as the files to be read by other commonly used CAD software, it still can output the STL files for the rapid prototyping (Liu 2004; Schreve et al. 2006). Using SolidWorks as support software, can save the research work to realize basic function, to focus on the key technology of reverse engineering. Solidworks provides the soft interface with programming language. Using this interface, SdRe system develops the interface model. Under SolidWorks environment, to run this model, input the feature data produced by feature recognition model, the CAD model of the product can be reconstructed.

128.3 Feature Recognition

The feature recognition model is the core of SdRe system. It completes feature recognition function, in order to realize 3D solid reappear. SdRe system read in the data of data ring, output the feature ring data for SolidWorks modeling.

128.3.1 Feature Types

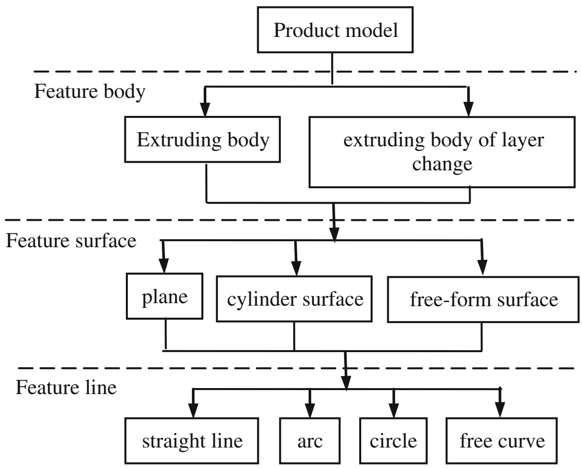
SdRe system to recognize the feature from the three levels of line, surface and solid, the feature types are shown in Fig. 128.2.

From the standpoint of feature body, the features that are constructed by SdRe system have two types: extruding body and extruding body of layer change. The extruding body is the feature that the shape and size of cross-section do not change; it is the equal cross-section body, such as the cylinder, prism. The extruding body of layer change is the body with variable cross-section, the size and shape of its cross-section are changed. The feature body of containing free surface is one of the extruding body of layer change. From the standpoint of feature plane, SdRe system can construct plane, cylinder surface, cone surface and free-form surface, each surface can be outside surface, also can be inner surface.

From the standpoint of feature line, SdRe system can construct straight line, arc, circle and free curve, as well as the polygon by their combination.

SdRe system recognizes the feature body and feature line with explicit recognition form, and the feature surface with implicit recognition form, for the

Fig. 128.2 Feature types



feature surface recognition is included in the recognition of the feature body and feature line.

128.3.2 Feature Recognition Manners

As mentioned above, the data ring actually is the data that a certain feature of object prototype is reflected in a certain cross-section. Some data ring that expresses the same feature surface of the object prototype, distributes in different cross-section are congregated, that is formed a new data chain, named solid ring. Solid ring is actually the data ring collection that expresses the feature surface of the object prototype. The solid ring after feature recognition is feature ring.

From the standpoint of automation, feature recognition has two manners: interactive recognition and automatic recognition (Li et al. 2003). Automatic mode can recognize the two types of feature line of straight line and free curve and all feature body; interactive mode can recognize all feature line and feature body. From the standpoint of checking the recognition results, in the interactive recognition there are two manners of relatively recognition and absolute recognition. For relative recognition, the system to the results of interactive recognition carries on fitting operations by means of least squares, in order to check the recognition correctness, if the error exceeds the specified threshold value (the value may be modified by user), then give warning information, and the user decides to recognize again or ignore the system warning. Using absolutely identify way, directly accept the artificial recognition results, no longer inspection. From the standpoint of working process, there are direct and indirect recognition. When carry on indirect recognition, the first is to recognize feature line, and then to recognize feature body, it is mainly used for recognizing the complex feature body. Direct recognition is to recognize the feature body directly, is mainly used for recognizing the simple feature body. If need to recognize the complex feature body, the system will guide users to recognize feature line.

128.3.3 Sub-Function Models

In order to carry on the feature recognition work efficiently and conveniently, it has carried on the function decomposition and model partition to the system, and developed the corresponding sub-function models. The structure of sub-function model system is shown in Fig. 128.3. Its main function models are briefly described as follows:

(1) Constructing solid ring
The process to construct the solid ring is the matching process of the data ring. That is according to certain principles and algorithms, all data rings of the same feature surface of the object prototype will be combined together to construct a solid ring. In order to calculate simply and improve efficiency, this software uses the data ring to match directly, that is using dot image of data ring to match, rather than the dot image of data ring is vectorized into the geometry image at first, then to match them again. In this way, it has spared the vectorization work of thousands of data ring dots in hundreds of images, greatly improving the processing speed.
Using dot image to match directly, at present there is no literature to introduce the algorithm. The data ring matching method that is constructed by our system, from the three aspects of shape, location and size of dot image to judge the matching relation of dot image. Completely matching in certain error range, compose the extruding body; incompletely matching, compose the layer changed extruding body; cannot match at all, that illustrates the dot images are belong to different feature surface separately. The modeling coefficient that expresses the matching relations can be adjusted through modifying the system variables by the system operator. Modeling coefficient size has determined the feature modeling precision and the feature number.
(2) Images display
In the different stages of the system running, all kinds of images will be displayed in the screen timely for operator to understand the situation and control the operation. After the solid ring is constructed, the operator can choose solid ring to display wholly, partly or single ring displays. The operator can be used the mouse to choose some one solid ring to edit or model. If need to recognize feature line, it will display the plane figure of the data ring, the operator can drag and move the mouse with the method of open Windows to choice the dot group.
(3) Solid ring editing
The construction of solid ring is completed automatically by system according to the modeling coefficients. The system operator can use the solid ring editing functions which is provided by the system to edit the solid ring, to carry on the

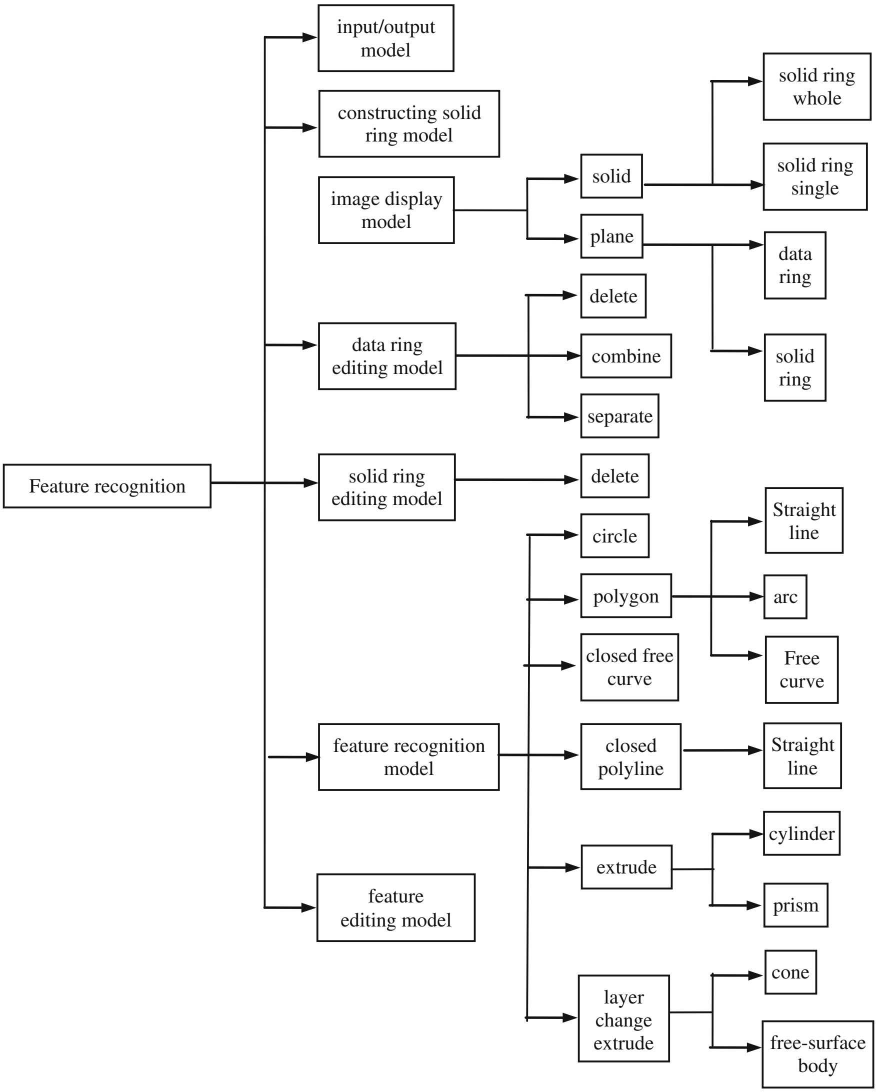


Fig. 128.3 The sub-function models of feature recognition

operations of deleting, separating and combining for the solid ring. Deleting solid ring, that is to modify the data of the original data ring in order to eliminate futility data like air holes and chips. Separating is from a solid ring (compound solid ring) to be separated another solid ring, one ring is became two rings. Combining is two solid rings will be combined into one ring. When combining, SdRe system will be according to the shape of the space position and the plane position of the two rings to judge whether the solid rings can be combined, if the system think them unfavorable combine, will give warning, please the operator confirm or give up; if the system think them cannot combine, it will give error messages, and refuse to combine.

(4) Data Ring Editing
The deleting operation for the data of solid ring can be done, that is to delete the current data ring (slicing) that is composed of the solid ring, in order to eliminate redundant data.

(5) Feature recognition
After solid ring is constructed, in order to construct the feature ring, the geometric recognition to the data composed of solid ring need be completed. The system uses the above various methods to recognize the feature line and feature body.

(6) Feature ring editing
Feature ring that has constructed already is displayed in the form of a tree, in order to do the editing work for it when necessary. This editing work is mainly to meet the requirements of SolidWorks. The editing work includes two contents, one is to adjust the modeling order of the feature ring, another is to adjust the corresponding relation of data point in surface body.

128.4 Conclusion

3D reconstruction method that puts forward in this paper is to directly construct the CAD solid model of the prototype based on slicing data of the prototype and under the commercial CAD modeling software environment, this is a new method. Previously, the reverse engineering method generally is to construct the local surface model of the prototype first, then to match and joint the surfaces and get the whole surface model. In the process of the surface matching and jointing, it is very complicated to deal with the problems of surface tearing and overlap. The method that research in this paper avoids these problems. The method is to realize 3D reconstruction in commercial CAD software environment, so it will save much time to develop the additional modeling software or models. In addition, in the mechanical manufacture field, the most of parts are composed of the regular surfaces, so this method has unique advantages in the reverse engineering of mechanical manufacture field.

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Chapter 129
Recommender System Based "Scenario-Response" Types Post-Disaster Emergency Supplies Planning

Gang Kou, Xin Zhao and Daji Ergu

Abstract In recent years, frequent outbreaks of unexpected natural disasters have caused great threats and losses to people's property and personal safety. Owe to the reality that natural disaster has the characteristics of wide affecting-areas, long duration, different needs of emergency supplies and inadequate rescue resources, it is strongly important to achieve effective planning for limited emergency supplies. The questions of how to ensure that each disaster-affected area gets emergency supplies matched with its losses and all demands of emergency supplies from different disaster areas met have become critical tasks of natural disaster emergency management. Based on the necessity and urgency of the emergency supplies as well as the real-time data of the scenario evolution of the disaster, this paper proposes an algorithm which combines recommender system and social tagging with allocation management to establish "scenario-response" type's poster-disaster emergency suppliers planning in order to reach higher performance in post-disaster recovery.

Keywords Group decision making · Post-disaster supplies planning · Recommender system · Scenario-response · Social tagging

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E. Qi et al. (eds.), *The 19th International Conference on Industrial Engineering and Engineering Management*, DOI: 10.1007/978-3-642-38391-5_129,

129.1 Introduction

The rapid development of economic globalization not only deepens the level of national industrialization and urbanization, but also increases the property losses and causalities which brought out by large-scale unexpected natural disasters. When such an event happens, all disaster areas are in great demands for emergency supplies (Fiedrich et al. 2000; Kevin and Liu 2004). Generally, different affected areas by different natural disasters such as typhoon, flooding, drought or earthquake etc. may have exactly different needs for different supplies. As for allocation management of emergency supplies in large-scale natural disasters, irrational distribution of resources usually leads to further expanse of personnel and property losses and deterioration of threats(Bakuli and Smith 1996; Zheng 2007), thus, more effective way based on the real-time data of the affected area is needed to achieve optimized post-disaster emergency supplies planning, which could ensure its fairness and rationality, greatly help reconstruction after disaster, speed up the recovery of order of daily life and production (Mezher et al. 1998).

At present, the allocation strategies of emergency supplies coping with large-scale unexpected natural disasters have the problems described as follows: (1) don't take the actual emergency supplies needs of disaster areas into consideration, the needless materials which don't need are over-supply while the much-needed supplies are on the contrary, which result in unnecessary waste of precious emergency supplies; (2) don't lay emphasis on the actual needs of different emergency supplies from different areas(Toregas et al. 1971; Yuan and Wang 2009).

In a word, the existing post-disaster supplies plans are rough and simple, the great imbalance of allocation makes them cannot respond well to the demands for emergency supplies of disaster-affected areas (Chang et al. 2007; Mailler et al. 2003). Therefore, advanced technologies are gradually introduced into post-disaster supplies planning.

129.2 Related Works

Because of the necessity and urgency of building more structure-optimized, high-performance poster-disaster emergency supplies planning, many scholars have carried out some researches and have achieved certain success. For instance, Zohar and Albert (2008) developed a system dynamics simulation for complex high-tech environment and calculated the expected net benefits; Kaan (Ozbay et al. 2004) proposed mathematical programming models with probabilistic constraints to address incident response and resource allocation problems; Barbarosoglu and Arda (2004) introduced a two-stage stochastic programming framework for transportation planning in disaster response; Chiu and Zheng (2007) developed a model formulation and solution for real-time emergency response in no-notice disasters.

Therefore, it can be concluded that most of the studies on planning of post-disaster emergency supplies paid more attention on the combination of allocation management with available transportation strategies (Gwo-Hshiung et al. 2007; Fang et al. 2007). However, it is obvious to see that numerous disaster areas usually have different needs for emergency supplies, including their quantity and category. The planning should be combined with the actual losses of the areas.

In this paper, based on the real-time data of the affected area and the evolution of the scenario, an algorithm that combines recommender system and social tagging with allocation management is proposed to establish a "scenario-response" type's poster-disaster emergency suppliers planning in order to reach higher performance in disaster emergency management and post-disaster recovery.

129.3 Methodology

The method of combining recommender system and social tagging information with post-disaster supplies planning is described in detail as follows.

(1) Assume the number of areas which suffer different losses in a large-scale unexpected natural disaster event is n, the set of the disaster areas is marked as I;
(2) Assume all of the disaster areas are considered as an integrated group G. Based on the actual damages and losses of the areas, *k-means* algorithm is applied to divide the group into m different clusters, which makes high similarity in the internal cluster and low similarity among the clusters, as shown in Fig. 129.1.
(3) For each cluster in the target group, looking at two different aspects: the data of damages and losses and tag information of emergency supplies, which are described in details in the following.

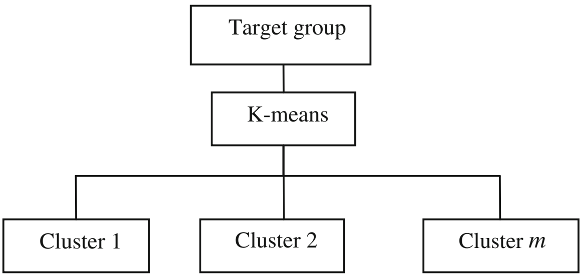

Fig. 129.1 Divides the target group into different clusters

129.3.1 The Aspect of the Data of Damages and Losses

(a) First, the average strategy is applied to aggregate the data of damages and losses of the group member in every cluster, which results in a single vector representing the integral damage degree of the disaster areas. Assume there are n_1 areas in the cluster; the first area's vector of damages and losses is $R_1 = (a_{11}, a_{12}, a_{13}, \ldots, a_{1i})$, the second area's is $R_2 = (a_{21}, a_{22}, a_{23}, \ldots, a_{2i}) \ldots$ where i indicates the number of the appointed attributes that are used to appraise the losses and damages of disaster-affected areas. Calculate the single vector that represents the integral damage degree of the disaster areas in the same cluster and denoted as $R_{cluster1}$, each number in the vector is the average damages and losses for the attribute i by all of the areas in the cluster.

$$R_{cluster1} = \sum_{j=1}^{n_1} R_j / n_1 \tag{129.1}$$

(b) Second, after getting the single vector that represents the integral damage degree of the disaster areas in the same cluster, consider it as a virtual disaster area v_1. To provide a recommendation list to show the needed quantity of the emergency supplies of the areas in the cluster, it is necessary to figure out the ratio in the whole dataset under the same attribute of every cluster, the ratio is marked as $r_{m,i}$, representing cluster m's ratio in the whole dataset under attribute i. Suppose that we have already known the total amount t_j of the emergency supplies through an emergency rescue site, j is the number of the category of the emergency resources. The recommendation list drawn from the specific data can be obtained by following formula.

$$R_c = r_{m,i}{}^{*} t_j \tag{129.2}$$

129.3.2 The Aspect of Tag Information of Emergency Supplies

(a) Classify the whole attributes which could represent the damages and losses of the disaster areas into different categories in accordance with their intrinsic correlation. Each category corresponds to different class of emergency supplies, for example, collapsed and damaged houses belong to the loss of buildings which could indicate the demand for emergency tent in an unexpected event;

(b) According to the real-time data of damages and losses of the disaster areas in each cluster, figure out the tag information of the needed emergency supplies in order, select the top-5 frequency tags as the most tag set which could shown the demands for the rescue resources of the clusters;
(c) Based on the ratio of the frequency of the tags deduced from the above steps, we can calculate another different recommendation list for quantity and category of emergency supplies which are needed by the clusters R_t .
What is to be addressed here is that the aspect of the data of damages and losses can be helpful in figuring out the similarity of demands for emergency supplies of different areas, while the tag information is used to figure out the differences between different areas in the same cluster, therefore it manages to compensate the shortage of simple post-disaster supplies planning strategies, which can fully reflect the needs of the disaster areas.
(d) Calculate the average of the two recommendation list, and then the quantity of the emergency supplies which allocated to each cluster can be easily obtained.

129.3.3 The Allocation Strategy Within the Same Cluster

It is true that even in the same cluster, different areas may have different demands for the quantity and category of the emergency supplies. Therefore, it is also important to find out good way to solve this problem. In the following section, the tag information of the disaster areas is used, and the detailed steps are proposed.

129.4 Case Study

In this section, a case study is conducted to explain the detailed steps of the proposed strategy for allocation planning of post-disaster emergency supplies.

Because of the existed unit inconsistencies in the original dataset, it is necessary to standardize the data first; the preprocessed dataset is shown in the Table 129.1.

Step1: Divide the fourteen disaster areas into three different clusters according to their actual data of damages and losses. The result is shown as follows:

Cluster1: Anhui, Fujian, Jiangxi, Shandong, Henan, Hubei, Hunan, Shanghai, Jiangsu, Hainan, Yunnan

Cluster2: Guangdong, Guangxi

Cluster3: Zhejiang

Step2: Average strategy is used to calculate the single vector that represents the integral damage degree of the disaster areas in the same cluster.

Table 129.1 The standardized dataset

Areas	Attributes							
	Victim	Death	Shift	Victim	Drought crop	Collapsed houses	Damaged houses	Economic loss
Shanghai	0.0006	0.0049	0.0085	0.0021	0.0000	0.0000	0.0000	0.0075
Jiangsu	0.0378	0.0071	0.0063	0.0932	0.0051	0.0088	0.0055	0.0101
Zhejiang	0.2059	0.0523	0.2874	0.1230	0.1119	0.0423	0.0935	0.0964
Anhui	0.0616	0.0487	0.0145	0.0830	0.1241	0.0664	0.0743	0.0998
Fujian	0.0535	0.0613	0.2268	0.0465	0.0459	0.0478	0.0744	0.0866
Jiangxi	0.0375	0.0340	0.0179	0.0350	0.0472	0.0818	0.0569	0.0508
Shandong	0.0042	0.0001	0.0071	0.0042	0.0005	0.0118	0.0104	0.0019
Henan	0.0000	0.0371	0.0207	0.0008	0.0001	0.0292	0.0045	0.0040
Hubei	0.0016	0.0055	0.0003	0.0020	0.0001	0.0001	0.0073	0.0020
Hunan	0.0331	0.0728	0.0241	0.0352	0.0915	0.0585	0.0261	0.0524
Guangdong	0.2762	0.3014	0.1528	0.2349	0.4533	0.4259	0.4580	0.1330
Guangxi	0.1825	0.0938	0.1744	0.2297	0.0993	0.1446	0.1345	0.2466
Hainan	0.0670	0.0717	0.0561	0.0545	0.0167	0.0025	0.0090	0.1522
Yunnan	0.0385	0.2096	0.0031	0.0559	0.0044	0.0804	0.0457	0.0568

Step3: Suppose the emergency supplies collected from an emergency rescue site are mineral water, instant food, relief tents and prevention medicines, the tag corresponding to each supply is water, food, tents and medicine. Here, t_1, t_2, t_3, t_4 indicate the quantity of the four kinds of supplies in the rescue site.

Step4: Calculate the ratio of the data that represents the damages and losses of the disaster areas.

Step5: Classify the whole attributes which could represent the damages and losses of the disaster areas into different categories in accordance with their intrinsic correlation.

The number of the attributes used in this case is up to 8, which can be classified into three categories, as shown in Table 129.2.

Step6: From Table 129.2, it is easy to figure out that the three categories of attributes are independently corresponding to prevention medicines, instant food and mineral water, relief tents. Therefore, the recommendation list for different

Table 129.2 Virtual disaster area for every cluster

Clusters	Attributes							
	Victim	Death	Shift	Victim	Drought crop	Collapsed houses	Damaged houses	Economic loss
Cluster1	0.030491	0.050255	0.035036	0.037491	0.030509	0.035209	0.028555	0.047645
Cluster2	0.22935	0.1976	0.1636	0.2323	0.2763	0.28525	0.29625	0.1898
Cluster3	0.2059	0.0523	0.2874	0.123	0.1119	0.0423	0.0935	0.0964

Table 129.3 The ratio of the data represents the damages and losses of the disaster areas

Clusters	Attributes							
	Victim	Death	Shift	Victim	Drought crop	Collapsed houses	Damaged houses	Economic loss
Cluster1	0.065468	0.167429	0.072086	0.095447	0.072865	0.097059	0.068263	0.142717
Cluster2	0.492441	0.658328	0.3366	0.591409	0.659885	0.786335	0.708216	0.568527
Cluster3	0.442091	0.174244	0.591314	0.313144	0.26725	0.116606	0.223521	0.288756

Table 129.4 Classify the whole attributes into three categories

Attributes	Category of damages and losses							
	People suffered			Crop destruction		Losses		
	Victim	Death	Shift	Victim	Drought crop	Collapsed houses	Damaged houses	Economic loss

Table 129.5 Average score of the three categories attribute

Cluster	Category of damages and losses		
	People suffered	Crop destruction	Crop destruction
Cluster1	0.101661	0.084156	0.10268
Cluster2	0.49579	0.625647	0.687692
Cluster3	0.40255	0.290197	0.209628

quantity for different emergency supplies can be obtained. Acquire the average score of the three categories attributes of the three clusters. The recommendation list R_c is:

$$R_c = \begin{pmatrix} 0.101661 & 0.084156 & 0.10268 \\ 0.49579 & 0.625647 & 0.687692 \\ 0.40255 & 0.290197 & 0.209628 \end{pmatrix} * \begin{pmatrix} t_4 \\ t_1 + t_2 \\ t_3 \end{pmatrix}$$

Step7: As for every cluster, figure out the frequency of the tag of the demands for the emergency supplies. For simplicity, cluster2 is used as an example, including Guangdong, Guangxi based on the standardized dataset; it is easy to get the tag information corresponding to the urgency of the emergency supplies.

Guangdong: tents, tents, instant food, medicine, medicine, medicine;

Guangxi: instant food, medicine, medicine, instant food;

Thus, the frequency of the tags can be obtained.

Step8: The similar method described in Step6 can be used to obtain the recommendation list R_t. Acquire the average score of R_c and R_t, then the final recommendation list can be obtained (Tables 129.3, 129.4, 129.5).

Step9: The allocation within the cluster could rely more heavily on the principles and tag rank.

129.5 Conclusion

Effective planning of post-disaster emergency supplies is critical for improving the level of natural disaster emergency management. Based on the existed researches, an algorithm is proposed to establish a "scenario-response" type's poster-disaster emergency suppliers planning in disaster emergency management and post-disaster recovery by combining recommender system and social tagging with allocation management. A case study is conducted to show the simplicity and feasibility of the proposed management strategy.

Future work will lay emphasis on more mature strategy and more complex situation. The distance between emergency rescue site and disaster areas is an important factor in affecting the allocation of emergency supplies, thus it should be taken into consideration. Otherwise, the data of damages and losses of the disaster areas are changing with the rescue activities; therefore, building a dynamic post-disaster supplies planning system based on the idea of "scenario-response" strategy is also important.

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Chapter 130
Research on the Simulation Case of Traffic Accident

Chao Wei, Xiang Gao and Miao-xin Nie

Abstract In order to accurately reconstruct the traffic accident, it needs to make the traffic accident simulation. In order to determine the choice of simulation parameters, it needs to extract the data when the traffic accident occurs. According to the actual accident status and logic analysis, we should verify the correctness of input parameters from the positive and negative aspects and get the simulation result with the accident reconstructing software PC-CRASH. The final simulation results should confirm the evidence of accident scene.

Keywords Traffic accident reconstruction · Simulation · PC-CRASH · Parameters

130.1 Introduction

Each traffic accident has its own unique. Variables of people, vehicles, road and environment have forced that each accident reconstruction should also consider the particularity on the basis of universality. The traffic accidents in this study are those shelved for many years with controversy.

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E. Qi et al. (eds.), *The 19th International Conference on Industrial Engineering and Engineering Management*, DOI: 10.1007/978-3-642-38391-5_130,

130.2 Overview of the Accident

On January 21, 2007, ten past eighteen, 1369 km + 300 m of 202 line, snowy, road had the ice and snow. The road was two-lane straight asphalt pavement, drove in different directions. Mr. Wang drove Santana LX sedan (with a passenger Mr. Zhang) from north to south. When driving to 1369.3 km in 202 lines, it had a collision with Mr. Lv in agricultural tricycle (with a passenger) from south to north. After the accident, the Santana sedan fell into the drain outside the slope, while the agricultural tricycle stopped in the road. The accident has caused damaged in varying degrees of Santana sedan and agricultural tricycle, and caused Mr. Wang and the passenger Mr. Zhang died on the spot.

130.3 Problems to be Solved

The problems are the speed of Santana sedan and agricultural tricycle when the accident occurred.

130.4 Simulation Process

130.4.1 Automobile Damage Condition

The central part in the right side of Santana sedan has severe hollow deformation, the right side of the ceiling has inward deformation, and the whole car has bending (See Fig. 130.1). The deformation zone is from the upper of right front wheel to the upper of right rear wheel with a length of 1170 mm and a distance of 360–1930 mm (the latter is the height after the deformation, higher than the original height size) from the ground. Within the deformation zone, the depth is about 870 mm, and the deepest area is 2570 mm to the rear. Within the scope of 110–310 cm from the front to the bear with the distance of 15–158 cm from the ground to the front and rear fender panels at the right side and the two doors, it has the overall impacting hollow, the right side has severe quasi-impacted marks, and the vehicle skin has left many scratches. Among them, the front corner of B column has the similar hollow with the front wheel shape of agricultural tricycle. For the Santana sedan, the shroud of the engine has deformation, the gearbox handle has damaged; the combined lamp in the right front has broken off, the front and rear windshield and right window has broken; there are many paints flakes off in the front and rear doors and the front and rear fender panel at the right side.

Fig. 130.1 Santana sedan

Fig. 130.2 Agricultural tricycle

Within the whole width of the vehicle, the front of agricultural tricycle has inhomogeneous deformation, and the front right deformation is more severe than the left; the down edge at the right front door and window has backward dislocation of 70 mm, the down edge of right door has backward dislocation of 170 mm; the down edge of left front door and window glass has backward dislocation of 15 mm; the whole front especially the front wheel hit the cover and has the hollow; the left front combination has broken off, and the right front combination cover has broken off; the windshield and right window has broken off; The two rearview has off (See Fig. 130.2); the right front corner of the head has hollow and deformation with obvious fold deformation, impacting cracks and scratch marks; The down edge of left corner has hollow with fold deformation and scratch marks; The left and right paints have broken off; The front wheel has broken off from the fork tray.

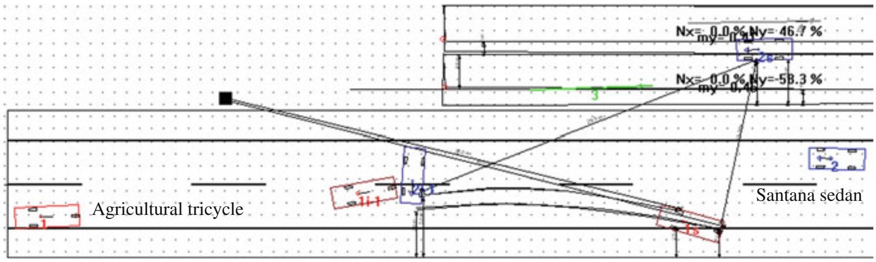

Fig. 130.3 Pre-crash station and post-crash station

130.4.2 Simulation Analysis

The accident process mainly adopts the establishment of momentum conservation model and functional conservation model, and then realizes with the computer simulation. The simulation software is PC-CRASH, and the required technical parameters should refer to the finished original data and actual use data. The crash process is shown in Fig. 130.3.

The test has proved that after the collision of the traffic accident, the two rear wheels of Santana sedan turn smoothly, while the rotation of two front drive steering wheels has friction with the resistance of variable drive axle. The collision focus area of Santana sedan firstly lies in the junction of B pillar at the right side and right front door, and the car shows the arcuate shape after the deformation. In this case, the front and rear wheels especially the right wheel has turned a steering angle respectively to right and left.

The accident scene sketch and vehicle inspection can show that the front fork of agricultural tricycle has steered to the tray and broken. The front end of two longitudinal beams has collision with the wheel to break and touched the road forming the friction defect. Even though the agricultural tricycle has no front wheel brake in the structural design, in this case, it can be seen that the front wheel braking is effective.

The accident scene sketches, survey notes and photos can show that after the collision, the left rear wheel of agricultural tricycle has left the braking traces, and the braking is effective. The vehicle inspection can show that whether the engine is working, the two rear wheels of agricultural tricycle have brake. Besides, the left and right rear wheel can be locked when the vacuum tank and piping are perfect, and the braking force of the left and right wheels is balanced. Thus it suggests that the braking of agricultural tricycle is normal and effective.

After the collision, the Santana sedan has across the road, curbs of 12 cm, green belt and slope (slope length is 326 cm, and the slope is about 58 %), and felt into the drain (Ladder, the width of bottom edge is 100 cm, the side length is 60 cm, and the slope is 47 %).

Because the curb of 12 cm and the green belt can hinder the movement of Santana sedan, it has set a low wall with the height of 12 cm representing the curb and green belt in the simulation process.

The deformation parts, features and size of the two vehicles can show that the front of right middle size of the vehicle was firstly contacted and had collision with the front wheel of agricultural tricycle, and the angle of the two vehicle direction at the collision is near 90°. The smaller deformation in the front of agricultural tricycle can show that the main part in the collision is the front wheel, which means that the collision has a larger rebound effect.

The instant speed and road condition before the collision can determine the moving distance of the agricultural tricycle in the transverse direction after the collision.

The relative position and the relative road direction status before the collision can determine the moving direction after the collision. The moving distance is mainly influenced by the collision speed of agricultural tricycle, the braking or not, the bending status, road condition and the conditions outside the road of curb and green belt.

Based on the above principle analysis, consulting the deformation size, feature and accident scene sketches of Santana sedan and agricultural tricycle; input the data of road traces, vehicle quality, vehicle technical parameters and road adhesion coefficient into the software.

Gradually set the parameters of collision initial speed, initial direction angle and initial position of Santana sedan and agricultural tricycle, simulate the moving trajectory, status and result, and make repeated comparison with the cite situation, especially the final stationary position, and we can get the speed at the collision:

$$\mathrm{V}_{\text{agricultural tricycle}} \approx 43.4\,\mathrm{km/h}$$
$$\mathrm{V}_{\text{Santana}} \approx 50.7\,\mathrm{km/h}$$

Because the Santana sedan has severe sideslip when close to the collision, the longitudinal axis is inconsistent with the speed direction. Component velocity of the head along the longitudinal axis is as follows:

$$\mathrm{V}'_{\text{Santana}} \approx 8.5\,\mathrm{km/h}$$

In addition, the total mass of the agricultural tricycle is heavier than that of Santana sedan; the road vertical speed of the former is larger than the latter. Besides, with the influence of curb and ditches, it seems that each wheel of the Santana sedan has free rotation after the collision, the speed direction and angular speed when the vehicle is close to stop has greatly influenced the stop position and direction, and the agricultural tricycle speed with larger mass and adopted the braking is relatively stable.

Because the accident scene has no road traces before the accident collision, it can not infer the vehicle moving status and trajectory. The initial speed and direction in the simulation analysis are to realize the relative status (collective speed, direction and the contact position and direction), but it does not represent the actual speed, for the driver may adopt the braking and steering operation from the initial time to collision contact.

The tricycle braking traces are in coincident with the impacting point. It needs a period of time for the braking from zero to maximum or from the beginning of braking to the appearance of braking trace in the braking process. In other words, the tricycle speed of the driver reaction, implemented operation and braking response is larger than that in the collision. With the analysis, we can get that the agricultural tricycle speed at 13 m (or 1 s) before the collision is about 45 km/h, and that at 26 m (2.1 s) before the collision is about 46.5 km/h. Because the Santana sedan has the sideslip status before the collision, it can not infer the speed before the accident.

130.5 Conclusion

With the above analysis and computer simulated result, we can infer that the Santana sedan speed was larger than 50.7 km/h at the collision, the component speed along the head longitudinal axis was about 8.5 km/h; The agricultural tricycle speed was about 43.4 km/h at the collision.

The agricultural tricycle speed at 13 m (or 1 s) before the collision was about 45 km/h, and that at 26 m (or 2.1 s) before the collision was 46.5 km/h.

Accident simulation should accurately extract the accident parameters. After obtaining the simulation results, we should take use of the result to verify the accident process to have a perfect combination of logic and evidence.

Acknowledgments My heartfelt gratitude goes to my doctoral tutor Xiang Gao in Jiangsu University for the valuable instructions, and I feel grateful for the help of doctoral tutor Hong-guo Xu in Jilin University.

Chapter 131
Regional Brand Development Model Under the Perspective of System Theory

Lai-bin Wang

Abstract The regional brand development is to enable regional brands sustained, orderly, stable and coordinated development under the constraints of the four elements of the government, business, social and other intermediary organizations, from this, the structural model of the regional brand development is formed. The article argues that the regional brand building and development must proceed from the following points: First, in the social subsystem, focus on the cultivation of social cultural, change people's traditional concept, nurture a kind of social culture of brand share, and strengthen the basic research for technological innovation; second, in the enterprise subsystem, improve product quality, good brand marketing, management and technological innovation; third, government subsystem, in terms of policy, capital, infrastructure, branding promotion, offer support; fourth, in other intermediary organizations subsystem, give full play the coordinating role of industry associations, human resources, financial resources, legal advice, and other aspects are inseparable from intermediary organizations.

Keywords Development model · Regional brand · Resource system theory

131.1 Introduction

The regional brand concept was first proposed by Keller et al. (1998), the location like the products or services as branding, brand name is usually the actual name of this region. The brand makes people aware of the existence of the region, and related associations. Keller et al. (1998) also believes that the region can be like as the brand of product or service (Kevin 1999). Rosenfeld (2002) believes that the

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E. Qi et al. (eds.), *The 19th International Conference on Industrial Engineering and Engineering Management*, DOI: 10.1007/978-3-642-38391-5_131,

implementation of the regional brand strategy based on industry clusters in less developed countries is a kind of way to enhance the competitiveness (Rosenfeld 2002; Simon 2007). In the development process of regional brands, Allen etc. believe that traditional brand theory is applied to the regional context, two especially critical issues must be considered, namely the management of stakeholder groups and government leaders to play the role (Simon 2007; Malcolm 2006; Eraydn 2010).

Domestic studies of the regional brand theory date from 2002. With the vigorous development of industrial clusters in China, in the industrial clusters of Zhejiang, Jiangsu, Guangdong, Fujian and other brand-name products gathered growth and brand regionalization phenomenon, theoretical studies of the regional brand begins to be the part of the attention of scholars. Xia Zengyu explores the regional brand building. After 2005, the regional brand research articles were published extensively, and researches involving the content, nature and characteristics of the regional brands, the formation mechanism and affecting factors (Sun 2009), regional brand values and interests regional brand and corporate brand, the effect of the regional brand, the regional brand equity and assessment (Yang 2005), regional brand governance mechanisms, regional brand building in the role of government (Cai 2008), dynamic evaluation and coordinated development of regional brands, the regional independent brand cultivation mode, regional brand management and other aspects of a more systematic study (Zeng 2000).

The current study mainly uses case studies, mostly stays in the qualitative phase, lack of quantitative research tools and methods, and seriously impact on the establishment of the theoretical framework of regional brands, therefore, on the basis of qualitative research, to develop a regional brand quantitative measurement tools which enhance the quantitative study of the regional brand, is an important direction for future research in this field.

Regional brand studies are now beyond the narrow boundaries of the marketing application, involving disciplines such as sociology, history, political which is little attention in the past marketing and branding. So disciplines involved with regional branding have extensive features and present the trend of multidisciplinary.

131.2 Connotation of the Regional Brand

Since the establishment of a socialist market economy, have emerged around a number of products suitable for local production, and gradually formed a large-scale industrial clusters and business clusters, and thus become regional brand being characteristics of region. The regional brand is the “industrial products” which have considerable size and strong production capacity, higher market share and influence within an administrative (geographic) area, is an area of industry group to build a unified brand. In addition to general brand unique, easy to distinguish and irreplaceable features, it has non-exclusive unique features, as well as non-competitive, external, regional, cluster and dispersed such.

Regional brand is the outward manifestation of the regional competitiveness, the strength of the competitiveness of the regional brand can reflect the level of regional economic development and government performance level. Therefore, regional brand is not only the practical issues of corporate, is also a scholar of great concern academic proposition.

It is generally believed that the regional brand is a product of regional economic development, is the industry within the region of considerable size and strong manufacturing capabilities, higher market share and influence of business and business-owned brand goodwill sum. It consists of two elements: regional and a good brand effect. In the backdrop of economic globalization, regional brand can make people will a certain image and its association with this region, there is a link up to drive regional economic development through regional brands to create and disseminate. The regional competition has become an important form of competition in the market; the regional brand has become a contemporary economic development and significant features. Regional brand is the inevitable outcome of the regional economic development, reflecting the core competitiveness of the regional economy, representing the subject and the image of a region.

In addition to general brand characteristics, regional brand has its own unique characteristics: First is symbiotic. Regional brand is a public brand and resource within a regional. Therefore, it has positive externalities; the utility has a good symbiotic which can be shared by enterprises in the region.

Second is the persistence. Regional brand is the result of collaboration of many enterprises in the region, the extraction of a number of brand essences, have a solid foundation, and brand effect more extensive and lasting.

Third is regional. Regional brand has a certain degree of regional and rooted. It deeply affected by local cultural, economic, political, regional factors and overall performance.

131.3 Formation Process of the Regional Brand

Regional brands have distinct characteristics and formation processes. Regional brand in China under the reform, opening up and the market economy environment, the formation process has a strong era, nationality. The formation process of the regional brand is the main formation of the regional brand building elements, including regional competitive industries to choose, the formation of industrial clusters, regional brand creation and the formation of brand economy chain.

The choice of regional advantage industry is the basic link of the regional brand, has a direct impact on the quantity and quality of the regional brand building. In a way, it is the premise of the formation of industrial clusters. The formation of industrial clusters is the basis of regional brands. The continuous development of the regional brand will inevitably bring about the brand economy chain. At the same time, the creation of the regional brand permeates every aspect of being.

131.4 System Theory and Regional Brand Development

131.4.1 System Theory

In this paper, the regional brand building still is a regional industrial clusters as the foundation, regional industry cluster stakeholders will naturally become the main body of the regional brand building, and these stakeholders is to constitute the elements of the regional industrial clusters, exist the complex contact among them; regional brand building is a strategic development to execution and then to the outside world to exchange feedback rating system, regardless of the strategy establishment, the follow-up implementation, the final regulatory assessment for feedback to the strategic plan amendment is influence each other, so the regional brand building based industry cluster is a complex system works.

131.4.2 Whole Course Regional Brand Development Model

(1) Input stage

In different brand-building phase, the investment of resources is also different. In the start-up period, due to the extremely limited resources of the enterprise, the lack of first-class industrial clusters, this requires the government to increase investment, make the related policies, and other intermediary organizations in technology, human resources, and financial resources need give strong support. Resources focus on investment to a single market to achieve rapid breakthrough of a brand, is a universal model for a regional brand to be established firmly in a market (Fig. 131.1).

In the period of rapid development, with the region brands is becoming well-known in the market, followed by rapid growth in the size of the industry cluster, government support and policy makers should be biased in favor of SMEs, to develop a reasonable market access system, and other intermediary organizations should strengthen resource inputs.

At maturity, the regional brand has a strong competitive position in traditional markets; status in the industry is about to changes from the pursuer to the transcender and the leader. The input resources are relatively abundant, but because of loss of the development of benchmarking, will have a more technical or market

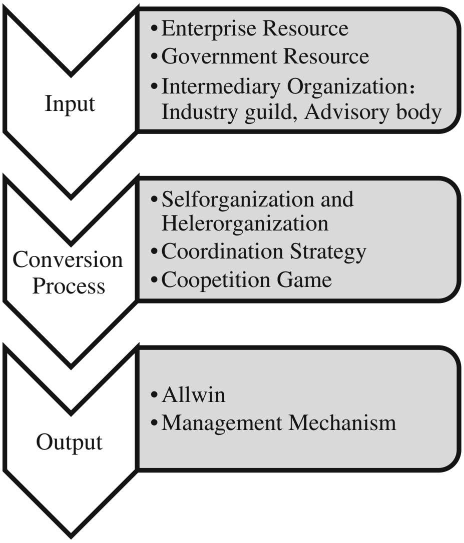

Fig. 131.1 Whole course regional brand development model

trial and error behavior. The right strategic choices of region brand development will lead to greater efficiency; otherwise it will bring huge economic losses.

In the recession phase of the regional brands, in order to re-establish the brand market image, you must change the development strategy, the liberal market access system, excellent products and good social public relations which can make regional brand reemerge to the former presence.

(2) Transformation process

The transformation process is the integration process of the resources, between enterprises, between enterprises and governments, enterprises and other intermediary organizations by competing collaborative strategy, heter-organization and self-organization, yield the greatest returns on investment resource.

Self-organization theory is called by a joint name including the dissipative structure theory, collaborative theory, super-cycle theory, and chaos and fractal theory. It is generally believed that the self-organizing mechanism is through the various elements of the system of "competing-Synergy". Synergy can be divided into positive and negative, positive synergy is Pareto improvement by repeated game, resulting in "social promotion", the negative synergy produce "social inserting". Visible, the results of competing is not really expected, in fact, a case in point is that a large number of clusters decline and disappear in external competing, which is manifestation of non-adaptability of the industry cluster and the regional brand.

Similar regional brand should not be conflict and contradiction, but should be a mutual learning, learn from each other, enhance each other the fraternal competing synergies, therefore, must be designed new means of communication, change the concept of the development of regional brands interested parties (enterprises, industry associations, government), and guide the development of similar regional brand moving in the benign interaction competing relationship.

(3) Output stage

After reasonable resources transformation process, business, government and other intermediary organizations achieve a win–win situation, regional brand of scientific management system, to promote local economic and socio-economic development, mainly reflected the knock-on effect in the regional brand.

131.5 Systematic Regional Brand Development Mode

Government, business, social and other intermediary organizations, regional brand building as the core, constitutes an interrelated complex system. The core of the regional brand development system is composed of four subsystems that is the government, business, social and other intermediary organizations, the basic structure shown in Fig. 131.2. Shown in Fig. 131.2, a regional brand development system not only has the characteristics of the general system, the interaction mechanism between the internal structure and systems, is much more complex than the general system. The sustainable development of the system depends not only on the coordinated development of the various subsystems, but also depends on the degree of coordination between the various subsystems.

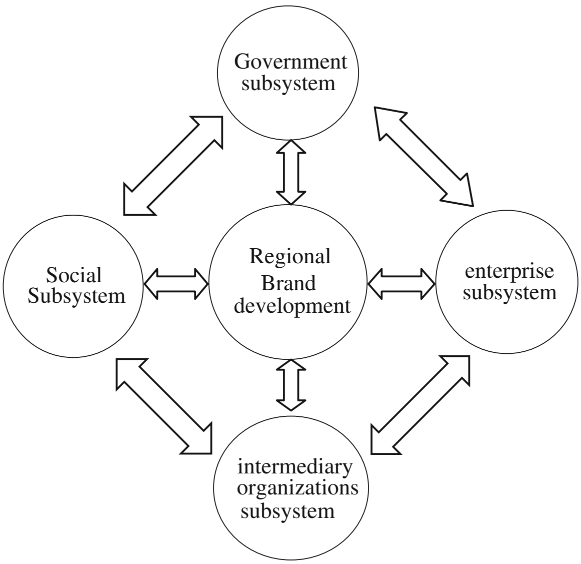

Fig. 131.2 Systematic regional brand development model

131.5.1 Government Subsystem

The government plays an extremely important role in regional brand building and development process. From the perspective of systems theory, government subsystem, use of local advantages of resources, take a variety of marketing tools, establish and promote regional brand, and in combination with the needs of the regional brand development process, make scientific support policies.

First of all, the government must conduct regional image marketing. In addition, the government should rationalize the ideas and mechanism in macroscopic level of the regional economic development, strengthen macro-guidance and promotion, improve relevant mechanisms, and develop appropriate policies and measures. The government need encourage brands to create famous brands, implement brand strategy and corporate incentives, and make preferential policies and incentives for brand-name enterprises to play a designer demonstration effect.

131.5.2 Enterprise Subsystem

Enterprises play a leading role in regional brand building, by nurturing large enterprises in particular in a comparative advantage industry in the region, as the core, and corresponding formation of a series of supporting vendors, large-scale enterprise communities can be formed in the region, through the corporate community acts to promote the development of competitive industries and industrial clusters, and form a certain reputation and influence of regional brands in the market.

In the enterprise subsystem, the enterprises of different sizes create quality products in the use of local comparative advantage resources, increase brand awareness and reputation, and lay a solid foundation for the construction of the regional brand. Then, this enterprise make use of modern marketing management concepts, methods, strategies and means to improve their own brand influence at the same time, strengthen the regional brand promotion. In addition, it is necessary for enterprise to improve the technological innovation capability. If no R&D innovation, always behind the others, the production would be not market advantage. The enterprise can improve production efficiency, reduce operating costs and improve management of resources, only through innovation of product design and production technology, establishment and improvement of the technological innovation system, the active use of advanced technology to transform traditional industries; only with high-tech, regional brand has a high brand value and market competitiveness.

131.5.3 Intermediary Organizations Subsystem

The development of regional brands requires a large number of professional intermediaries in professional support services, such as policy coordination withered, standard setting, trademark use, legal services, technical support, management consulting, disciplinary mechanism, as well as qualified guarantee (such as loan credit guarantee), etc. Thus, industry associations, chambers of commerce and other intermediary institutions should give full play to its functions.

Industry Association plays an important coordination and communication role between enterprises. The Association is composed of voluntary corporate, non-governmental organizations, has connection function in the construction of regional economic between the enterprise and the market, business and government. Association does depth analysis of the regional brand development, in consultation with relevant government departments to help enterprises solve difficulties and problems of brand development process, through the development of a regional brand development plans and unified applicable policies of regional brand, the exchange of experience in regional brand building in the industry and strive to create a higher value of regional brands.

131.5.4 Social Subsystem

Long-term development of the regional brand cannot be separated from local economic development, support services, is also affected by the impact of local social and cultural environment. In the beginning of the construction of regional brand, creating a brand-sharing culture has an important role in the development of the regional brand. It is necessary to establish and perfect a set of brand sharing mechanism that is shared investment, shared interests, to coordinating operation, the formation of clusters acting criteria, and accompanying cost estimates and cost-sharing mechanism, with a strict barrier to entry, put an end to the subversive opportunistic behavior to the regional brand image.

Social progress is also very important to the development of regional brands. We should speed up reform of the scientific research system, and construction to meet the requirements of the market economy, the investment system, scientific research and development mechanisms and the growth of talent and incentives. The same time increase the distribution system reform to meet the requirements of the market economy; enhance technological innovation through technology shares and other forms of power. To create a social environment of the growth of technology professionals, scientific and technological personnel to be able to get enough market-oriented, institutionalized incentives for technological innovation to develop and retain a sufficient number of qualified personnel.

131.6 Conclusion

Through the above measures, the contradiction in these subsystems can be effectively avoided, and promote the coordinated development between the various subsystems, finally achieve economic benefit, social benefit and environment efficiency unification, so as to realize the sustainable development of regional brand system.

Of course, the article on regional brand development structure model is only limited to theoretical studies, large amounts of data investigation and analysis on the basis of use of systems analysis tools such as system dynamics on empirical research, which can be better to provide a reference for the development of regional brands.

Acknowledgments I would like to thank Anhui Education department humanities and social science fund (SK2012B338) for their support in this research.

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Chapter 132
Research on Bayesian Estimation of Time-Varying Delay

Meng Wang, Ying Liu and Ji-wang Zhang

Abstract Time delay estimation is one of key techniques to array signal processing, and it has already had several mature algorithms. According to its different scenes, time delay estimation can be transferred to the estimation of coefficients of adaptive filter, which is on the basis of parameter model of adaptive filter. The simulations of Bayesian methods including Extended Kalman Filter, Unscented Kalman Filter and Bootstrap Particle Filter show that under Gaussian nonlinear system, EKF and UKF can estimate time-varying delay effectively. Besides, algorithms of UKF perform better than that of EKF, which are only subject to Gaussian system. In the nonlinear non-Gaussian system, BSPF is able to estimate time delay exactly.

Keywords Time delay estimation · Extended Kalman Filter · Unscented Kalman Filter · Bootstrap Particle Filter

132.1 Introduction

Time delay, which is resulted by different transmission distance of signals, refers to the time difference accepted by different homologous receivers. The earliest method of time delay estimation is Generalized Cross Correlation (GCC) algorithm put forward by Knapp and Carter in 1976 (Knapp 1976).

Traditional methods of time delay estimation like GCC algorithm and higher order cumulant approach can effectively estimate fixed delay under certain circumstances (Xie et al. 2008). Nevertheless, Extended Kalman Filter (EKF) and Unscented Kalman Filter (UKF) that adopts Unscented Transformation (UT) are

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E. Qi et al. (eds.), *The 19th International Conference on Industrial Engineering and Engineering Management*, DOI: 10.1007/978-3-642-38391-5_132,

widely used in location and tracking in nonlinear dynamic system. EKF achieves filtering by first-order linearization (Taylor series expansions), which inevitably results in extra error and leads to divergence in strong nonlinear system (Crassidis 2005). UKF applies unscented transformation so as to transfer mean and covariance nonlinearly and substitutes Jacobian matrix of EKF with simple mathematics (Ma and Yang 2009).

UKF algorithm is of high precision, but it can only be used in the system that noise obeys Gaussian distribution. As a sub-optimal estimation algorithm, particle filter is commonly applied in nonlinear and non-Gaussian systems. The thesis simulates EKF, UKF and particle filter and analyzes their performance according to different scenes, producing relatively good estimation.

132.2 Signal Model of Time Delay Estimation

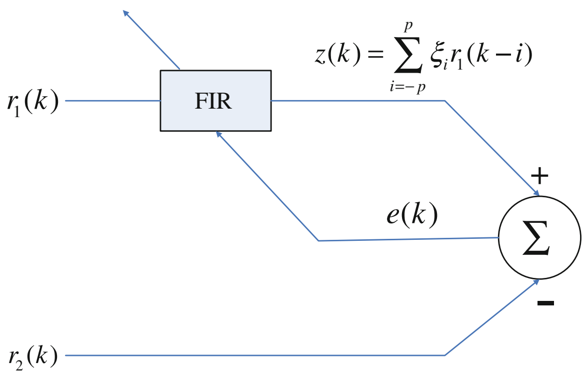
Assuming that s(t) represents signals from the same mobile transmitter, then at t, the signals received by two independent base stations can be formulated as follows:

$$\begin{cases} r_1(t) = s(t) + v_1(t) \\ r_2(t) = As(t - \tau(t)) + v_2(t) \end{cases} \tag{132.1}$$

In order to facilitate analysis, the said formula is simplified. A is amplitude ratio; $S(t - \tau(t))$ stands for delayed signal; $\tau(t)$ denotes time-varying delay; v1(t) and v2(t) refer to noise interference of tow signals, which is assumed to be independent Gaussian white noise.

By using parameter model of adaptive filter, the problem of time delay estimation can be resolved by the procedure presented in Fig. 132.1 (Ching and Chan 1988). r_1(k) and r_2(k) are samples of r_1(t) and r_2(t). If sampling time T = $\Delta\delta$, output of FIR filter is:

Fig. 132.1 Block diagram for adaptive estimation of two time delays



$$z(k) = \sum_{i=-p}^{p} \xi_i r_1(k-i) \quad p \to \infty \tag{132.2}$$

The minimum quadratic sum of error e(k) = z(k) − r2(k) can be achieved by adjustment of ξ. If $r_1(t)$ and $r_2(t)$ are expressed as formula (132.1), then in according with sampling theorem, expression is as follows:

$$\xi_i = A \sin c(i - \tau(k)) = A \frac{\sin \pi(i - \tau(k))}{\pi(i - \tau(k))} \tag{132.3}$$

In practice, with tolerance for certain truncation error, error can be basically ignored, as long as p is larger than maximum time delay $\tau(k)_{\max}$, for instance $p > \left[\tau(k)_{\max}+5\right]$, the error can be basically ignored. By this way, process of estimation becomes less complicated without considering signals' waveform.

$\tau(k)$ is regarded as state variable. Providing that the transmitter moves at a constant velocity in a straight line with noise (Gaussian white noise) disturbance, the state equation and observation equation of the system are:

$$\begin{cases} \tau(k) = \tau(k-1) + (k-1)/100 + w(k-1) \\ r_2(k) = \sum_{i=-p}^{p} A \cdot \sin c(i - \tau(k)) \cdot r_1(k-i) + v(k) \end{cases} \tag{132.4}$$

$w(k-1)$ and $v(k)$ represent system noise and observation noise respectively. $r_1(k-i)$ is a number sequence of a known waveform. In such a case, signal model of time delay estimation is completed.

132.3 Bayesian Filtering Techniques

132.3.1 Bayesian Estimation

Signal processing model of Bayesian filtering can be expressed by state equation and observation equation:

$$\begin{cases} x_k = f_k(x_{k-1}, w_{k-1}) \\ y_k = h_k(x_k, v_k) \end{cases} \tag{132.5}$$

k denotes number of time series; $\{x_k, k \in N\}$ means state sequence; $\{w_{k-1}, k \in N\}$ and $\{v_k, k \in N\}$ are noise series of independent identical distribution; $f_k(\cdot)$ is state transfer function of the system; $h_k(\cdot)$ is observation function of the system. State function can be depicted by transfer probability matrix as $p(x_k|x_{k-1}), k \geq 0$. Likewise, observation function can be depicted as $p(y_k|x_{k-1})$,

$k \geq 0$. Bayesian filtering is mainly applied to estimate x_k on the basis of known observation vector $y_{1:k} = (y_1, y_2, \ldots, y_k)$ and initial distribution $p(x_0|y_0) = p(x_0)$.

The essence of Bayesian filtering is to use all the information known to construct the posterior probability density of the system's state variables, that is, to predict prior probability density of the state by system models. And then use the recent measurements to amend it, in this way, get the posterior probability density. Aiming at the state space model, the best estimation of the state can be obtained through confidence $p(x_k|y_{1:k})$ of different value in recursive calculation on x_k by measurement of data $y_{1:k}$ (Fu and Cui 2009).

The results of filtering $p(x_k|y_{1:k})$ can be attained by prediction and updating. Assuming that probability distribution $p(x_k|y_{1:k-1})$ is obtained at time $k-1$, the state transfer probability matrix $p(x_k|x_{k-1})$ will help to produce the prior probability distribution at k:

$$p(x_k|y_{1:k-1}) = \int p(x_k|x_{k-1}, y_{1:k-1}) \cdot p(x_{k-1}|y_{1:k-1})dx_{k-1} \tag{132.6}$$

Assuming that the above formula in a system model which obeys a first-order Markov random process, which satisfies the following equation:

$$p(x_k|x_{k-1}, y_{1:k-1}) = p(x_k|x_{k-1}) \tag{132.7}$$

New observation data y_k is available at k. Based on Bayesian principle, prior probability distribution can be updated by force of measurement model $p(y_k|x_k)$ so as to reduce expected results of filtering:

$$p(x_k|y_{1:k}) = \frac{p(y_k|x_k)p(x_k|y_{1:k-1})}{p(y_k|y_{1:k-1})} \tag{132.8}$$

and

$$p(y_k|x_k) = p(y_k|x_k, y_{1:k-1}) \tag{132.9}$$

$$p(y_k|y_{1:k-1}) = \int p(y_k|x_k)p(x_k|y_{1:k-1})dx_k \tag{132.10}$$

Formulas (132.6) and (132.8) represent two basic steps of prediction and updating, the recursive computation of which contributes to optimal Bayesian estimation.

If noise w_{k-1} and v_k is zero-mean white Gaussian noise of independent distribution with known parameters, the state equation $f_k(x_{k-1}, \omega_{k-1})$ is a given linear equation of x_{k-1} and w_{k-1}, the observation equation $h_k(x_k, v_k)$ is a given linear equation of x_k and v_k. The optimal solution $p(x_k|y_{1:k})$ can be achieved by Kalman Filter, in the setting of consecutive x_k (Kalman 1960).

In many cases, $f_k(x_{k-1}, w_{k-1})$ and $h_k(x_k, v_k)$ are nonlinear, and noise w_k and v_k is non-Gaussian, under which Kalman Filter won't work well. Some extended algorithms of Kalman filtering, like Extended Kalman Filtering and Unscented

Kalman Filter can be employed in nonlinear conditions. Furthermore, Algorithms based on Bayesian theory like particle filter can be used in non-Gaussian noise cases.

132.3.2 Introduction of EKF, UKF and BSPF

Kalman Filtering features minimum mean squared error under linear system estimation. Through recursion and iteration, its updating can be completed by calculation of estimated value and current input value, which is beneficial to real-time processing. EKF is a classic algorithm used in nonlinear estimation. It adopts linear transformation of Taylor expansion to approximate nonlinear models, and combines Kalman Filtering to estimate. EKF algorithms are simple and less calculated, but they can only work in the weak nonlinear Gaussian condition.

Actually, the approximation of probabilistic statistical characteristics of random quantity by limited parameters is easier than that of arbitrary nonlinear mapping function. Great importance has been attached to approximation of nonlinear distribution by sampling, solutions to nonlinear problems, like Unscented Transformation (UT) (Kastella 2000; Gordon et al. 1993; Julier and Uhlmann 2004). UKF employs Kalman Filtering frame and uses UT to process mean and covariance, instead of linearizing the nonlinear function. UKF doesn't need derivation of Jacobian matrix, without ignoring the higher order term, so its nonlinear distribution statistics is of high precision. Though the calculation of UKF is as less as that of EKF, its performance is better than that of EKF.

Particle filter achieves approximation of probability density function $p(x_k|y_k)$ by a pairs of random samples that are transmitted in state space, and has sample mean instead of integral operation so as to produce state minimum variance estimation. These samples are called particles. Importance density function is one of the key techniques, which exerts a direct impact on the effectiveness of the algorithm. Besides, the number of particles will become increasingly less along with iteration, which is the phenomenon called "particle shortage". Two effective solutions to particle shortage are selection of optimal importance density function and adoption of resampling methods. From an application perspective, most importance density functions adopt $p(x_k|x_{k-1})$ which can easily achieved by sub-optimal algorithms. The resampling methods are to increase the number of particles by the resample of particles and probability density function denoted by corresponding weight. Common resampling methods include random resampling, stratified resampling and residual resampling,etc. BSPF is built on optimal importance density function and resampling. Particle filter serves as the main filtering tool for the nonlinear non-Gaussian system.

132.4 Three Algorithms of Time-Varying Delay

132.4.1 The Estimation Based on EKF

State equation and observation equation of time-varying estimation:

$$\begin{cases} \tau(k) = \tau(k-1) + k - 1/100 + w(k-1) \\ r_2(k) = h_k(\tau_k, k) + v(k) = \sum_{i=-p}^{p} A \sin c(i - \tau(k)) r_1(k-i) + v(k) \end{cases} \tag{132.11}$$

w_k, v_k are respectively stand for the statistics of system noise and observed noise, in addition, R_{wk}, R_{vk} are the covariance matrix.

The following are steps of the time-varying delay estimation.

(1) Initialization: assuming that the time-delay state value is equal to τ_0, as k = 0, and the initial variance is p_0.
(2) Time prediction:

$$\begin{cases} \hat{\tau}(k|k-1) = \hat{\tau}(k-1) \\ P(k|k-1) = P(k-1) + R_w(k-1) \end{cases} \tag{132.12}$$

(3) Updating Measurement:

$$\begin{cases} K(k) = P(k|k-1)[H(k)]^T \left(H(k)P(k|k-1)[H(k)]^T + R_v(k)\right)^{-1} \\ \hat{\tau}(k) = \hat{\tau}(k|k-1) + K(k)[r_2(k) - h_k(\hat{\tau}(k|k-1), k)] \\ P(k) = [I - K(k)H(k)]P(k|k-1) \end{cases} \tag{132.13}$$

$$H(k) = \left.\frac{\partial h_k(\tau(k), k)}{\partial \hat{\tau}(k)}\right|_{\hat{\tau}(k)=\hat{\tau}(k|k-1)} = \left.\frac{\partial}{\partial \hat{\tau}(k)}\left[\sum_{i=-p}^{p} \sin c(i - \tau(k)) r_1(k-i)\right]\right|_{\hat{\tau}(k)=\hat{\tau}(k|k-1)}$$

After recursion operation, the estimated value of $\hat{\tau}_{1:k}$ can be acquired.

132.4.2 The Time-Delay Estimations Based on UKF

The signal model follows the formula (132.4). N is the dimension of τ_k, N = 1.

The steps of UKF estimation include:

(1) Initialization: assuming that the time-delay state value is τ_0, as k = 0, and the initial variance is p_0.
(2) Calculation of the Sigma point set and the corresponding weight.

$$\begin{cases} \chi_{k-1}^{(0)} = \bar{\tau}_{k-1}, & i = 0 \\ \chi_{k-1}^{(i)} = \bar{\tau}_{k-1} + \left(\sqrt{(N+\lambda)P_{k-1}}\right)_i, & i = 1, \ldots, N \\ \chi_{k-1}^{(i)} = \bar{\tau}_{k-1} - \left(\sqrt{(N+\lambda)P_{k-1}}\right)_i, & i = N+1, \ldots, 2N \end{cases} \tag{132.14}$$

$$\begin{cases} \omega_0^m = \lambda/(N+\lambda) \\ \omega_0^c = \lambda/(N+\lambda) + \left(1 + \alpha^2 + \beta\right) \\ \omega_i^m = \omega_i^c = 1/[2(N+\lambda)],\ i = 1, \ldots, 2N \end{cases} \tag{132.15}$$

In the above formulas, $\lambda = \alpha^2(N+k) - N$ is a scalar; k is used to set distance from the sigma point to the average point. α, which is usual a very small positive number, was responsible for controlling the high-order information errors in nonlinear transformation. β is applied to inputting the prior information of random variables. If the state variable is of single variable, the parameters will be first set to $\alpha = 1, \beta = 0, k = 2$ and ω_i represent those corresponding weights, $\sum_{i=0}^{2N} \omega_i = 1$.

(3) Time estimation:

① Substituting the sample points into the state equation to figure out the predicted point set:

$$\chi_{k|k-1}^{(i)} = \chi_{k-1|k-1}^{(i)} + (k-1)/100 \tag{132.16}$$

② Calculating the mean value and variance based on the predicted point set.

$$\hat{\tau}_{k|k-1} = \sum_{i=0}^{2N} \omega_i^m \chi_{k|k-1}^{(i)} \tag{132.17}$$

$$P_{k|k-1} = \sum_{i=0}^{2N} \omega_i^c \left[\chi_{i,k|k-1} - \hat{\tau}_{k|k-1}\right] \cdot \left[\chi_{i,k|k-1} - \hat{\tau}_{k|k-1}\right]^{\mathrm{T}} \tag{132.18}$$

(4) Updating the measurements:

① Calculating the measured point set in the basis of nonlinear mapping:

$$\psi_{k|k-1} = h\left(\chi_{k|k-1}\right) = \sum_{i=-p}^{p} A \sin c\left(i - \hat{\chi}_{k|k-1}\right) r_1(k-i) \tag{132.19}$$

② Calculating mean value, variance and covariance of the measured points set:

$$\hat{r}_{k|k-1} = \sum_{i=1}^{2N} \omega_i^m \psi_{k|k-1}^{(i)} \tag{132.20}$$

$$P_{k|k-1}^{rr} = \sum_{i=0}^{2N} \omega_i^c \left[\psi_{i,k|k-1} - \hat{r}_{k|k-1}\right] \cdot \left[\psi_{i,k|k-1} - \hat{r}_{k|k-1}\right]^T \tag{132.21}$$

$$P_{k|k-1}^{\tau r} = \sum_{i=0}^{2N} \omega_i^c \left[\chi_{i,k|k-1} - \hat{\tau}_{k|k-1}\right] \cdot \left[\chi_{i,k|k-1} - \hat{r}_{k|k-1}\right]^T \tag{132.22}$$

③ Updating the state and the variance value, calculating the gains of filtering:

$$K_k = P_{k|k-1}^{\tau r}\left(P_{k|k-1}^{rr}\right)^{-1} \tag{132.23}$$

$$\hat{\tau}_k^i = \hat{\tau}_{k|k-1} + K_k\left(r_k - \hat{r}_{k|k-1}\right) \tag{132.24}$$

$$P_k = P_{k|k-1} - K_k P_{k|k-1}^{rr}(K_k)^T \tag{132.25}$$

(5) Applying the recursive operation to calculate the value of $\hat{\tau}_{1:k}$.

132.4.3 The Estimation Based on BSPF

(1) Initialization: set k = 0 and sample.

$$\tau_0^i \sim p(\tau_0),\ w_0^i = \frac{1}{N}, \quad i = 1, 2, \ldots, N. \tag{132.26}$$

(2) Importance sampling,

$$\tau_k^i \sim p\left(\tau_k|\tau_{k-1}^i\right), \quad \mathrm{i} = 1., 2, \ldots, \mathrm{N} \tag{132.27}$$

(3) Calculating the weight and then normalizing:

$$w_k^i = w_{k-1}^i p\left(r_k|\tau_k^i\right) \tag{132.28}$$

$$\bar{w}_k^i = \frac{w_k^i}{\sum\limits_{i=1}^{N} w_k^i} \tag{132.29}$$

(4) Calculating posterior probability:

$$p(\tau_k|r_{1:k}) = \sum_{i=1}^{N} \bar{w}_k^i \delta\left(\tau_k - \tau_k^i\right) \tag{132.30}$$

(5) Estimating the time-delay value at the moment of k:

$$\hat{\tau}_k = E[\tau_k] = \int \tau_k p(\tau_k | r_{1:k}) d\tau_k = \sum_{i=1}^{N} \bar{w}_k^i \tau_k^i. \tag{132.31}$$

(6) Resampling to get a new set of points $\left\{\tau_k^{i*}\right\}_{i=1}^{N}$ and then conducting stratified sampling.

132.5 Simulation Results

To compare the performance of these three methods—EKF, UKF, BSPF, we applied these three filtering methods in one experiment. The system noise separately obeyed normal distribution ($N(0,1)$) and uniform distribution. The measured noise obeyed normal distribution. The initial state value of simulation was set to 0.1, and the variance was made equal to 1, the number of sample points for simulation was 500, moreover we had taken 1000 particles in BSPF. As to UKF, the parameters were α, β and i which were respectively equal to 1, 0 and 2.

Simulation 1: the simulation of the system noise conformed to Gauss distribution ($N(0,1)$) (Figs. 132.2, 132.3).

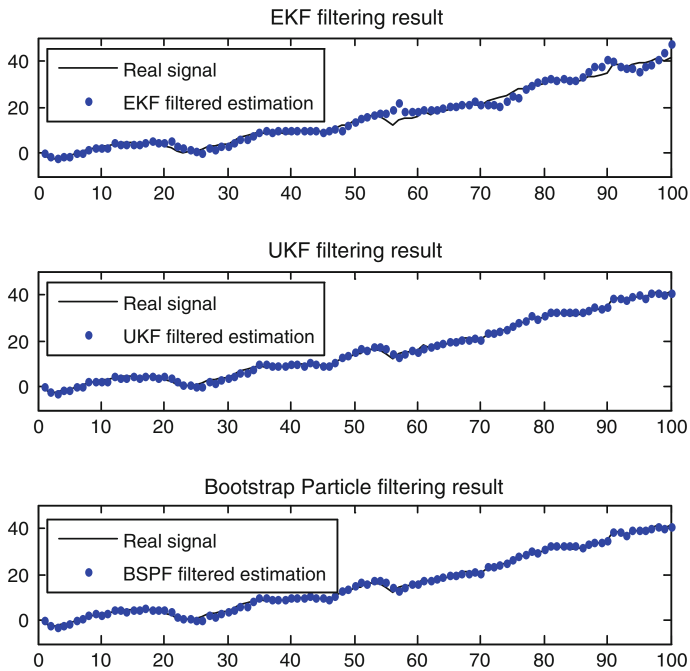


Fig. 132.2 The filtering results under the Gauss noise

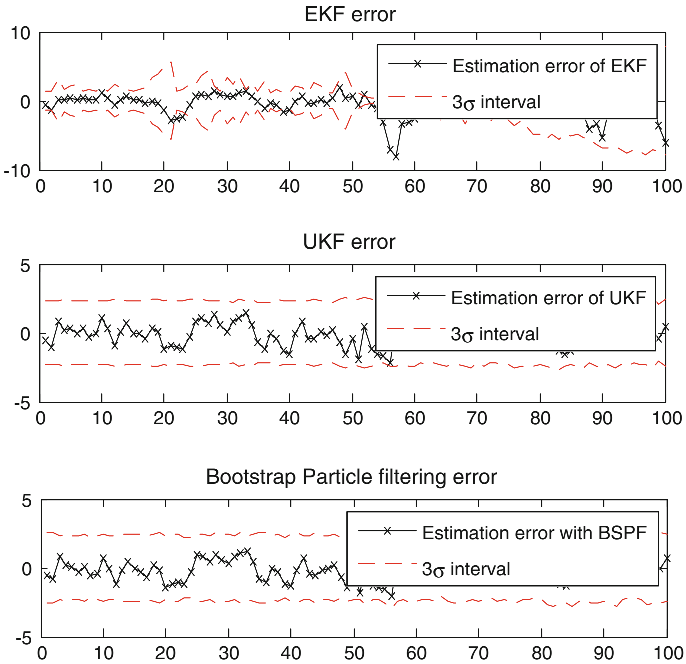


Fig. 132.3 The absolute filtering error under the Gauss noise

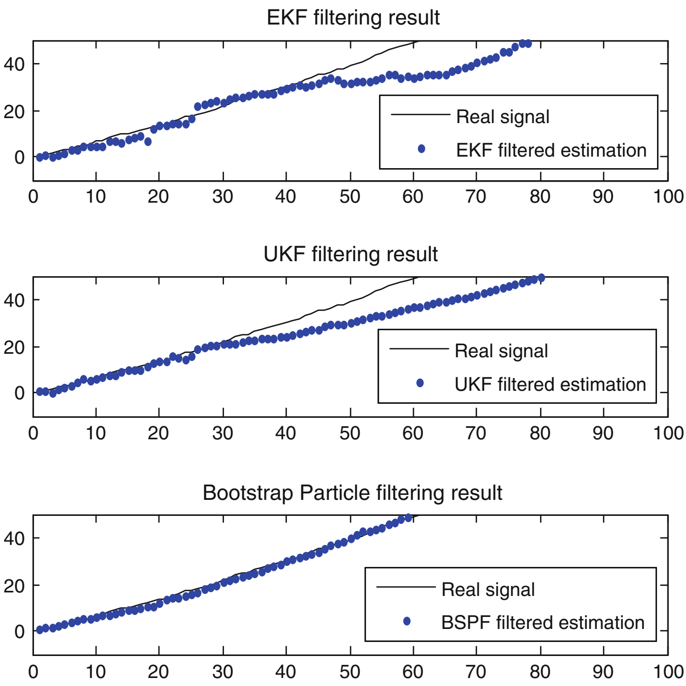


Fig. 132.4 The filtering results under uniform distribution

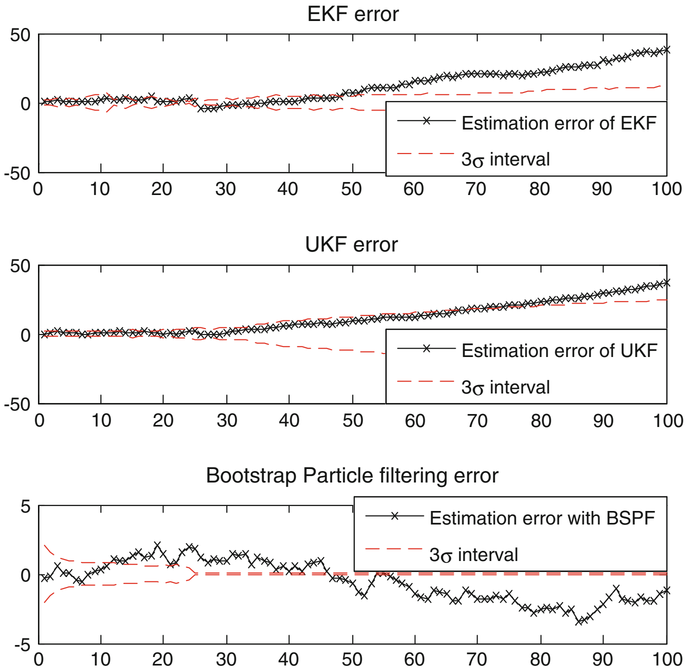


Fig. 132.5 The absolute filtering error under the uniform distribution

In order to compare the estimating performance of time-varying delay in EKF, UKF and BSPF, we defined the average variance of one independent experiment:

$$MSE = \left(\frac{1}{T} \sum_{k=1}^{T} (\hat{x}_k - x_k)^2 \right)^{1/2}$$

The symbol T represented one time step length, MSE of the algorithms in the figure above respectively equal to 6.9328 (EKF), 6.6033 (UKF) and 6.4577(BSPF). Therefore, according to filtering results and squared error, we could find that the three filtering methods can all get comparatively good results. The reason went like this: firstly, hypothetic model was the Gaussian; secondly, the nonlinearity of model was weak.

Simulation 2: the simulation of system noise conformed to uniform distribution (U [0, 1]) (Fig. 132.4).

Figure 132.5 showed that the MSE were respectively 125.5421 of EKF, 127.0202 of UKF, and 8.5351 of BSPF. From these data, it was found that EKF and UKF could not estimate the true values of time-varying delay accurately. The MSE of EKF and UKF were two orders higher than that of BSPF, which could deduce a conclusion that in both EKF and UKF, the system must be confined to the Gauss model for a good performance; in the meanwhile, the BSPF has advantages in estimation of nonlinear and non-Gaussian systems.

132.6 Conclusion

This paper had introduced Bayesian filtering theory and the algorithm steps of EKF, UKF and BSPF. Then we had separately simulated in a Gauss nonlinear system and a non-Gauss nonlinear, which was in order to compare the results of EKF, UKF and BSPF. It was found that in Gauss nonlinear system, EKF, UKF and BSPF could all perform well because of the weak nonlinearity. But in non-Gauss nonlinear system, both EKF and UKF could no longer conduct estimation with accuracy. They would cause much higher MSE than BSPF which proved to be more suitable for estimating a non-Gauss nonlinear system.

Acknowledgments This paper is supported by National Natural Science Foundation of China (Grant No. 61172130).

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Chapter 133
Research on Design and Analysis Platform for Modular Spacecraft

Xiao-wen Zeng, Zhao-xia He and Hao Luo

Abstract In spacecraft structure design process, modular technology is very important for improving efficiency and reducing cost. Based on the modular design method, a deployable on-orbit spacecraft modular configuration was established. The influence of simultaneously deployment solar panel and modular structures under the situation of weightlessness on the spacecraft's gesture was simulated and analyzed with the assistance of virtual prototype technology. The simulated result shows that the deployment of module structures is vital to the angle of spacecraft's gesture and its velocity. Within the Eclipse development environment, an integrated platform which includes design and analysis for spacecraft was developed with J2EE. In order to acquire rapid response to the whole process, which includes structural design, digital prototype assembly and dynamics analysis, the structure design, assembly and dynamics analysis of spacecraft were well integrated.

Keywords Integrated platform · Modular design · Spacecraft · Virtual prototype technology

133.1 Introduction

With the development of space technology, larger and more complex structure of the spacecraft system is needed in space exploration. Therefore, when modern and advanced spacecraft is designed, some factors must be considered, such as the size

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E. Qi et al. (eds.), *The 19th International Conference on Industrial Engineering and Engineering Management*, DOI: 10.1007/978-3-642-38391-5_133,

and complexity. Since modular spacecraft structure design concept was put forward in NASA's Goddard Space Flight Center (Bartlett 1978) in the seventies of the twentieth century, Modular, Adaptive, Reconfigurable System (MARS) (Jaime 2005), modular spacecraft design concepts for on-orbit deployment based on MARS (Sugawaraa 2008), concepts and technology for on-orbit servicing (Rodgers and Miller 2005) in modular spacecraft design have been experienced. It can be seen that more and more attention was paid to modular spacecraft design concept. Recently, there are mainly two kinds of modular spacecrafts for on-orbit deployment-Hexpak (Hicks et al. 2005, 2006) and Panel Extension Satellite (PETSAT) (Higashi et al. 2006). References (Hicks et al. 2005; Hicks et al. 2006; Higashi et al. 2006; Larry and Rolland 2013 ; Edward 2013; Deborah and Grau 2013; Jon et al. 2002; Murata et al. 2002) elaborate a lot of research on spacecraft structures for on-orbit deployment and many kinds of mechanical interfaces. However, related dynamics analysis on such mechanism configuration is rarely reported.

In this paper, based on the idea of modular design, a spacecraft module configuration for on-orbit deployment assembled with unified hinge mechanism is designed, which could deploy different modules according to task demands. With the assistance of virtual prototype technology, spacecraft attitudes influenced by the deployment sequence of solar panels and modular spacecraft mechanism are simulated and studied in the state of weightlessness in space. On this basis, based on J2EE Technology, a design and analysis platform is developed for modular spacecraft design in Eclipse environment. The configuration design process, model and data association demand in assembly and simulation and a variety of design and simulation software integration requirements are considered in this platform.

133.2 Design of Modular Structure and Dynamics Simulation of Deployment

133.2.1 Rapid Design and Assembly of Spacecraft Structure Driven by Parameters

Modular design is usually directed at the same series of spacecrafts and each module's geometry dimensions are relatively invariant. In order to increase the flexibility of structure design, each module is designed driven by parameters. Therefore the design and assembly speed is improved to realize rapid response.

The designed spacecraft consists of two parts-spacecraft body and solar panels, as shown in Fig. 133.1. The spacecraft body is made up of five similar modules which can be lay flexibly according to the functional requirements. Each module could be installed with different equipment and instruments according to the task requires, as shown in Fig. 133.2. There are positioning pins in the modules which are connected with hinges and driven by motors. The positioning pins are used to

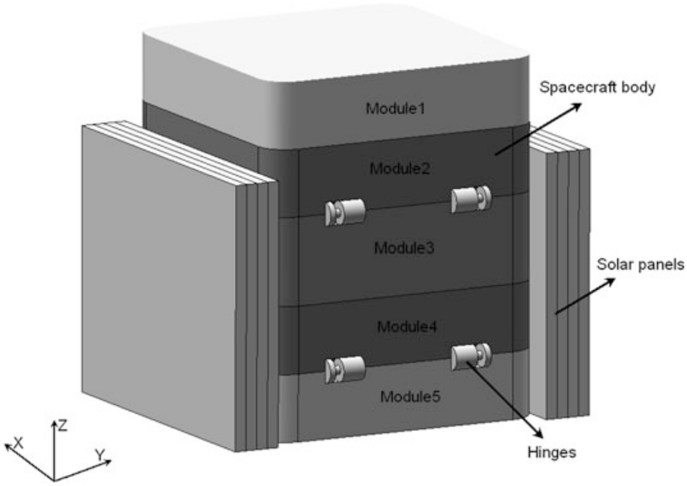
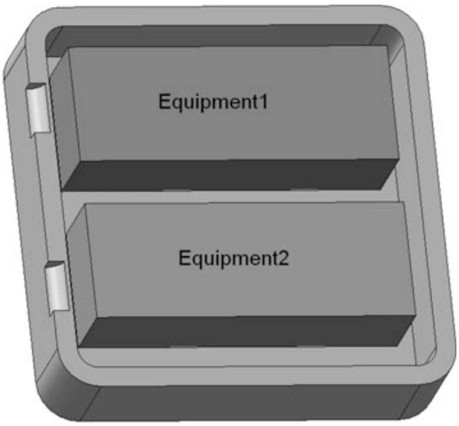


Fig. 133.1 Spacecraft configuration and assembly form

Fig. 133.2 Equipment and instruments installed in the module



locate each module in the process of deployment. The solar panels are also connected with hinges and driven by torsion springs. Each solar panel is made up of 4 pieces of rigid boards of which the geometric dimensions are 1750, 1500 and 30 mm.

The solar panels are folded before released, parallel to each other and fixed on the spacecraft body. When released on orbit, the solar panels mounted on both sides deploy at the same time driven by the torsion springs. Table 133.1 shows mass properties of spacecraft modules and solar panels.

In the process of analysis, the spacecraft body's coordination is fixed to module 1. The X direction is parallel to each module when deploys, the Y direction is parallel

Table 133.1 Mass properties of spacecraft modules and solar panels

Mass properties	Modules names				
	Module 1	Module 2	Module 3	Module 4/5	Solar array 1/2/3/4
Mass (kg)	510.73	413.15	378.91	223.90	183.47
Jx (kg m^2)	87.03	74.44	67.87	57.01	53.44
Jy (kg m^2)	97.89	86.54	81.71	60.09	34.43
Jz (kg m^2)	170.53	148.85	138.28	110.27	19.07

to solar panels and the Z direction is perpendicular to the spacecraft body and solar panels.

133.2.2 On-Orbit Deployment Dynamics Simulation Based on Virtual Prototype Technology

In the simulation, the power output of the motors could be applied by two methods which are torque and rotational speed. In this paper, a constant speed is applied to simulate the driving force of the motors. The solar panels are connected with hinges and driven by torsion springs. Torque calculation formula of the torsion spring is as follow (Bai et al. 2009):

$$\boldsymbol{T} = \boldsymbol{T}_0 - K\boldsymbol{\theta} \tag{133.1}$$

where T_0 is Initial torque of the torsion spring, K is stiffness of the torsion spring and θ is the deployment angle of the solar panels.

Closed Cable Loops (CCL) is currently the most common synchronous deployment control mechanism (Tianshu et al. 2000; Yuan et al. 2009), which is made up of the grommets fixed to hinges, grommet guides and soft cable. It is a synchronous transmission device to realize the inside and outside solar panels deploy at the same time. The basic principle is shown in Fig. 133.3 where L is the distance of two grommets and r is the radius of the grommet.

When the unfolding angles of the adjacent solar panels are the same, the mechanism doesn't work. But when the solar panels don't move synchronously, the angles of the two grommets don't equal that would causes the upside edge tight and the downside edge loose. The tight edge would be stretched and the force F

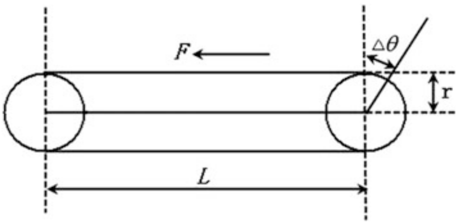


Fig. 133.3 Principle of CCL

will be applied on the grommet. So there will be a torque caused by F in the grommet which makes the solar panels tend to synchronize. The principle formulas are as follows:

$$\boldsymbol{T}' = K'(\boldsymbol{\theta}_i - \boldsymbol{\theta}_j) \tag{133.2}$$

$$\boldsymbol{F} = \boldsymbol{K}' \times \boldsymbol{r} \times \Delta\boldsymbol{\theta} \tag{133.3}$$

where T' is the controlling torque provided by CCL, K' is the equivalent torsional stiffness of CCL, θ_i and θ_j are the two adjacent solar panels' unfolding angles correspondingly.

The process of deployment is simulated by using the analysis software Adams. The spacecraft body and solar panels are regard as rigid bodies. The solar panels are connected to spacecraft body by hinges and so do as the solar panels. In the dynamics simulation, the motors drive all the modules to deploy of which speeds are set to 30 red/s. For all the solar panels are driven by torsion springs, when the inside solar panel deployed to the angle 90°, the deployment angle of the outside solar panel will be 180°. Therefore, it could be concluded from formula (133.1) that the torque of the outside solar panel is 1 time larger than that of the inside one. The stiffness of the torsion spring is set to 0.1 N m/(°) and damping influence is ignored. So the pre-tightening torque of the inside and outside solar panel is 9 and 18 N m correspondingly. The solar panels' synchronous deployment is controlled by the connection joint in Adams. The transmission ratio of the connection joint is set as 1:2 and that of the adjacent rotation joint is set as 1:1.

The virtual prototype of the designed spacecraft is shown as Figs. 133.1 (the initial state) and 133.4 (the final state of the deployment). There are 3 deployment sequences for the spacecraft: spacecraft body and solar panels deploy at the same time (Named as sequence 1); solar panels deploy before spacecraft body (Sequence 2); spacecraft body deploys before solar panels (Sequence 3). All of the 3 deployment sequences are simulated. The attitude angles affected by the deployment sequences are shown as Figs. 133.5 and 133.6.

As shown in Fig. 133.5, the attitude angles of the X direction are very small. The value of sequence 3 is the largest and it is 2.15°. Sequence1 costs 9.8544s, which is less than the others. The attitude angles of the Z direction are very similar.

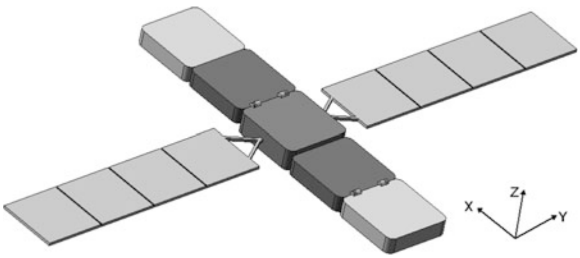


Fig. 133.4 The spacecraft's final state of the deployment

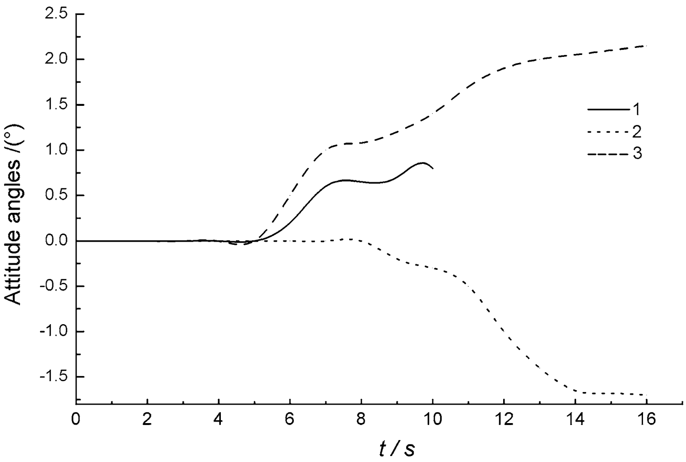


Fig. 133.5 The attitude angles of X direction

Form Fig. 133.6, it could be seen that the attitude angles of the Y direction are very large, no matter what the sequence is. The deployment of the solar panels has almost no influence on the attitude angle change.

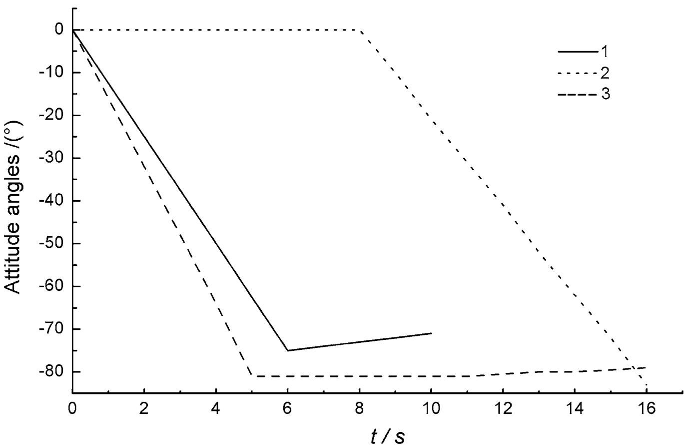


Fig. 133.6 The attitude angles of Y direction

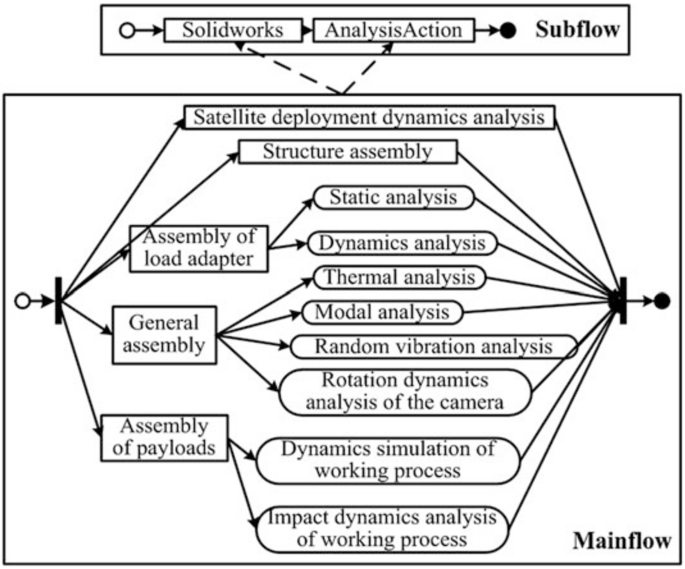


Fig. 133.7 Flexible and multi-level design and analysis flow of modular spacecraft

133.3 Design and Analysis Platform for Modular Spacecraft

133.3.1 Flexible and Multi-level Design and Analysis Flow of Modular Structure

Multi-level design and analysis flow is made up of systematic flow of spacecraft and modular part analysis flow, including various types of structure design and analysis, such as configuration design, system assembly, static and dynamic analysis etc. Figure 133.7 is a sketch map to explain the flexible and multi-level design and analysis flow.

The main flow controls the execution sequence of sub flows and manages the association of analysis data. But it doesn't participate in analysis process.

At the aspect of platform realization, by using WFCP-net's function of multiple instance management, multiple flows could be managed to realize multiple working conditions and flexible flow regression function.

The main flow's management engine operates as a server on the serve computer that could make all the parallel sun flow distribute on different client computers. This distributed flow can obviously improve execution efficiency.

The sub flows are responsible for the scheduling and execution of analysis tasks. By associating main and sub flows, the states of sub flows could be controlled. Client programs control sub flows' operation and analysis tasks are

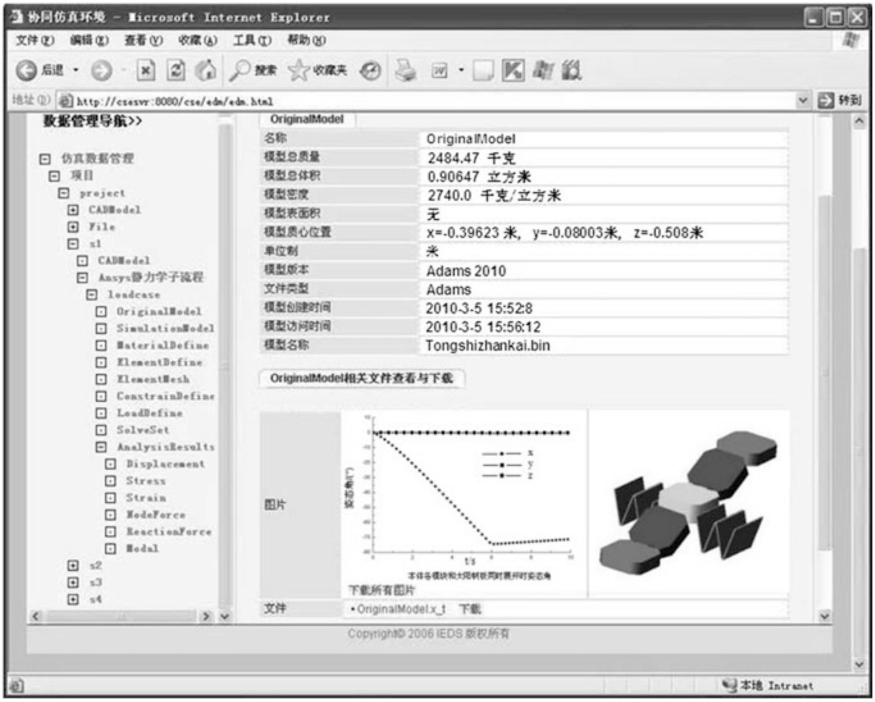


Fig. 133.8 The sketch map of simulation data of spacecraft deployment on-orbit

completed by specific analysis software. At the same time, client programs can also control the states of analysis tasks.

The design and analysis flow is very flexible in which flows' operation process could be changed according to researchers' judgments. The analysis flow could be retreated to specified analysis step. The existing designed models and analyzed results could be reused.

133.3.2 *Automatic Association of the Design and Analysis Data Which is Reusable and Centralized*

The designed model and analysis data includes the initial CAD models, experiment data, simulation models and simulation results etc. All of the models and result data are associated in the platform. So the operators could view and obtain these data quickly.

(1) Automatic association of flow tasks' models and data.

Design and analysis data management is to manage uniformly by concentrating design and analysis data distributed in the clients to data server, which associates and transfers models and data of different flows automatically.

According to different task demands of spacecraft systems, designed models and analysis data could be obtained and reused quickly by controlling the work condition of analysis flow and the data version. In this way, the design and analysis knowledge could be reused.

(2) Automatic obtainment of designed models and analysis data.

The platform could be visited by Web browser which is clear and intuitive. The researchers can view and download any analysis data that includes various initial data, intermediate process data and analysis result data. The analysis data could be shown in many forms, such as thumbnails, pictures and visual animations. Figure 133.8 is the sketch map of simulation data of spacecraft deployment on-orbit.

133.4 Conclusion

Based on the concept of modular spacecraft design, a modular spacecraft configuration is designed for the deployment on-orbit. By the way of virtual prototyping technology, the designed spacecraft is simulated in the analysis software Adams. Considering the space's weightlessness environment, the effects of the spacecraft's attitudes caused by the different deployment sequences of the modules are studied. It is concluded that the deployment of the spacecraft modules affects the attitude angle more than solar panels.

Based on Multi-level design and analysis (D&A) flow management, D&A data management and reused technology of D&A knowledge facing to tasks, a D&A platform is established for the modular spacecraft. In this platform, modeling, assembly and a variety of mechanical analysis are managed by being concentrated together to realize the fast response of modeling and analysis.

Acknowledgments This work is supported by the Scientific Research Fund of Hunan Provincial Education Department under the grant No. 10C0756.

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Chapter 134
Research on H-Point of Driver Based on Human Physical Dimensions of Chinese People

Lin-lin Sun, Fan-sen Kong, Duo-nian Yu, Bao Lan and Xiang-bei Wang

Abstract The H-point is an important reference point in the general arrangement of the design of car body, which determines the convenience and comfortableness of the driver. The referred standard in the arrangement of the H-point is the agreeable position curve in SAE J1517. The curve, however, does not apply to Chinese, so the Chinese manikin was used. In order to guarantee the comfortableness and vision, H-point position of the 5th percentile woman, 10th, 50th, 90th and 95th percentile man sitting models were adjusted, and the coordinates of points were recorded. MATLAB software was applied to process these data, so that the corresponding H-point trajectory equations were fit, and curves of the equations were plotted in the same coordinate system. The suitable H-point position regions are areas enclosed by these curves. Using CATIA, American H-point regions were calculated in the same way. Finally, the obtained two areas were compared and analyzed.

Keywords Comfortableness · H-point · H-point trajectory curve equation · Manikin

134.1 Introduction

In order to reduce the degree of fatigue of driving and riding when arranging the interior, the requirements for human comfort posture must be met in the design, which is the basis of the layout of the human body and seat design. The

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E. Qi et al. (eds.), *The 19th International Conference on Industrial Engineering and Engineering Management*, DOI: 10.1007/978-3-642-38391-5_134,

comfortableness of driver or occupant is a very important performance indicator in the body layout. The comfortableness covers widely, which includes the sitting, the dynamic, the thermal and the contact etc., and have comprehensive, subjective, individual characteristics. The Comfort is multidimensional, and is dependent on a variety of factors such as direction, intensity, frequency, time, individuals. The concept of comfort defined in the ergonomics is that there being no uncomfortable state (Hockenberry 1979). From a physiological point of view, the comfort should be a minimization of energy engaged in physical activity under certain constraints (SAE 1988). Thus, the minimum uncomfortable sitting posture is just the sitting comfort.

Actual automotive point H has a great significance in the auto body layout design: After the driver or occupant takes a seat with a normal driving position or the posture seat, most of the weight will be borne through the buttocks by a cushion, the other part be supported by the backrest via the human back, while only a small part will be applied to the floor through the left foot heel. Under this posture, the pilot body when operating often moves through the axis of the horizontal level around the H point. Therefore, the actual H-point position in the auto body determines the convenience and comfortableness of the pilot operation, which is why it has become a reference point in the body internal dimension.

In the 1980s, Nancy LPhilippart etc. from General Motors Corporation in the United States proposed a H-point position curve model suitable for the driver, which were used to predict the driver's H-point position. In 1985, the model was included in SAE J1517 by the American Society of Automotive Engineers. It is a set of H-point position curves when a different percentile driver is driving suitably, in which each one is characterized by horizontal and vertical position relationship between the H-point position and orientation reference point. Congenial H-point position curves in the SAE J1517 were generated statistically based on the driver's body and test data in the United States in the 1960s, in which body size, layout constraints and posture and other factors implied. These factors are used to determine the H-point adjustment range and to meet the required fitness theoretically. However due to be constrained by the time and region, this method has some shortcomings, mainly in the following aspects:

(1) Congenial H points on a curve or a straight line, only corresponding to an H-point in a H30 value.

(2) Recommended H point position curves given based on the human data published by the SAE does not apply to Chinese human body.

(3) Recommended H-point position curves with the ankle fixed at 87 degrees a as one of prerequisites, thus increasing a redundancy for the layout of the pedal, but also limiting the layout space of other elements.

(4) Recommended H-point position curves with the comfortable body posture as a consideration, obviously factors to be considered too small (Huang et al. 2000).

The shortcomings mentioned above will be considered significantly in the study of the H-point layout method. The Chinese manikin will be used of for layout design. For the ankle constrained angle range is 78°–105°, and in addition to the driver's comfort considered, to, requirements for the vision of the dashboard and direct forward visibility and traffic light vision also were taken into account in the design process, so that the H-point design is not only meet the comfort but also ensuring a good vision.

134.2 Methodology

134.2.1 Comfortableness

Studies have shown that comfort or not are affected essentially by the subjective feeling when maintaining a specific posture, in which the joint angle has a very important influence on the subjective feelings of the comfort. Of course, there are also a number of other factors that are likely to affect the feeling of comfort, such as the contact pressure distribution between the person and the seat (Bubb and Estermann 2000). The comfort and fatigue degree during the body driving and the ride are related to the posture determined by the joint angles in the design. Therefore, various manikin can be positioned according to a comfortable joint angle so that its vision, encompasses, comfortableness etc. be able to evaluated (Ren et al. 2006). The major joint angle adjustment range of drivers' in a comfortable posture has been described as shown in Fig. 134.1 and Table 134.1

Each joint angle range of activities can be divided by the preferred angle editor in CATIA manikin posture analysis module, and then the current position will be able to be assessed globally and locally by the system. Edit Preferred angle "button" clicked after entering the module, the corresponding angle to α2–α7 in Table 134.1 were found in the manikin. The scope of activities of each angle is divided into two areas; one is into the area within the comfort range marked with

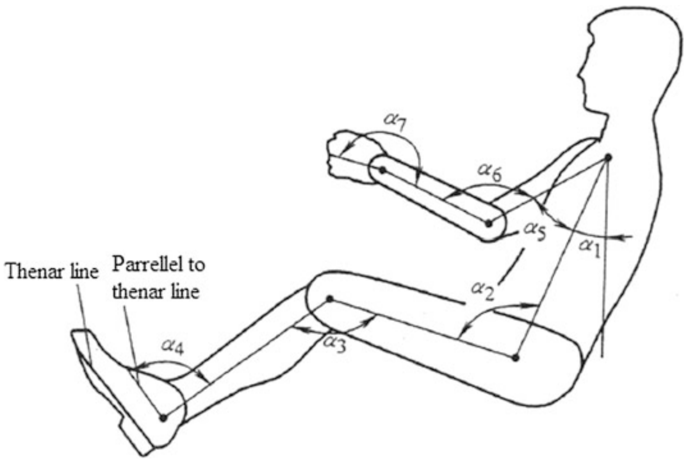

Fig. 134.1 Comfortable posture

Table 134.1 Human joint angle range under a comfortable sitting

α1	α2	α3	α4	α5	α6	α7
20°–30°	95°–120°	95°–135°	78°–105°	0°–50°	80°–170°	170°–190°

green, another falling into the region outside the comfort indicated by orange. For the comfortable driver sitting angle, it focuses mainly on the plane of the side view, and the comfortable angle of the other views given little studies. So in order to prevent the angle change in other views caused by the manikin posture changes, the freedom of each joint in the other directions was locked using the Lock function. After locked, the parts cannot perform any operation in the locked freedom direction, the angle value does not change with other joints', thus ensuring only the angle in Table 134.1 impacted in the adjustment process.

Because α_1 is related with the seat's backrest angle but not with a joint in the body, we can not constrain it by using the above methods, but at the hinge pairs in this section, and the rotation angle range of the kinematic pair is defined as 20°–30°, so that the backrest angle can only be adjusted within the range of comfort without out of range.

After defining the comfort range of different angles, open the dialog box of the manikin posture assessment and analysis in a manikin posture analysis module, the system provides two kinds of display modes analyzing for postures, a list type as shown in Fig. 134.2, and the other a chart type shown in Fig. 134.3. Values in Angle (angle) item in the list indicate the zero angle values of parts and positions under a certain degree of freedom. The result (evaluation results) was expressed as a percentage. It was used for indicating the comfort degree of postures, the higher the score the more comfortable it is. Score (score) item indicates that the one when the angle in the preferred area. In the chart, the color of the various parts complied with the one set at its preferred angle region. When the angle is in the different regions, it represent the color bar of the parts will be displayed in different colors. If the color of the preferred angle region not set, the moving parts would not have the appropriate colors.

134.2.2 Concept of Point H

H is the hinge point of the human body and thigh, i.e. the hip point (hip Point). In determining the man-machine interface geometric size relationship of the auto body, it is often with this point as the basis of positioning of the body. The actual H is the midpoint of the left and right H-point marking connections on the manikin when the 3D H-point manikin placed in the car seat according to the specified steps. It indicates the position of the hip joint in the car after the driver or occupant seated (SAE 1998, 2002).

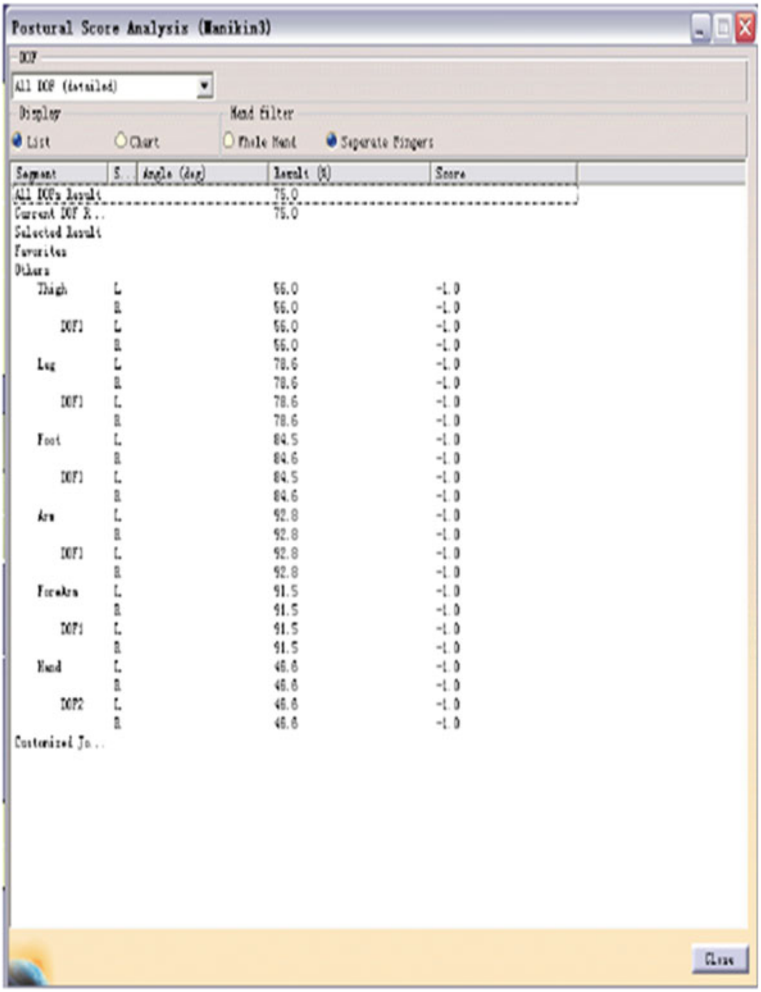

Fig. 134.2 Dialog box of assessment and analysis for manikin posture (List type)

134.2.3 Determination of H-Point Trajectory Curve Equation

CATIA assembly module was used to import the human sitting posture model and the parameterized dashboard vision design model into the same environment (CATIA Object Manager 2000; CATIA 2000), as shown in Fig. 134.4.

Clicking the "open horizons window" button in the human modeling module in Ergonomics, the system will pop up a vision window, in which images is within sight of the manikin. Then entering the body of the analysis module of the model, opening the "manikin posture assessment and analysis" dialog box and selecting the chart

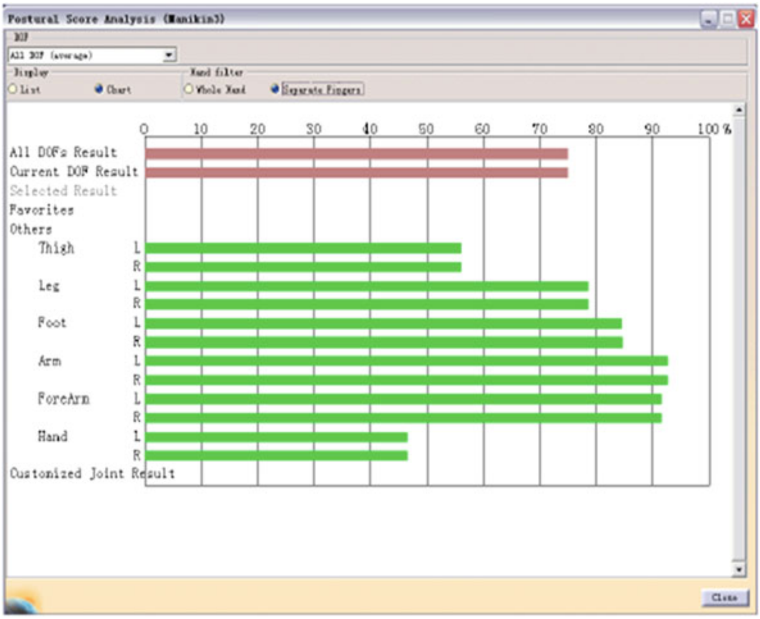

Fig. 134.3 Dialog box of assessment and analysis for manikin posture (Chart type)

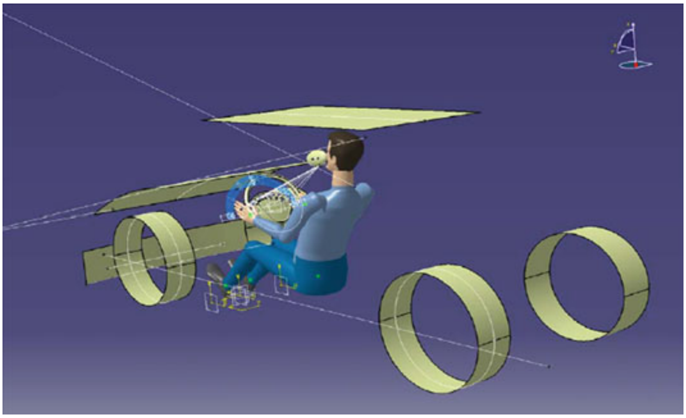

Fig. 134.4 Manikin imported

pattern, finally into the electronic prototype module and opening the motion Simulation dialog box, the posture control of the manikin can be realized through the adjustment of three driving commands of the dialog box. The size to be adjusted was constrained by using the windows of the vision and the manikin posture assessment. When the color bars in the window of the manikin posture assessment are all into green and the images in the window of vision able to meet the requirements of the dashboard vision and the front vision, the right value of the slide adjusted by the first two drive commands is the H point coordinates. The entire adjusting interface was shown in Fig. 134.5.

The gender, percentile and nationality of dummies can be modified in Properties of the manikin, and the modified position of the model and the related settings remained unchanged, so the manikin with different percentiles can be easily and quickly studied in the same file to obtain H-point coordinates of each percentiles.

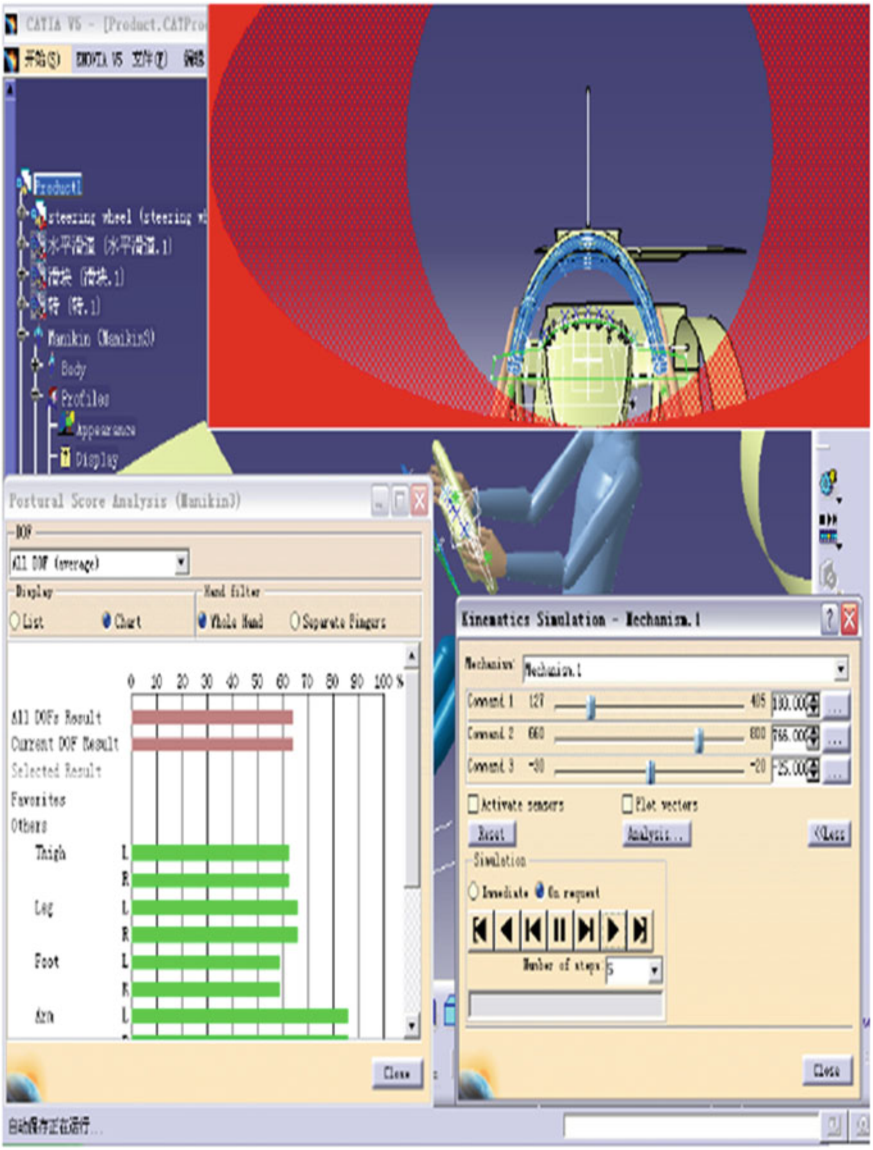

Fig. 134.5 Adjustment interface of H point

With the heel point as the origin of coordinates, 10 mm in the Z direction as a step, it can be found the range of the X coordinates of H-points of each percentiles meeting the vision and comfortableness. The curves of the each equation above were plotted in the same coordinate system, indicating the boundary curves of H-point adjustment range of 5th, 10th, 50th, 90 h and 95th percentile manikin (Sundin et al. 1966), as shown in Fig. 134.6.

MATLAB software was used to fit the curves, H-point trajectory curve equations (134.1) of the each percentile Chinese manikin were the following:

$$\begin{cases} Z_{95th-1} = -0.003864X^2 + 4.547X - 1042 \\ Z_{95th-2} = -0.001547X^2 + 21.94X - 7496 \\ Z_{90th-1} = -0.003795X^2 + 4.349X - 950.6 \\ Z_{90th-2} = -0.008559X^2 + 11.19X - 3372 \\ Z_{50th-1} = -0.002326X^2 + 2.113X - 159.9 \\ Z_{50th-2} = -0.006999X^2 + 8.536X - 2308 \\ Z_{10th-1} = 0.01581X^2 - 19.58X + 6273 \\ Z_{10th-2} = -0.1397X^2 + 183.6X - 60020 \\ Z_{5th-1} = -0.01055X^2 - 14.53X + 5171 \\ Z_{5th-2} = -0.02228X^2 + 23.51X - 5810 \end{cases} \tag{134.1}$$

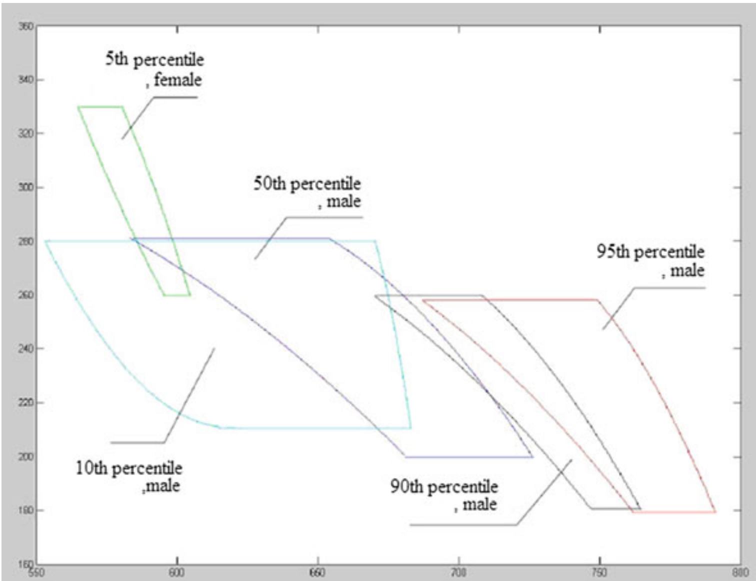

Fig. 134.6 Adjustment scope of H point suitable for Chinese body

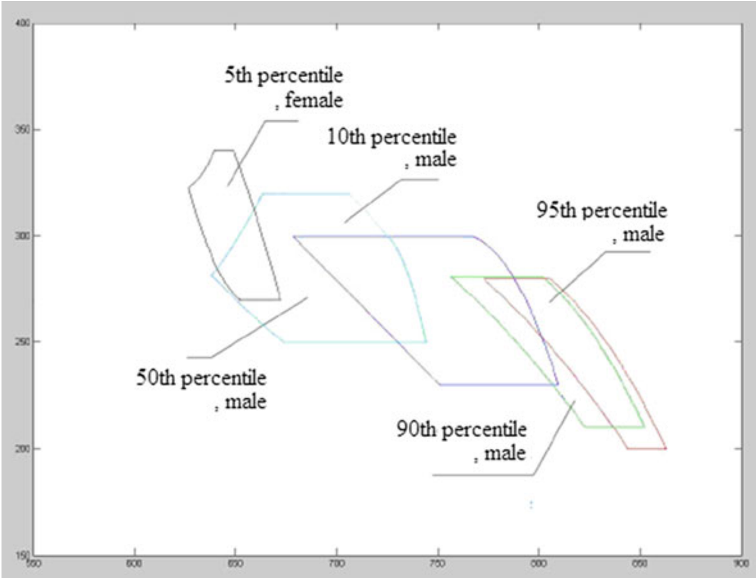

Fig. 134.7 Adjustment scope of H point suitable for American body

For the American manikin, the same method can be applied to find the H-point ranges of each percentiles meeting the vision and the comfortableness, as shown in Fig. 134.7. The fit H-point curve equations (134.2) were:

$$\begin{cases} Z_{95\text{th}-1} = 0.003887X^2 + 5.167X - 1392 \\ Z_{95\text{th}-2} = -0.01078X^2 + 16.59X - 1608 \\ Z_{90\text{th}-1} = -0.003547X^2 + 4.535X - 1120 \\ Z_{90\text{th}-2} = -0.0125X^2 + 19.27X - 7134 \\ Z_{50\text{th}-1} = -0.0001384X^2 - 0.7642X + 881.9 \\ Z_{50\text{th}-2} = -0.03041X^2 + 46.31X - 17330 \\ Z_{10\text{th}-1} = \begin{cases} 0.0108X^2 - 12.53X + 3879(X < 638) \\ 0.003364X^2 - 5.297X + 2292(X > 638) \end{cases} \\ Z_{10\text{th}-2} = 0.09494X^2 + 136.9X - 49050 \\ Z_{5\text{th}-1} = \begin{cases} 0.05769X^2 - 71.67X + 22580(X < 627) \\ 0.05522X^2 - 72.69X + 24190(X > 627) \end{cases} \\ Z_{5\text{th}-2} = -0.02075X^2 + 24.39 - 6749 \end{cases} \quad (134.2)$$

It can be found through the comparison of Figs. 134.6 and 134.7 that congenial H-point curves of the human of Chinese and Americans have a large differences. Thereby if the population differences ignored and only a single standard used to design in R & D process, it is bound to produce defects, adversely affecting the quality of the product.

134.3 Conclusion

Combined with requirements of the vision and the comfortableness, the H-point range of the driver has been researched and the boundary curves of the 5th, 10th, 50th, 90th, 95th percentile driver's H-point range obtained. Only the joint angle was divided into the comfortable and the uncomfortable when evaluating the comfortableness. In the uncomfortable angle range, regardless of their proximity to the comfort zone, the same score was adopted to assess. Thus it brings an inconvenience for the flexibility of the scoring system. In conclusion, the relationship between the joint angle and the comfortableness should be improved further.

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Chapter 135
Research on Modeling Framework of Product Service System Based on Model Driven Architecture

Xin-zhi Zhao and Xin Cai

Abstract Produce Service System (PSS) has attracted much attention in recent years for its providing new methods to the combination of product manufacturing with service. Model building of PSS has become a basic question of related researches. This article aims to propose a modeling framework able to characterize elements and structures of PSS. First, present research achievements on PSS modeling are analyzed. Second, PSS spatial structure and application model facing to its whole life cycle are proposed. Third, a 4-layer modeling framework of PSS is put forward; the meta-model of PSS is defined. At last, PSS single-view modeling is discussed, so is the application of this PSS modeling framework based on MDA.

Keywords Model driven architecture · Meta-model · Product service system

135.1 Introduction

PSS is developing rapidly as a new kind of manufacturing paradigms, which is highly integrated of product and service and wholly optimized and formed in the mode of extended producer responsibility in which manufacturing enterprise is responsible to product service in its life cycle (Gu et al. 2009). For its systematic mode of "product and service", PSS has become a main solution of manufacturing enterprise extending to service enterprise. It is widely discussed and studied in international academic and industrial field. How to build PSS model should be the first question to be solved among related studies. PSS includes so many elements, such as product, service,

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E. Qi et al. (eds.), *The 19th International Conference on Industrial Engineering and Engineering Management*, DOI: 10.1007/978-3-642-38391-5_135,

manufacturing process, manufacturing resource, participation subject, value delivery and commerce mode etc., that it needs a systematic framework to conduct its model descriptions. This framework should be able to achieve the following: describe, manipulate and organize every possibly existing enterprise entities, system organizations, products, services, processes and supporting technologies; provide different application views to describe a whole PSS model; offer modeling language with enough expression abilities to describe all kinds of applications and the relationships among them; support model reuse in its system.

Present widely applied frameworks, for example CIM-OSA, ARIS, GRAI/GIM, GERAM, IEM, PERA, Zachman, TOGAF, UML, IBM overall enterprise architecture framework and NIIIP etc. (Xu et al. 2007), mainly adapt to single enterprise modeling but hard to PSS modeling for its higher demands of expression abilities, openness and maneuverability. However, the Model Driven Architecture (MDA) technology can meet the demands much better, which describes models from different levels of information structures, business logics and information expressions with meta-model definition and single-view modeling.

135.2 Main Achievement of Existing PSS Modeling

Lin-yan Sun built an architecture based on the amalgamation of commerce mode and producing organization style which integrates services and manufacturing. Manufacturing enterprises cooperated with each other by the way of exchanging manufacturing-process-level service; producer service enterprises offered customers products and services through sharing manufacturing enterprises and customers business-process-level service covering whole life cycles. With integration of product manufacturing, service offering and consuming, intellectual capital, human capital and industrial capital were amalgamated together to construct a value adding aggregation. Sun believed this architecture was a new kind of commerce mode and also a new way of producing organization (Li et al. 2010).

Ping-yu Jiang analyzed the structure of PSS from the view of engineering science and divided it into configuration system, scheduling system and service supporting system. This structure focused on service transition but ignored interface and product/service terminals (Jiang and Zhu 2008).

Meier proposed a hierarchy covering driving force, business environment, business mode, capacity management, core business service, organization structure, society technology network, cost risk control and other relevant factors mainly from the view of value network which was fairly completed but not clear enough on expression of factors interaction (Meier et al. 2010).

Gu et al. 2009 put forward an architecture of product service life cycle management, which was actually a model of life cycle management of PSS based on the platform of life cycle management system.

Qi et al. 2010, starting from the background of modern manufacturing services, on the basis of analyzing the content of manufacturing services of PSS life cycle, proposed a wheel structure of service-Embedded manufacturing. In fact, this was a content structure of all kinds of manufacturing services in the process of PSS life cycle.

Many existing researches try to explain the whole system with single structure, while product service system is a complicated system consisting amounts of elements, which means single-structure-explanation is an unrealistic thing. Besides, present researches on output forms usually stay at the level of "product and service" without regarding it as an integrated system, which makes them too simple to be completed enough. Therefore, to build the whole PSS model, it should be started from the systematic integration of product and service according to its spatial and temporal characteristics.

135.3 Analysis of PSS Structure

According to the structure characteristics of PSS and shortages of present frameworks, PSS structure is analyzed from the angle of PSS spatial structure and application model of PSS life cycle, which is a foundation for further modeling research in this paper.

135.3.1 Spatial Structure of PSS

Present researches rarely focused on PSS structure. It was usually considered as simple "product and service" which manifests as product and service being relatively independent, or core products combining with additional service. These descriptions were too simple to reflect the essential characteristics of PSS, which was an important defect resulting in lack of further research.

As shown in Fig. 135.1, PSS is a system providing a unity of product and service as terminal by which customers and other subjects can participates in PSS. PSS has interfaces to interact with subjects, ports to access networks, and networks to connect PSS platforms and other terminals. With the ports, PSS enables all kinds of interaction between product and product, product and service, service and service, product and platform, service and platform, etc. The essence of different PSS systems lies in configuration of these structure elements.

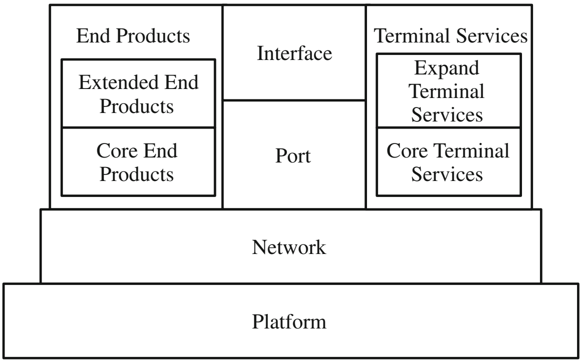

Fig. 135.1 Spatial structure form of PSS

135.3.2 Application Model of PSS Life Cycle

PSS is a product highly integrating serving with manufacturing, ultimately aiming at customer's maximum demand, taking the life cycle of product and service as temporal scale and material supplier to final customer as spatial scale with service running through all activities of manufacturing services network to realize continuous value adding. Its application model contains full application of producing service and serving production, as shown in Fig. 135.2. The former refers to all kinds of services around manufacturing process, such as technical services, information services, logistics services, management consulting, financial services, human resource services, legal services, etc. while the latter refers to before-sale, in-sale and after-sale activities including installation, commissioning, maintenance, upgrades and remanufacturing, etc.

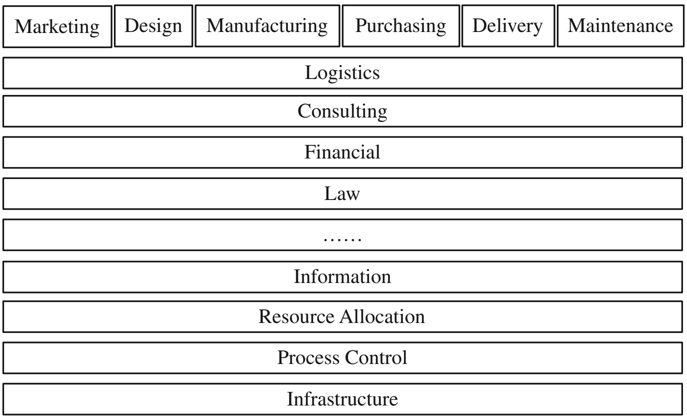

Fig. 135.2 Figure of application model of PSS life cycle

135.4 PSS Modeling Framework Based on MDA

Above analysis of system structure is only conceptual representation of PSS, which cannot be directly used for modeling. In the following part, according to PSS system structure, this article manages to construct a PSS modeling framework based on MDA via construction of meta-model, meta–meta-model, and single-view models based on meta-model.

135.4.1 Model Driven Architecture

In the field of MDA, Object Management Organization (OMG) technology defined a kind of 4-layer modeling framework which contains meta–meta-model layer (M3), meta-model layer (M2), model layer (M1), and run-time layer (M0). Among these, meta–meta-model layer contains the required elements of defining modeling language. Meta-model layer defines the structure and syntax of modeling language. Model layer defines a specific model of a system. Run-time layer includes running status of objects of a model (OMG 2009). MDA based on meta-model has been applied in the field of enterprise modeling but not been seen in PSS modeling (Wan et al. 2012; Li et al. 2008).

135.4.2 4-Layer Modeling Framework of PSS

Figure 135.3 shows a 4-layer PSS modeling framework based on MDA. In this framework, meta-model layer defines the semantic relationship of various elements, and model layer is a kind of instantiation of PSS. Due to the complexity of PSS system structure, it is difficult to build a model from one single dimension. Therefore, this paper proposes a PSS system model with single-view model based on meta-model in model layer from different dimensions, such as organization, process, product/service, communication, control, knowledge, and quality etc. All views are unified together through the intrinsic correlation of meta-model. Data layer mainly contains run-time information and data for PSS to describe its running status.

135.4.3 Meta-Model of PSS

Shown in Fig. 135.4 is meta-model of PSS, which defines the basic elements of PSS including: (1) terminals, meaning the "*products + services*" combination delivered to customers; (2) interface, meaning the interaction interface between the

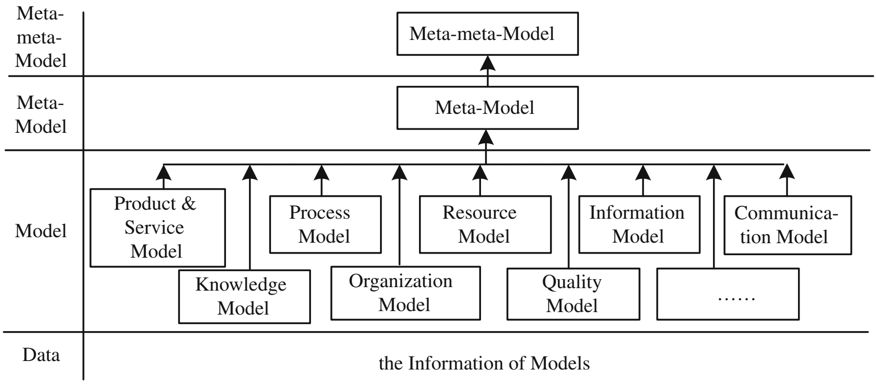

Fig. 135.3 The 4-layer modeling framework of PSS

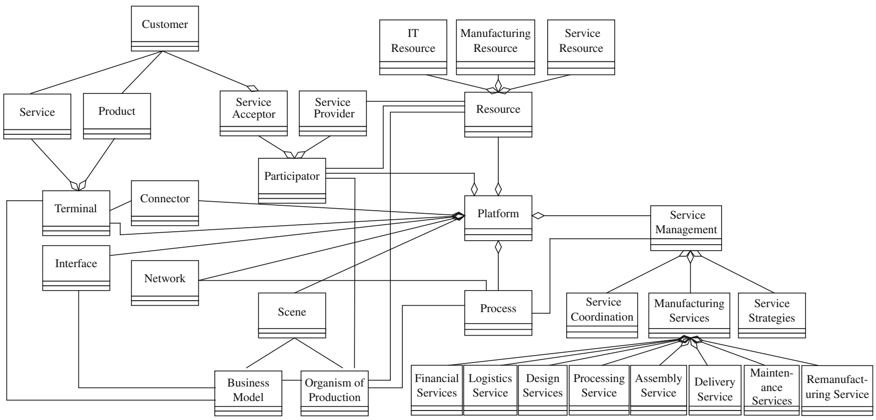

Fig. 135.4 The meta-model of PSS

system and customer; (3) connector, which managing connections like products and products, services and service, products and services, or product/service and PSS platform; (4) platform, main part of the PSS, including process, participants, resources, business model, production organization, service logic and application, etc. The meta-model also defines the inherent relationship among various elements, including two basic relationships affecting and containing.

135.4.4 Single-View Model of PSS

Single-view model of PSS mainly includes product/service model, process model, organization model, resource model, information model, communication model, knowledge model, quality model etc. The first six models are the core ones. MDA

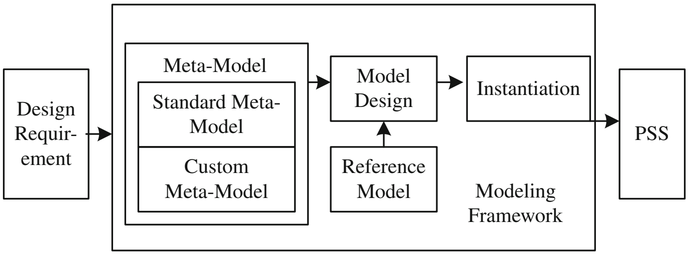

Fig. 135.5 The application of the PSS modeling framework based on MDA

emphasizes independence of each other among platforms, which means if the internal consistency of semantics and syntax of different models is ensured, any modeling methodology can be applied. Zhang et al. (2010) summarized the modeling methodologies of process model and organization model. In particular, there are varieties of modeling techniques applied to product and service modeling, which mainly focus on only product or service but few on their integration. It is indeed a kind of segmentation which results in the loss of characteristic information of PSS. Therefore, the product/service model must provide a clear definition of product, service, interface and network which is completed enough to meet the demands of PSS model being systematic. Sadek (2009) provided an integrated modeling framework for product/service without specific modeling technology. UML and XML are believed to be able to meet related requirements in application.

135.4.5 The Application of the PSS Modeling Framework Based on MDA

The PSS modeling framework proposed in this paper aims to provide a methodology for PSS modeling in PSS structure analysis and design.

In the process of PSS analysis and design, as shown in Fig. 135.5, PSS modeling framework can be applied for building visual model, acquiring semantic information of system structure, analyzing status data of system elements or some other activities. Reuse a standard meta-model or customize a new one at first. Second quote or refer to the reference models to proceed with single-model design. After instantiation at last, a PSS model can be obtained.

135.5 Conclusion

PSS is a multi-elements, multi-subjects complicated manufacturing system. Aiming at its system modeling, this paper presented a modeling framework basedon MDA technology. Also, here proposed PSS structure form and application model, put forward a 4-layer modeling framework, defined its meta-model, and discussed PSS single-view modeling methodology. This framework is able to describe the complex relationships among various PSS elements and support PSS analyzing and designing. On this basis, customization and change of meta-model shall be further discussed to support PSS modeling better.

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Chapter 136
Research on the Civil Aircraft Customer Service System Simulation Based on SD Model

Jun Xu and Cui-xia Bi

Abstract Customer service ability is one of the key competitiveness in market competition for civil aircraft manufacturers who participate. To establish the mature reliable civil aircraft customer service system based on the service strategy is an important aspect to reflect the customer service skills. Based on the idea of system dynamics, this paper constructed a system dynamics model (SD model) of the customer service system of COMAC, and through the simulation of the system, analyzed the key factors which affect the running of the customer service system, to provide the basis for decision-making and measures.

Keywords Civil aircraft · Customer service system · Simulation · System dynamic model

136.1 Introduction

Customer service ability is one of the key competitiveness in market competition for civil aircraft manufacturers. To establish a mature reliable civil aircraft customer service system based on the service strategy is an important aspect to reflect the customer service skills, and has a close relationship with the well development of China's civil aircraft industry.

The customer service system of COMAC, is involving COMAC, customer service center, suppliers, airlines and other subjects. These different subjects relate to each other, and interact with each other, which together form a large complicated system. In the situation that we cannot completely achieved quantitative

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E. Qi et al. (eds.), *The 19th International Conference on Industrial Engineering and Engineering Management*, DOI: 10.1007/978-3-642-38391-5_136,

data, in order to analyze the working principle and the system function of the large and complex system better, this article chooses using system dynamics model to research problems. The article will construct SD model of the customer service system of COMAC, and through the simulation of the system, to analyze the key factors which affect the running of the customer service system, to provide the basis for decision-making and measures.

136.2 Establish the SD Model of Civil Aircraft Customer Service System

System dynamics is an efficient approach to understanding the behavior of complex system. It deals with internal feedback loops and time delays that affect the behavior of the entire system (Wang 1994), and has been applied extensively in multiple fields (Lyneis 2000; Tan and Wang 2010; Ovalle and Marquez 2003; Gao et al. 2006; Angerhofer and Angelides 2000; Kim 2003).

Customer service system of COMAC as the subsystem of the social economic system, is a organic whole, its external system is the environment, which mainly including the social, political, economic and other external environment, also including systems of suppliers, logistics system, COMAC, airlines and other clients systems, which closely related with its operation.

COMAC customer service internal system is included management system, technology system, security system, the evaluation system. The relationship of each subsystem and relationship between systems and external environment are shown in Fig. 136.1.

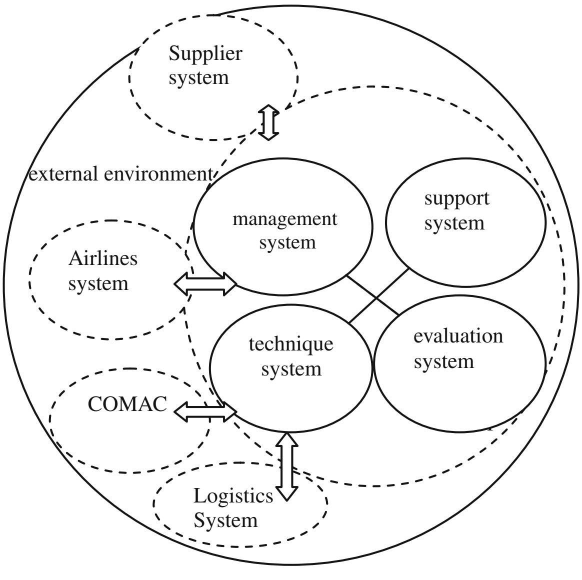

Fig. 136.1 System structure of customer service system of COMAC

Customer service system of COMAC is an open, dynamic and complex time-varying system, the main internal factors is including the demand of customer service, the progress level of science and technology (such as infrastructure construction level, inventory management ability, modernization of the organization operation and management, information level and working staff), customer service capability (include fast response time, service satisfaction) and so on. The main external factors are social and economic development level, COMAC profit level, the investment of COMAC for customer service center, the service level of the supplier and the supply capacity, logistics development level, etc.

In order to simulate COMAC customer service system, we must comprehensive considerate the internal and external influence factors.

In this paper, the SD software Vensim PLE 32 (Ventana Simulation Environment Personal Learning Edition) was applied to establish the customer service system based on its practical operation and powerful design tools.

136.3 Establish the SD Causality Diagram of COMAC Customer Service System

By the comprehensive analysis of the causality relationship between the internal and external factors of COMAC customer service system, this paper give an SD causality diagram of COMAC customer service system as shown in Fig. 136.2.

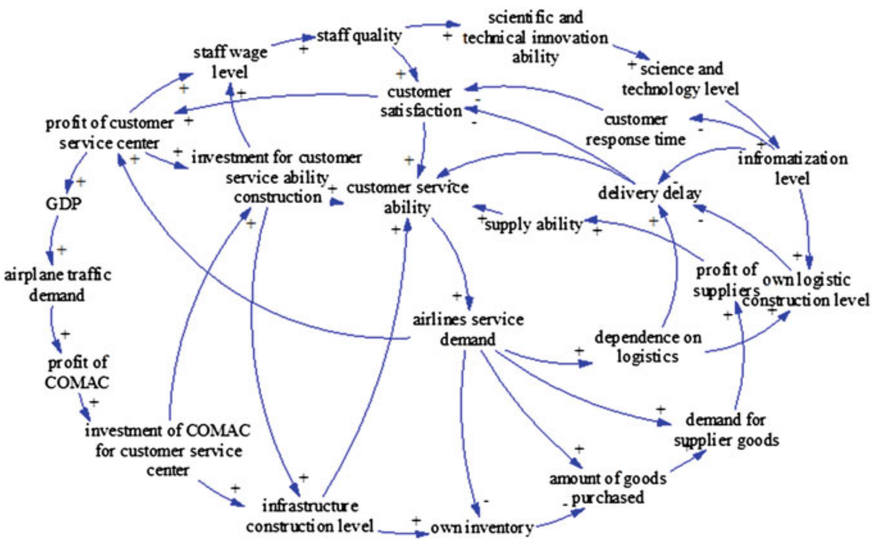

Fig. 136.2 The SD causality diagram of COMAC customer service system

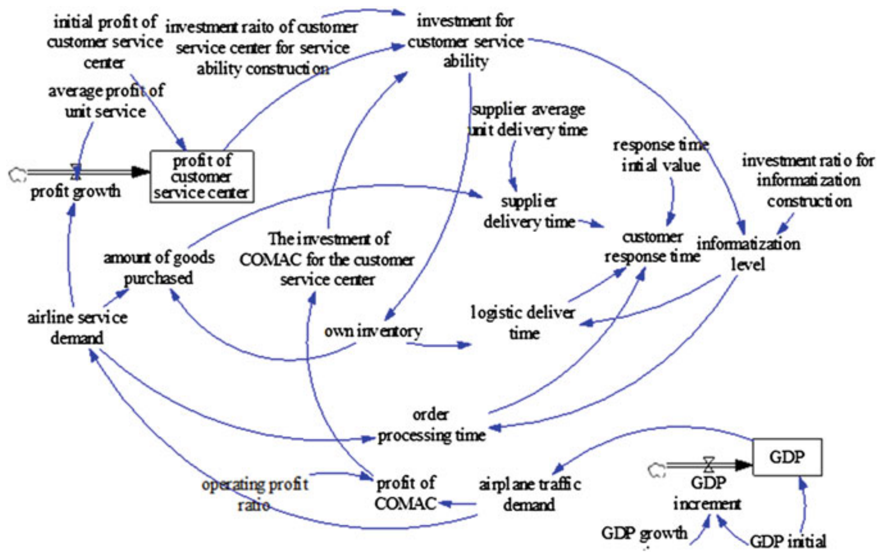

Fig. 136.3 SD flow figure of COMAC customer service system

This paper used flow figure to research the system dynamic simulation of COMAC customer service system. This paper based on the analysis of the causality diagram of COMAC service system to determine the flow figure.

In Fig. 136.3, this paper use the customer response time to stand for the service ability level of COMAC customer service system, use the information level to stand for the customer service center investment in logistic and information level construction, use the supplier delivery time to stand for the supplier availability (Hui and Jha 1999; Jenkins 1999). This paper is based on these hypotheses, to carry on the SD simulation experiment. Specific variables and equation set of this paper as follow.

136.3.1 Equation of State

In the model there are two state variables that are GDP value and profit of customer service center. Two equations of state as follow.

- GDP value = GDP initial value + GDP increment
- customer service center profit = profit initial value + profit increment

State variable is connected with its initial value and growth rate. The growth rate is description by rate equation.

136.3.2 Equation of Flow Rate

In the model there are two flow rate variables that are GDP increment and profit increment. Two equations of flow rate as follow.

- GDP increment = GDP value * GDP growth rate
- profit growth = Airline service de mand * average profit of single service.

136.3.3 Assistant Equations

Assistant equations can make the rate equation be expressed briefly. In this paper the assistant equations as follow.

- The civil aircraft traffic demand

In this paper the civil aircraft traffic demand can be obtained by regression analysis based on the proportion of annual air transportation in GDP value.

According to the data of China Statistical Yearbook from 2000 to 2010, by simple linear regression we got the formula as follow.

$$y = 0.0081 ^* x + 565.08, \quad R^2 = 0.9756 \tag{136.1}$$

We can see the goodness of fit is greater than 0.95, it is means that the fitting precision is high, the equation is available. The unit of airplane traffic volume is hundred million passenger-kilometers.

- Profit of COMAC

Suppose the relationship between the plane traffic demand and the operating profit is linear, the operating profit ratio is referred to the ratio of BOEING, and set it to be 8 %. The profit of COMAC can be obtained by the formula as follow.

The Profit of COMAC = The civil aircraft traffic demand * the operating profit ratio.

- Airline service demand

Suppose the relationship between the airplane traffic demand and the service demand is linear. And also suppose the service demand of unit traffic demand is 0.3.

- The investment of COMAC for the customer service center

Suppose the investment takes up about 20 % proportion in the profit of COMAC.

- The investment for the construction of customer service ability

This investment = the investment of COMAC for the customer service center + profit of the customer service center * the investment ratio for customer service ability construction

Suppose the ratio is 30 %.

- Information level

Information level = the investment for customer service ability construction * the investment ratio for information construction

- Order processing time

Order processing time = square of airlines service demand/Information level

- Own inventory

Own inventory = the investment for customer service ability construction * 0.5 * 0.8

Own inventory is the spare parts of airlines demand which can be met by their own stock. We suppose there is about 50 % of the investment for service ability construction of the customer service center to be used for spare parts inventory level construction. And suppose there is about 80 % of the own inventory can meet the demand.

- Amount of goods purchased

Amount of goods purchased = airlines service demand- own inventory

- Logistics delivery time

Logistics delivery time = Square of own inventory/information level

- Supplier delivery time

Supplier delivery time = Amount of goods purchased * Supplier average unit delivery time

In this paper the unit delivery time is supposed to be 2.

- Customer response time

Customer response time = Supplier delivery time + Logistics delivery time + Order processing time

136.3.4 Model Constant

- GDP initial value

This paper chose the value of 2010 to be the initial value; it is about 39 trillion RMB.

- The initial value of Customer service center profit

This paper chose the value of 2010 to be the initial value. In this year the profit is −790, the income is about it is about 95.33 million RMB.

- GDP growth ratio

This paper chose the average growth ratio between 1980 and 2010 to be the GDP growth ratio. By calculating it can be determined to be 10 %.

- Average profit ratio of single service

Suppose average profit ratio of single service is 15 %.

- The investment ratio for information construction

Suppose this ratio is 20 %.

136.4 The System Simulation Results Analysis

This paper based on the above assumptions to carry on the simulation of the model, took the customer response time to be the target variable, to examine the response time change level in different conditions. In this paper result 1 is obtained based on the original hypothesis. Result 2 is obtained based on the condition that the ratio of investment for information construction is raised to be 40 % and the other conditions remain unchanged. Result 3 is obtained based on the condition that the ratio of investment for inventory construction is raised to be 60 % and the other conditions remain unchanged. Result 4 is obtained based on the condition that supplier average unit delivery time changed to be 2.5 and the other conditions remain unchanged. Result 5 is obtained based on the condition that the ratio of investment of COMAC changed to be 40 % and the other conditions remain unchanged. Result 6 is obtained based on the condition when the ratio of investment for inventory construction has been raised to be 0.5 and the other conditions remain unchanged. In the research the choice of time span for 5 years, and the result as follow.

We can see from Fig. 136.4 that, the best results are result 1 and result 2, the better results are result 5 and result 6, the curve of the result 3 has a transitory decline at first and then rose again as same as result 4. So we can get some inference from this.

- The result 2 shows that the information construction level has large contribution to the customer response time, so the service center should strengthen the construction for it. Here the information network not merely be the construction

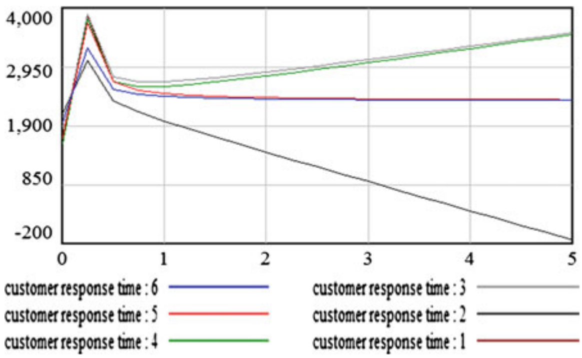

Fig. 136.4 Contrast figure of customer response time

of information network system, but also be the logistic network system. For the customer service center of COMAC, if it has its own logistic team, it can save the customer response time and rise customer satisfaction.

- We can see from the result 5 and result 6 that at present the construction for basic ability should be strengthened, but after the time when basic ability had met the demand, more investment will not bring about more contribution.
- We can see from result 3 that when the center input too much on the inventory construction, the repay may not homologous be more, but may be bad. That because when the investment for inventory is too much, the spare parts inventory will be too much, the pressure on the management of inventory will be too high, this may lead to a negative influence for the operation of the center. That is in accordance with the principle that Inventory and not the more the better.
- We can see from result 4 that the supplier average unit delivery time does negative influence for the customer service ability. So in the process of the customer service center development, it should be put more attention on the choice of suppliers.

136.5 Conclusion

Insufficient and inaccuracy data, difficulty of quantifying the relationship are knotty problems in the research of social and economic problems study. The structure of the SD model is based on feedback loop, the existence of the multiple feedback loops make the system behavior pattern is no sensitive to parameters. So the system behavior can be similar so long as the parameters are in accepted scope. Just because this principle this paper gave the SD simulation of the civil aircraft customer service system, and the result is objective and credible.

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Chapter 137
Research on the Modeling Method of Wargaming for Equipment Support on Computer

Xiao-ming Du, Gui-qi Wang, Ping Gu and Lu Gao

Abstract The study of modeling is a core problem to actualize the function of wargaming for equipment support on computer. The chessman is an information carrier to show the situation of support force and also an assignment carrier to implement the support activity in the wargaming system based on the computer. Firstly, the method of modeling which is based on the period of chessman's life is put forward on the basis of analyzing the state of chessman's life. Then, the method is described, and the framework of model for wargaming is established by the method. Finally, a case is introduced to explain the application of the method.

Keywords Chessman · Equipment support · Modeling · Wargaming

137.1 Introduction

The wargaming (Peter 1990) for equipment support on computer is the application of wargame's principle in equipment support, by using which, the commander using the wargame map and units representing the real battle field and military or using the computer simulation model (Yang 2007; Peng et al. 2008) in terms of the rule and the principle of probability theory to command the activity of equipment support in the war for verifying and improving the equipment support project.

The activity of equipment support is a complex system, and how to study the model for wargaming is a core problem to carry out the function of wargaming based on computer. The scientific property of model connects with the capability of wargaming flow and result. In the text, the method of modeling which is based on the period of chessman's life is firstly put forward on the basis of analyzing the state of chessman's life to establish the system of model for wargaming.

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E. Qi et al. (eds.), *The 19th International Conference on Industrial Engineering and Engineering Management*, DOI: 10.1007/978-3-642-38391-5_137,

137.2 The Analysis for the State of Chessman's Life

137.2.1 The Concept of Chessman

The function of chessman is to show different classes of army and weapons, and the commander who uses the system of wargaming could inquire the ability parameters which are evaluated by the level of the army's training or the capability of the unit's equipment through the chessman (James 1997). The chessman's parameters of the wargaming for equipment support are composed of the value of movement, defense, support, attack, and are composed of the information of support object and unit's code, and so on, as shown in Fig. 137.1.

The chessman is an information carrier to show the situation of military and is an assignment carrier to implement the action in the wargaming system which is based on computer (Liu et al. 2008). The forms and movements of chessman are basically function achieved for the system working.

137.2.2 The Analysis for the Cycle of Chessman's Life

Anything has a process from produce to perish. The chessman's process which involves produce change perishes; illuminate the flow of the wargaming. The chessman's movement is the carrier for wargaming (Ross 2006).

Firstly, the chessman's entity is made by experts in military affairs through generalizing the information and the attribute of equipment support forces and combat forces. When the wargaming begin, the chessman is working on the purpose of commanders who operate the command platform on computer and working under the trigger conditions. The movements of chessman involve mobility deployment maintenance regress, and so on. At the same time, the chessman's status messages are changing along with the movements of chessman, and are displaying on the situation display platform for the commanders who want to know it on real-time. In course of wargaming, if the chessman is exposed to the firepower strike from enemy force, then the damage or perishes of the chessman is coming, as shown in Fig. 137.2.

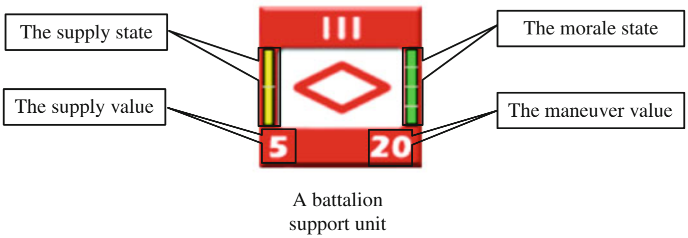

Fig. 137.1 The chessman

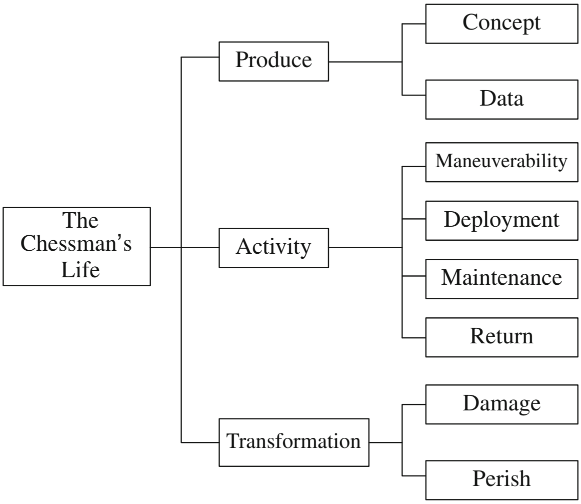

Fig. 137.2 The chessman's life

137.3 The Development of the Model System for Wargaming

137.3.1 The Method of Modeling

The activity of wargaming for equipment support is a complex system; include the support entity, the combat entity, the interactive relationship between the entity and the correlation of the entity. So we need an effective method of modeling to describe the entity, operating modes of system, complicate battlefield environment, relationship between the entity and the arbitrage formulae.

The method of modeling which is based on the period of chessman's life is put forward on the basis of analyzing the state of chessman's life to establish the system of model for wargaming. In course of modeling process, the chessman is a main. The relevant model is established by analyzing the chessman's life and the variation state of chessman in different phases, and the homonymic model architecture is developed to describe the wargaming from the chessman's life based on the method. The entity model is coming with the produce of the chessman, to describe the static and dynamic attribute of the entity, to model the support force and the combat force. The structuring model is coming with the trigger conditions of the chessman's business activities, to describe the subjection relationship and correlation relationship between the chessmen, to ascertain the support relationship so as to the chessman's business activities is under the right order. The behavior model which is the core in the modeling is coming with the development of the chessman's business activities; it is composed of maneuverability model deployment model and so on. The information model and the interactive formulae model are coming with the change of the chessman's state, to describe the process how the chessman's state is changed and how the message and information is transferred when the chessman is working. Otherwise the probability model and the terrain environment model are developed to describe the haphazard and the environment.

137.3.2 The Development of the Model

- The entity model is described the structure of entity, the attribute of entity and the correlation of the entity (Xin et al. 2010). The wargaming entity model is usually composed of the ability parameter, the structure and the state of the military force. For example the support force entity model include the information of the support units, such as the ability to maneuver support recovery, the object and the range of operation, to be grounded on the realization of the dispatching order. The combat force entity model is the object of the support force, and it isn't central model relative to the support force entity model, so the model is simply described the equipment information, the comeback parameter of combat, the real-time state and so on. Otherwise the equipment entity model is developed to describe the equipment information, such as maintenance type, mean time to repair.
- The structuring model is developed to describe the subjection relationship and the correlation relationship between the chessmen, and to build up the organizational relations of the chessman, the support force correlation, and the rights of wargaming seat (Peng et al. 2009). The model's function is to establish a relationship between the commander's order and the chessman's movement. The model is described the rights formulae for the wargaming seat to develop the maneuver relationship between the wargaming seat and the chessman, is defined the trigger conditions to develop the order's produce and implement. The subjection relationship and the correlation relationship are developed by defining the relationship of chessman and the attribute of chessman to implement the dispatching order and the return order.
- The maneuverability model is developed to describe the process, the chessman's movement to the destination after incepting the relevant order. It is based for quantifying the maneuverability ability of the chessman, synthetically referring to the influencing factors of environment and enemy's situation, to estimate the case of chessman's maneuver on the road. The model of wargaming is described the attribute of force, the type of maneuver, the geography information, the formulae to manage the haphazard. The attribute of force is composed of the entity's type, the force's level, the maneuver ability, the real-time state, etc. The type of maneuver is composed of the maneuver mode, the beginning

rapidity, the destination coordinate, the real-time point information. The function of geography information is to provide the battlefield environment data for the maneuverability model, it include the weather parameter and the landform influencing factors. The formulae to manage the haphazard is developed to describe the case, when the haphazard happen, the chessman automatically manage it, for example when the chessman is attacked, the formulae may operate to tell the chessman to remain in concealment firstly, and retaliate upon, then wait for the commander's order, but not to sequentially move on the road.

- The deployment model is described when the chessman's state accord with the trigger.
- Composed of the support force attribute, the deployment formulae, the deployment time, the information of operation site, etc.
- The model is the most important model in the behavior model, it is described the maintenance business process (Xu 2008). When the degree of damage equipment and the level of maintenance unit are accordant the chessmen which substitute the force begin a maintenance activity to the damage equipment. According to the class and the amount of damage equipment, the hours of maintenance task is counted, then the value of maintenance force ability is established by integrating the utilization of time and the grade of enemy force. The chessman take turns to maintain the damage equipment until the list of task is clear. If all of the tasks are achieved, then the maintenance model is over, if not the wargaming is going on while the formulae judge the grade of enemy force and the availability of the equipment.
- The information model is developed to describe the process, the information transmitting and exchanging in the wargaming activity, the logic relation between the chessmen and the data. The function of the model is to manage the data transmitting between the entity models, the structuring model, the behavior model, the interactive formulae model on the computer. In the wargaming the information includes the command message, the feedback message, state change message, etc.
- The interactive formulae model is developed to describe the process, the chessman's state changing when the chessman's state accord with the trigger conditions and the interaction effect happen (Liu et al. 2011). The interactions in the wargaming for equipment support mostly include the value translation between support and combat, the value of the support force change under the enemy force. The model's parameter is composed of the correlation type, the trigger formulae, the support value, the combat value, the coefficient translation.
- The probability model is described the haphazard in the battlefield. In the traditional handwork wargaming, the designer makes use of the probability number list and the dice to simulate the effect of the haphazard. But in the modern wargaming system based on computer, the haphazard is simulated by establishing the probability model through the probability function.

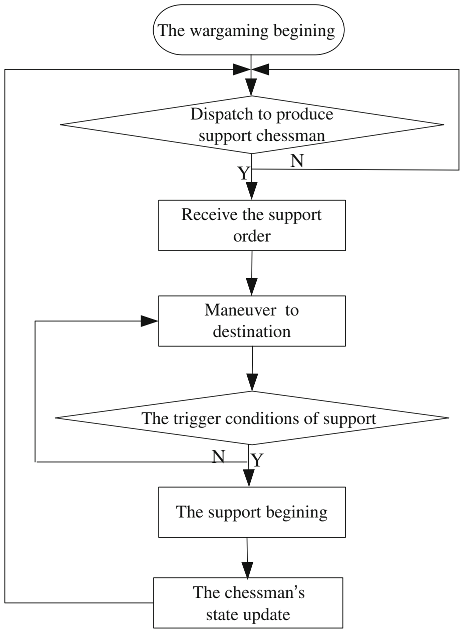

Fig. 137.3 The flow of wargaming with focus on chessman's life

137.4 A Case

There is a case which is an equipment support activity in the wargaming to verify the method for establishing the framework of the model integrality.

The flow of an equipment support activity: the commander assign a maintenance unit to maintain many damage equipments after judging the situation in the battlefield. When the chessmen arrive at the destination, the activity is operated according to the trigger conditions, and the value of the chessman's state is changing at the same time (Fig. 137.3).

The analysis for modeling: after the commander make the dispatching order, the chessmen are produced by distilling the state of the support units and the combat units, the process is making the entity model. The commander make the task order to the unit chessman to arrive at the combat unit chessman which one needs support, the process is making the structuring model. After the unit chessman receives the task order, and maneuvers, deploys, maintains, returns, the process is making the behavior model. When the unit chessman begin the support activity, the transfer of the value between the chessmen is doing, the process is making the interactive formulae model. In the whole activity, the data and information are transferring at all times; the process is making the information model (Fig. 137.4).

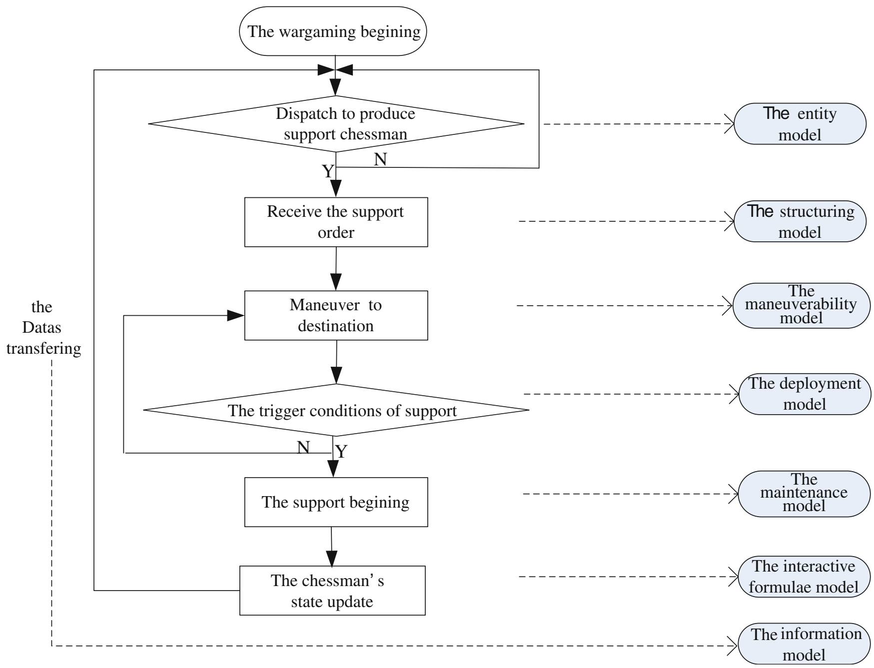

Fig. 137.4 A corresponding relationship between the flow of wargaming and the framework of model

137.5 Conclusion

The method modeling which is based on the period of chessman's life is put forward in the text, we establish the framework of the model for wargaming on computer, and a case is introduced to explain the application for the method. But the method has limitations, we should summarize the other methods on modeling technique at home and abroad to amply design the models for the wargaming system under the framework system of model based on computer.

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Chapter 138
Risk Sharing Proportion of Cooperation Between the Banks and Guarantee Agencies Based on Elman Neural Network

Jun Liang and Qiang Mei

Abstract Considering the problems such as weak practicality generated from the application of the mathematical model to calculate risk sharing proportion between banks and guarantee agencies. This paper puts forward that Elman neural network model can be adopted to study risk sharing proportion between banks and guarantee agencies. The computing process is as followed. First of all, selecting the existing sample to train network model, and then proving network availability through the tests, finally inputting the actual data operations to obtain the evaluation results. The result indicates that Elman neural network model exhibits more effective performance than traditional mathematical model on estimating the risk sharing proportion in practice.

Keywords Banks · Guarantee agencies · Neural network · Risk sharing proportion

138.1 Introduction

In the process of cooperation between banks and guarantee agencies, mathematical model is universally applied to calculate the risk sharing proportion (Wang and Zou 2011; Fu and Zhao 2006). But in this way there are unreasonable hypothesis and unfavorable application blocking the using in practice which requires an extra evaluation method to assess risk sharing proportion. This paper suggests a way to

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E. Qi et al. (eds.), *The 19th International Conference on Industrial Engineering and Engineering Management*, DOI: 10.1007/978-3-642-38391-5_138,

study the cooperation of banks and guarantee agencies on risk sharing proportion with the application of Elman neural network model (Jia et al. 2012, Liu et al. 2011).

Neural network model has the ability of self-organizing, applicability, self-learning (Dong et al. 2007). Different from mathematical model, neural network model particularly suitable for issues which needs considering a variety of factors and imprecise and vague information processing. Neural network model is represented by the network topology, node characteristics, and learning rules instead of particular logic function (Chen et al. 2005). The application of this method greatly relieves the modeling difficulty and reduces modeling time and also it significantly decreases the interference of human factors and effectively reduce the number of auxiliary variables and intermediate variables which will make the hypothesis be more reasonable. What's more, provided the ample study samples, reasonable network structure and well-designed training parameters trained based on samples, neural network can automatically extract knowledge rules from historical data to operate accurately the simulation among variables complex mapping relationships (Wang et al. 2010, You et al. 2012), so as to overcome the limitations of traditional mathematical models.

138.2 Elman Neutral Networks Model

138.2.1 Basic Principle

The neural network model has already been widely applied in assessment and prediction of various economic indicators and phenomena (Li 2002). Elman neural network is a feedback neural network. Compared with feed forward neural network, it has many advantages such as fast approaching, and high calculation accuracy (Li et al. 2011). In assessment of the proportion of risk sharing, mathematical model computes the extreme point of income of banks and guarantee agencies to determine the reasonable proportion. While the Elman neural network model, to calculate the optimal fitted values of risk sharing proportion within the reasonable range of error by fitting the complex relationships between the variables in the cooperation of banks and guarantee agencies (Li and Su 2010).

The planned process includes the selection of the existing sample to train network model, the test of proved network availability, and finally the obtaining of assessment result by inputting of actual data (Zhao et al. 2005, Hou et al. 1999).

This paper employs the segmentation method to form the risk sharing proportion. According to the data acquired from the 12th national joint session of guarantee agencies for small and middle-sized enterprises, most domestic banks, at present, are not willing to share the risks with the guarantee agencies. Even if some banks think over to share risk, the sharing proportion is generally less than 10 %. But referring to the experiences and data analysis of the cooperation of banks and

Table 138.1 List of risk sharing proportion

Fuzzy comprehensive evaluation levels	V1	V2	V3	V4
Risk sharing proportion	[15 %, 20 %]	[10 %, 15 %)	[5 %, 10 %)	[0 %, 5 %)

guarantee agencies at home and abroad, it shows that bank are likely to share more risks after assessing risks of guarantee agencies in the process of cooperation. The upper limit of bank risk sharing proportion is configured as 20 %. Therefore, this paper adopts the upper limit.

Meanwhile with reference to the present situation of guarantee agencies in Jiangsu province, risk sharing proportion is theoretically segmented into four levels as V1[15 %,20 %], V2[10 %,15 %), V3[5 %,10 %), V4[0 %,5 %) of bank risk sharing proportion. V1 stands for the less risky guarantee agencies, banks tend to share the highest [15 %, 20 %] level of risks. The V2 represents comparably secure guarantee agencies, banks are willing to share [10 %, 15 %) of the risks. The V3 stands for the generally risky guarantee agencies, banks can share [5 %, 10 %) of the risks. V4 represents the most risky guarantee agencies that banks are usually unwilling to share the risks which means banks will share [0 %, 5 %) of the risks. Specific data is shown in Table 138.1.

Based on the rating method calculated by Elman neural network model and the evaluation value interval in Table 138.1, the level of the evaluation value of guarantee agencies can be conjectured, and then decided the risk sharing proportion that banks are willing to share with guarantee agencies.

138.2.2 Fulfillment Process

The process of evaluating the proportion of the specific risk shares by Elman neural network model are as following (Cong and Xiang 2001, FECIT Science and Technology Product Development Center 2005):

(1) Select parameters. Referring to researches and experiences at home and abroad and considering the analysis result of the data of the guarantee agencies in Jiangsu province, selecting capital, asset ratio, guarantee business profitability, guarantee compensation rate, compensatory loss rate, margin ratio, re-guarantee proportion, and willingness of cooperation, which is standardized as input parameters of Elman neural networks.
(2) Determine the target output model. The level of risk sharing proportion between banks and guarantee agencies are divided into four levels, using the following array to indicate target value:

$$\begin{aligned} V1 &:(1, 0, 0, 0) \\ V2 &:(0, 1, 0, 0) \\ V3 &:(0, 0, 1, 0) \\ V4 &:(0, 0, 0, 1) \end{aligned}$$

(3) Input sample data to train Elman neural network. The network should be ensured to meet the evaluation requirements of cooperation of banks and guarantee agencies.
(4) Input test samples. The trained model Establish learning network to evaluate the error, according to European norm theory.
(5) Input the evaluation indicators to calculate by Elman neural network.
(6) Acquiring the bank risk sharing according to the output vector-valued. The largest dimension of the output vector s is the risk rank which the bank wants to share. For example, output (0.6, 0.3, 0.1, 0.1), risk sharing for V1, namely [15 %, 20 %].

138.3 Empirical Analysis

Before empirical analysis, the data input and the collection of original data require to be processed in specific patterns to meet the request of the model. So the first mission is to unify and standardize the data format (FECIT Science and Technology Product Development Center 2005; Song and Bai 2010).

(1) Design of input and objective vector
Elman neural network's input parameters consist of seven indexes including the capital, guarantee scale, guarantee business profitability, margin ratio, the asset-liability ratio, compensatory loss and cooperation aspiration. The original data of the number of the vector from a level, in order to prevent partial neurons to supersaturated, so before inputting to the neural network, these data should be standardized, and then provide system for the corresponding operation. Here sample data are standardized between [0, 1].
(2) Using Elman model for the evaluation of risk sharing proportion between banks and guarantee agencies.

One of the most important inputs of Elman neural network model is learning sample. The same data, according to different ways of learning training, will produce different outcomes, so the set of study sample directly affects the output. Table 138.2 gives the input vector of the twelve group study sample data (standardized sample data), and output vector corresponding is the bank risk sharing proportion, it is known that risk allocation proportion is set to four interval [0 %, 5 %), [5 %, 10 %), [10 %, 15 %) and [15 %, 20 %].

Table 138.2 Data samples of risk sharing proportion

Number	Sample characteristics								V1	V2	V3	V4
1	0.392	0.875	0.612	0.000	0.396	0.260	0.000	1	1	0	0	0
2	0.551	0.875	0.589	0.020	0.355	0.486	0.000	1	1	0	0	0
3	0.435	0.875	0.566	0.018	0.330	0.434	0.000	1	1	0	0	0
4	0.391	0.875	0.640	0.175	0.176	0.146	0.000	1	0	1	0	0
5	1.000	0.875	0.564	0.200	0.049	0.294	0.000	1	0	1	0	0
6	0.184	0.000	0.661	0.211	0.341	0.605	0.000	0	0	1	0	0
7	0.108	0.000	0.573	0.251	0.643	0.134	0.000	1	0	0	1	0
8	0.184	0.000	0.661	0.272	0.233	0.161	0.000	0	0	0	1	0
9	0.092	0.875	0.611	0.475	0.301	0.020	0.000	0	0	0	1	0
10	0.049	0.875	0.592	0.582	0.317	0.222	0.788	0	0	0	0	1
11	0.051	0.000	0.658	0.652	0.344	0.062	0.000	0	0	0	0	1
12	0.091	0.000	0.564	0.846	0.370	0.533	0.067	0	0	0	0	1

The formal evaluation of neural network will be started after determining the learning sample. Four steps are required which include network creation, network training, error inspection and network output. These steps will be illustrated in the following parts.

The first step: network creation.

The three layers of network are considered to be a fairly effective solution to recognize the general pattern issues. The three layers comprise an input layer, hidden layer and output layer. Among the three layer network, the number of hidden neurons is two times of the number of the input layer plus 1.

According to the principles above, this paper designs the network according to the following way: The number of neurons inputting layer network is 8, so that the number of neurons in hidden layer is 17, and output layer number of neurons is 4.

For the convenience of analysis, the following data structure can be used to create he network model. The standardized network ensures the input vector in range of [0, 1], hidden neurons in the transfer function of using tansig tangent function, the output layer neural function using logsig logarithm function, so that the output model could satisfy the network of output requirements.

$$threshold = [0\,1; 0\,1; 0\,1; 0\,1; 0\,1; 0\,1; 0\,1; 0\,1]$$
$$net = \text{newelm}(\text{minmax}(P), [17, 4], \{'\text{tansig}', '\text{logsig}'\})$$

Among them, threshold defines the input vectors to the maximum value and the minimum value. Network parameter is shown in Table 138.3.

The second step: network training.

Traingdx function will be called through the following codes.

Table 138.3 Network parameters

Training function	Learning function	Performance function
trainlm	learngdm	mse

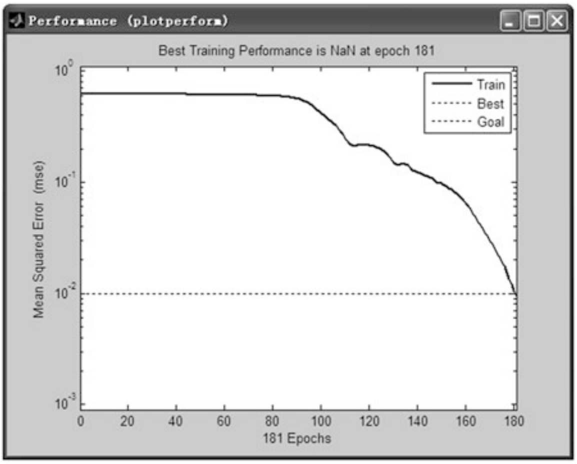

Fig. 138.1 Training records of risk sharing proportion

$$net.trainParam.epochs = 500$$
$$net.trainParam.goal = 0.01$$
$$net = \mathrm{train}(net, P, T)$$

The P and T respectively are set for input vector and target vector. The Fig. 138.1 shows that, with the increase of the training intensity, convergence speed gets higher. Network did not meet requirements, until the 181th training.

The third step: the error inspection.

The test is taken to display whether the network can meet the requirements of the evaluation. Four groups of new data are selected as test data, as shown in Table 138.4.

Test result:

$$\begin{aligned} \mathrm{Y1} &= (0.0000 \quad 0.0977 \quad 0.4264 \quad 0.0031) \\ \mathrm{Y2} &= (0.9994 \quad 0.0054 \quad 0.1293 \quad 0.0000) \\ \mathrm{Y3} &= (0.0000 \quad 0.2146 \quad 0.0002 \quad 0.9992) \\ \mathrm{Y4} &= (0.0360 \quad 0.0072 \quad 0.9991 \quad 0.0000) \end{aligned}$$

The level is planned to be determined by the largest element from numerical vector according to Elman neural network analysis, so it is suitable to use the evaluation results of vector ∞-norm to calculate the errors. These errors of the assessment were 0.0023, 0.0006, 0.0008 and 0.0009. Obviously these errors are within the acceptable limits (−0.003, +0.003) in the statistical scale. So it is acknowledged that, the network could meet with the requirements of the risk sharing proportion between bank and guarantee agencies after training.

The fourth step: network output.

Table 138.4 Test data for risk sharing proportion

Data	Assessment index data								Risk sharing proportion
Test data 1	0.160	0.000	0.801	0.628	0.140	0.709	0.000	1	[10 %, 15 %)
Test data 2	0.511	0.875	1.000	0.222	0.160	1.000	0.223	1	[15 %, 20 %]
Test data 3	0.084	0.000	0.109	0.754	0.103	0.309	0.000	0	[0 %, 5 %)
Test data 4	0.065	0.000	0.831	0.000	0.119	0.457	0.000	0	[5 %, 10 %)

Table 138.5 Risk sharing proportion of banks

Guarantee gencies	V1	V2	V3	V4	Risks sharing proportion
1	0.453	0.003	0.935	0.016	[5 %, 10 %)
2	0.042	0.957	0.006	0.002	[10 %, 15 %)
3	0.008	0.029	0.034	0.998	[0 %, 5 %)
4	0.118	0.016	0.469	0.008	[5 %, 10 %)
5	0.054	0.001	0.863	0.079	[5 %, 10 %)
6	0.025	0.090	0.003	0.979	[0 %, 5 %)
7	0.014	0.574	0.001	0.252	[10 %, 15 %)
8	0.006	0.002	0.999	0.383	[5 %, 10 %)

After inspection above, the estimated result of the risk sharing proportion is accurate. The risk sharing proportion for the eight guarantee agencies are shown in Table 138.5, which was calculated by the same method.

138.4 Conclusion

Elman neural network is used to estimate the risk sharing proportion between guarantee agencies and banks. The process contains selection of the existing sample to train network model, tests to prove network availability and finally input of the actual data to calculate evaluation results. The application of artificial neural network is predicted to perform effectively and scientifically to estimate the risk sharing proportion and guarantee magnification for better practical generalization.

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Chapter 139
Simulation Analysis on Effect of the Orifice on Injection Performance

Yu-lan Li, Xiang-bi An and Da-hai Jiang

Abstract The injector is one of the precision components for a diesel engine, and it is inevitable to wear fault during utilization. For the fault of the orifice expansion and the orifice obstruction, they are essentially changing the structure parameters. In order to analyze the effect of the orifices on injection performance, the simulation model of a certain type diesel injector was established based on AMESim. And a simulation for a whole injection cycle of this injector was performed, thus the injection characteristics and the relevant information about motion of the needle valve was obtained. The effect on the velocity of the needle valve, the flow rate and the volume of the fuel oil injection, etc. had been analyzed by changing the number, or the diameter of orifices, and setting different diameters for each orifice. The analysis would provide some references in structure design, optimization, testing data analysis and fault diagnosis.

Keywords AMESim · Diesel injector · Orifice · Simulation analysis · Working process

139.1 Introduction

The injector is one of the precision components for a diesel engine, and it is inevitable to wear fault during utilization. The orifice expansion and the orifice obstruction are two of the most common fault phenomena.

The orifice expansion is due to constant spray and erosion of high-pressure fuel oil flow on the orifices during the injector working. It drops the injection pressure,

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E. Qi et al. (eds.), *The 19th International Conference on Industrial Engineering and Engineering Management*, DOI: 10.1007/978-3-642-38391-5_139,

shortens the injection distance, which leads the diesel atomizing worse and increasing the carbon deposit in cylinder.

The orifice obstruction is due to half or complete block caused by the nozzle corrosion during long-term storage for the diesel engine, or some solid impurity particles mixing into the fuel oil, or the carbon deposit caused by bad combustion accumulating around the orifices and making the orifices be in half blocking state (Jin 2008).

These two kinds of fault phenomena are essentially changing the structure parameters of the orifice, from the point of view of the physical mechanism. It is difficult to record the parameter variable in real time during the working process of the injector. So simulation is the common method for analysis on the injector (Lv et al. 2009).A hole-type injector model is built based on AMESim to simulate an injection cycle, and to analyze the effect of the orifices on the injection performance, which can provide some references in structure design, optimization, test data analysis and fault diagnosis.

139.2 Phenomena Analysis on Effection of the Orifices on Injection Performance

The combustion process of the traditional diesel engine is mainly diffusion combustion, and its combustion heat release rules and its fuel economy depends on the fuel injection spray and the spread mix. So it is a high requirement for the spray quality (Zhou 2011). The fuel injection spray process is very complex. As the fuel spraying into the cylinder, the processes of fuel bunch rupturing, the fuel droplets colliding and polymerizing, the fuel droplets running up against the cylinder wall, and the fuel droplets evaporating spread, all accomplish in tiny space and time scale (Xie 2005). The diameter and number are important parameters for the fuel injection system in the diameter. The diameter of orifice has a great influence on the fuel injection column shape, spray quality, fuel and air mixing state (Ma et al. 2008).

It is in favor of the fuel mixture formation to decrease the orifice diameter, but it will also prolong the injection duration, in condition of the same cam lift and the same injector open pressure. The average diameter and the heterogeneity of the fuel oil droplets increase, the injection flow rate increases, and the fuel oil injection duration is shorten, with the increasing of the orifice diameter (Jia et al. 2003). However, smaller orifice diameter improves the low speed performance, meanwhile leads worse emission of NO_X (Zhang et al. 2008). Therefore, the smaller injector orifice diameter is more advantageous to forming the injection rectangle. And the larger orifice diameter is benefit for reducing the diesel engine noise, vibration index and emission levels, with being in line with the ideal fuel injection law requirements of continuous acceleration injection until the quick broken fuel oil injection process at the end (Wang et al. 2012).

It is inclined to cause the fuel oil mist adhering to the cylinder wall and producing more soot with too few orifices. It causes higher temperature inner the cylinder and it is inclined to cause interference and overlap of the fuel oil bunch, thus producing more NO_X and soot, with too many orifices (Zhou et al. 2008; Ding et al. 2008; Wu et al. 2010; Zhou et al. 2008).

139.3 Simulation Model and Injection Process Analysis

LMS Imagine.Lab AMESim offers a complete simulation suite to model and analyze multi-domain, intelligent systems and to predict their multi-disciplinary performance. The software creates a physics based model of the system, which doesn't require a full 3D geometer representation. AMESim can be used to study the system or the components of steady state and dynamic characteristics. It adopts top-down modeling method to achieve the complex system being modularized and the abstract system being materialized. Now AMESim has been used to analyze the fuel oil injection performance for the injector in practice (Boudy and Seers 2009; Wen and Zhang 2010; Zeng et al. 2008).

The simulation model including physical model of mechanical motion and fluid movement is built according to the working principle of the injector. The model can mainly be divided into the volume unit, the movement unit and the leakage unit, in order to be convenient for analysis.

The concentrated volume of the injector is mainly in the nozzle, which is a pressure chamber formed by clearance between the needle valve and the valve body. In AMESim, the model of a conical poppet valve shown as in Fig. 139.1a is used to signify the needle valve, and simulate certain valve by setting corresponding structure parameters.

The movement unit of the injector points to the movement parts includes the valve body and the mandril. In AMESim, the models are as shown in Fig. 139.1b and c are used to signify the two components separately.

In order to signify the fuel oil leakage during the working process for the injector, a model shown as Fig. 139.1d is used in AMESim.

The model of diesel injector composed of the three units above and other necessary auxiliary components, which are as shown in Fig. 139.2. The model

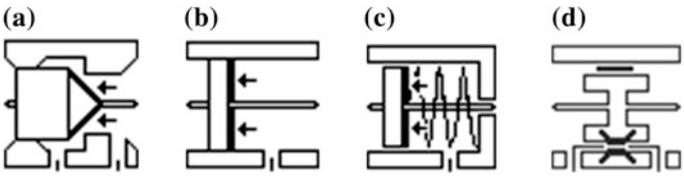


Fig. 139.1 Main model units of the injector. **a** Model of conical poppet valve; **b** Model of mandril; **c** Model of valve body; **d** Model of leakage unit

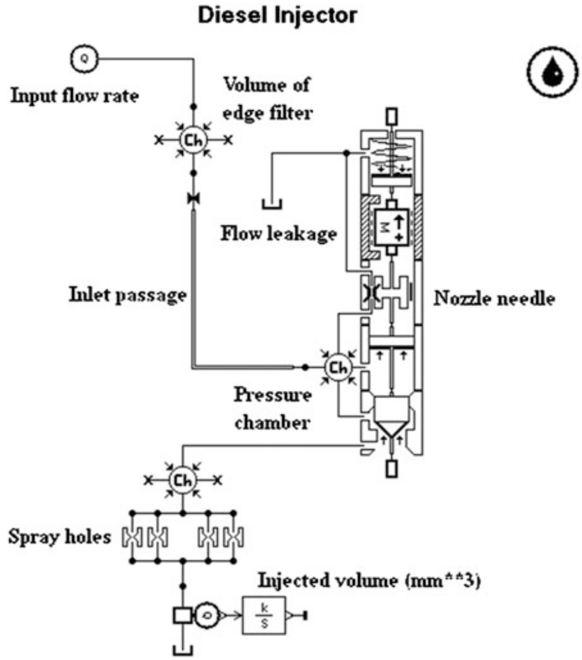


Fig. 139.2 Model of diesel injector

simulates with the hypothesis that the fuel oil in the inlet passage is to motionless at the beginning of the injection, because of stickiness force. That is the pressure in the whole injector and the density of the fuel oil to be equivalent. The simulation process computes a whole injection cycle, including the needle valve opening time, the fuel oil injection duration tine and the needle valve closing time.

The basic parameters are four orifices with the same diameter of 0.28 mm. Each parameter is set to basic parameter except the control parameter. In order to analyze how the orifices affect the injection performance, the model batch runs taking different parameter as control parameter respectively.

139.3.1 Analysis on the Injection Performance with Different Number of Orifices

Setting model with 7, 6, 5, 4 or 3 orifices respectively, the curves of each performance with different number of orifices are draw in the same graph.

The orifice number does not affect the injection time, but the injected volume is slightly more with more orifices. It exerts great influence on the change process of the injected volume. Usually, it takes shorter time to reach the maximum injected volume and finish the injection process with more orifices. However, the influence weakens after the orifice number increasing some value. The results are as shown in Fig. 139.3.

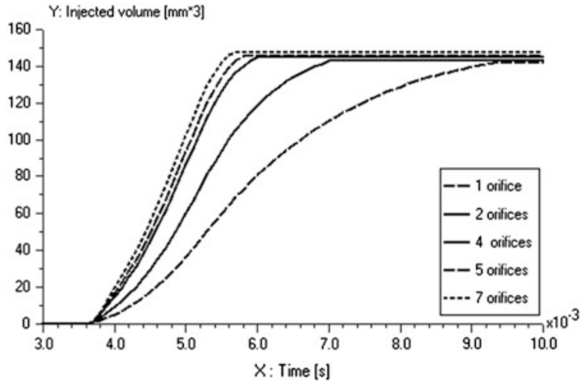


Fig. 139.3 Curves of injected volume with different number of orifices

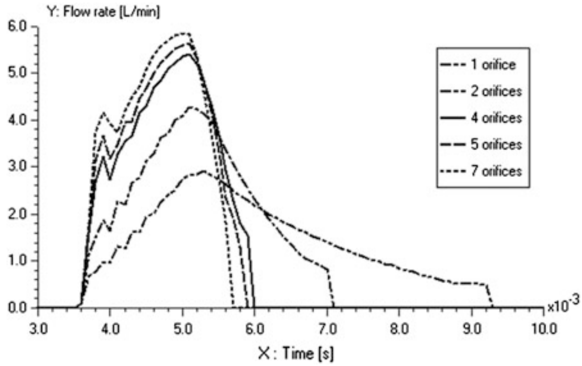


Fig. 139.4 Curves of flow rate with different number of orifices

The fuel oil flow rate reaches maximum rapidly and then drops to zero quickly with advisable orifice number, which closes to the ideal fuel oil flow rate curve. Meanwhile, too few orifices leads to increase slowly after the injection, keep short at the maximum flow rate, and take too long dropping to zero, which does not conform to the requirements that begins and stops supplying fuel oil to the combustion chamber quickly. The results are as shown in Fig. 139.4.

The needle valve rises following the law of slow first and then rapid, which also being an ideal state of the injector. The needle valve rises rapidly at start time and stays long at the maximum displacement. The results are as shown in Fig. 139.5.

139.3.2 Analysis on the Injection Performance with Different Needle Valve Diameter

Shown as the curves in Fig. 139.6, the beginning injection time is brought forward and the injection during time is longer with increasing of the needle valve diameter. That is because the pressure-bearing surface area of the needle valve increases with

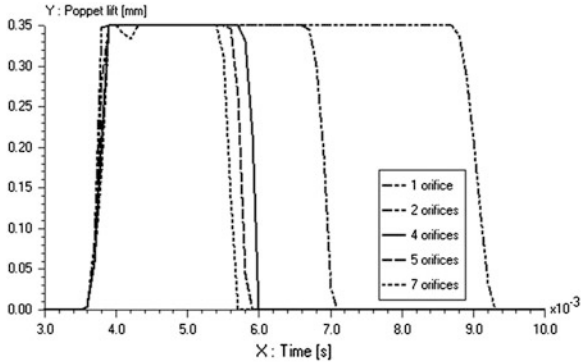


Fig. 139.5 Curves of the needle valve lift with different number of orifices

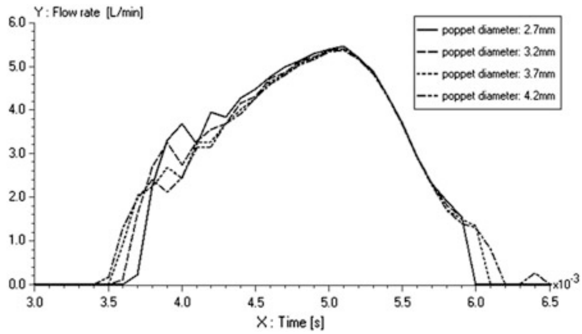


Fig. 139.6 Curves of flow rate with different needle valve diameter

the increasing of the needle valve diameter, which makes the volume in the pressure chamber decrease correspondingly. So the pressure in the chamber increases fast, and the needle valve opens earlier. The pressure falls slowly after the needle valve opening which makes the needle valve keep the maximum displacement for longer. At the end of the injection, the needle valve takes its seat quickly under the force of the spring preload, and the injection flow rate falls to zero rapidly. But too large needle valve diameter can make the pressure in the chamber fall slowly and produce pressure wave that exceeding the needle valve opening pressure at the time of the needle valve taking its seat, compelling the needle valve go up again as a result to generate a twice-injection. However, too small poppet diameter can intensify the volatility at the beginning injection time.

139.3.3 Relation Between Different Parameters

The effect of the orifice on injection performance is relevant to the orifice number and orifice diameter. With different diameter for each orifice, the injected volume and the injection flow rate computes as equivalent to convert the corresponding number of diameter of the same orifices in the model.

Fig. 139.7 Curves of the pressure at the orifices with different needle valve diameter

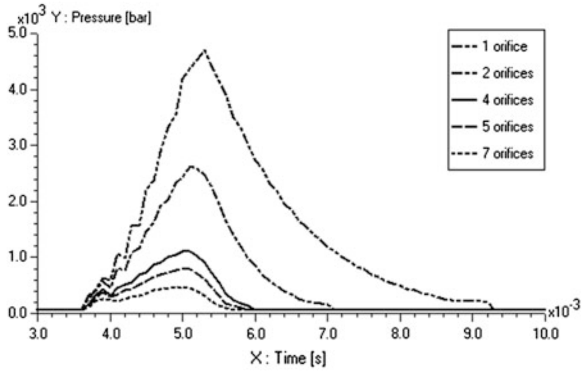
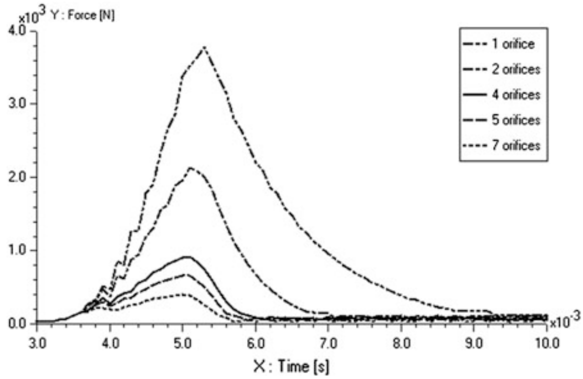


Fig. 139.8 Curves of the force on top of the needle valve with different needle valve diameter



Shown as the curves in Fig. 139.7 and 139.8, it is exactly the same form for the curves of the pressure at the orifices and the curves of the force on top of the needle valve. In other words, it will get same value with normalizing the corresponding data.

139.4 Conclusion

The simulation model of a traditional diesel hole-type injector is built up based on AMESim. By simulating an injection cycle with different needle valve parameters, and analyzing the effect of the orifice on the injection working process, the conclusions are given below:

(1) It computes fast and accurately by simulating the injection performance based on AMESim for the injector. And it offers important references for well matching with the engine, designing and optimizing the injector.

(2) The parameters such as the flow rate, the injected volume, the velocity and the lift of the needle valve, which character the injection performance. The parameters are not mutually independent but have inherence relations with each other. And they are coincident to each other. It is to examine how each parameter satisfies the diesel engine features in certain aspect that analyzes the curves of each parameter independently.
(3) The orifice number affects the duration of the injection process, especially with too few orifices to meet the requirement. The injection flow rate increases slowly at first, and drops to zero taking quite a long time after reaching the maximum value, which does not accord with the requirement of the instantaneous injection, shown as the movement of the needle valve that it residences too long at the maximal displacement, going against the throughout distance and the spray column cone angle meeting required values.
(4) The orifice diameter has little effect at the beginning of the needle valve opening, while has great effect on stopping supply fuel oil during later of the injection process.

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Chapter 140
Simulation and Optimization Analysis of a Wharf System Based on Flexsim

Na-qing Lin and Xiao-yan Zhai

Abstract From the viewpoint of production efficiency, a general cargo wharf system optimization analysis is discussed in this paper. Wharf of Huangpu Port is taken as an example. A simulation model of the general cargo handling system is built by applying Flexsim simulation technology, which simulates the real operation process of wharf once being run. Then the analyses on the system bottlenecks, problems and causes are carried out by figuring out the system output index such as throughput, equipment occupying rate, average stay time of truck etc., on the basis of which, a series of optimization approaches to solve the problems are proposed.

Keywords Flexsim · General cargo wharf · Optimization analysis · Simulation

140.1 Introduction

Modern logistics becomes important considerations in the government's "twelfth five-year plans", which emphasizes further improvement of transportation system so as to upgrade modernization level of coastal port groups, and which proposes further construction of organic links between railway, road, port, airport and city transportation in order to accelerate the development of comprehensive transportation hubs. Wharf logistics plays a critical role in goods' collecting and distributing, which once is optimized, large profit is at heel.

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E. Qi et al. (eds.), *The 19th International Conference on Industrial Engineering and Engineering Management*, DOI: 10.1007/978-3-642-38391-5_140,

Huangpu Port is located on the estuarine area of the Pearl River, in the southeast of Guangzhou City, which is a branch company of Guangzhou Port Group Co., Ltd. Its business involves import and export bulk and general cargo handling, storage and transportation. Taking responsibility of more than 60 % cargos collecting and distributing, General Cargo Wharf of Huangpu nowadays encounters some problems. Combining with research program of Guangzhou Port Business Management System Construction, a simulation model for the practical operation of general cargo wharf of Huangpu Port is built based on Flexsim technology. By running the 3D model, system bottlenecks are recognized. And then, a series of proposals are designed, which finally are validated by system simulation.

140.2 Status Quo of Huangpu Port and Wharf System Simulation

140.2.1 Problem Description

Throughput of Huangpu Port reaches more than 28 million tons a year. For the extensive economy hinterland, covering the Pan-Pearl River Delta region and trading relationship with more than 60 countries and regions, it is one of the important trade ports in South China. General Cargo Wharf is regarded as characteristic wharf of Huangpu Port. However, in the recent year, handling capacity is difficult for breakthroughs. 4 Problems are summarized as follows:

(1) Operation dispatching is based on experience management. Experience is accumulated by operation planners or instructors who work on their job for a long time, so that decision making is random and lack of scientific backing.
(2) Wharf service is simple, which mainly covers storage and transportation of domestic cargo business, especially cargo handling, storing and transportation of cargos in Pearl River Delta.
(3) Wharf information technology is in low level, and business process is slow. Most business data is collected and handled manually. For the wide varieties of cargo, bills of document are comprehensively delivered.
(4) Traffic jams occur frequently on the roads of wharf, which annoys customers, some of whom complain a lot of it and some of whom just stop further cooperation.

140.2.2 Building Wharf System Simulation Model

Flexsim is one of the most popular simulation software in the world, which contains technology of 3-dimensional image processing, simulation, artificial intelligence and data processing (Shi and Wang 2011), which is tailored to serve in manufacturing and logistics industry. In this paper, taking general cargo wharf of Huangpu Port as an example, a practical and visual wharf simulation system is developed for decision making of wharf operation by Flexsim simulation technology, which simulates wharf operation by importing real data and which outputs effective index to help managers recognize key problems and make good decision.

General cargos consist of steel, mechanical equipment, and cargos with packaging, among which, steel takes up more than 50 %. In this paper, steel is chose to be representative of cargos in the model. The equipments taken into use mainly include gantry crane, jib crane, fork lift and trailer. Most cargos arrive at wharf by water and leave by truck, in order to simplify the model, which is treated as the only way of cargo flow in this paper.

The main part of wharf operation system can be simplified as a queuing system of G/G/1. All the service wharf offers could be looked as service counter, and truck or ship are service targets (Gao 2011), while truck service would be the focus in this paper, which could be specified into detail service of truck scale, check-in and loading (Fig. 140.1).

Assume that λ is average arrival rate per minute, μ is the average service rate per minute, so that is

(1) The average minutes a truck spends on queuing

$$W_{\text{q}} = \frac{\lambda}{\mu(\mu - \lambda)} \tag{140.1}$$

(2) The average minutes a truck stays in the system comprises time of running (T_t), queuing and being served

$$W_s = T_{\text{r}} + W_q + \frac{1}{\mu} \tag{140.2}$$

(3) The rate if a truck arrives but couldn't be served timely and has to wait

$$P_w = \frac{\lambda}{\mu} \tag{140.3}$$

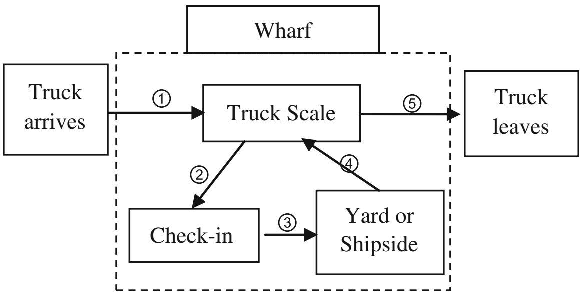

Fig. 140.1 Truck service process sketch of general cargo wharf from huangpu port

We can build a practical and visual wharf system simulation model by applying G/G/1 queuing mathematics model and Flexsim simulation technology.

140.2.3 Simulation Result and Analysis

By running the model for 7200 min (5 days), we can get the following data: berthing time of ship is 23.4 h; and if a truck carries 60 tons, wharf handling capacity is 3444 tons daily (Table 140.1). The counters of truck scale and check-in are too busy, particularly truck scale, busy at 98 % of time (Table 140.2); Vacancy rate of crane and fork lift is high, and there is large space for storage or other operation on the yard (Table 140.3)

The time a truck spends in the system includes running on the road of wharf, waiting for service and being served. Truck arrival time interval has Poisson distribution, and the average interval is 12 min. Assume that it takes 14 min for running on the road per truck. During 5 days, 287 trucks arrive, being served and leave, so that is

$$\lambda = \frac{1}{12} \approx 0.08$$

$$\mu = 287 \div (7200 - 287 \times 14) \approx 0.09$$

Plugging them into formula (140.1–140.3), we can get: it takes 134.65 min for a truck to queue for service; it takes 159.74 min for a truck to stay on wharf; and the rate that a truck arrives but have to wait for service is 0.92.

By investigation, we find that: Truck scale works for weighing and measuring for truck and goods on it, which then print a weight note for goods loaded on each

Table 140.1 Throughput of model 0

	Stay time	Average content	Input	Output
Entry road	4.40	0.35	449	–
Exit road	4.00	0.16	–	287

Table 140.2 Other data report of model 0

	Vacancy rate
Truck scale	0.02
Check-in	0.48

Table 140.3 Vacancy rate of equipment of model 0

	Gantry crane	Jib crane	Fork lift
Vacancy rate	0.65	0.95	0.94

truck. Truck license number and weight note number are typed by hand, the computer working for truck scale is aging and slow. Besides, there is little information sharing between truck scale and other departments including scheduling department and check-in office. The arrival truck must go for truck scale to have weight record of empty truck and then go for the check-in office. Check-in officer will check the truck's pick-up document and search for the corresponding release sheet and then keep record on the tally sheet when the truck is loaded. For all the documents are written by hand, it's troublesome to find the history record, which leads to average 10 min for truck check-in. All of these may result in traffic jams near truck scale system. By the analysis above, we can focus on the handling effectiveness on truck scale and check-in system. Proposals for optimization are as follows.

140.3 Optimization Analyses

140.3.1 Constructing Business Management System and Sharing Digital Information Between Departments

Taking advantage of the current strategy of Guangzhou Port for constructing business management system, upgrading the effectiveness of truck scale is attainable. In the business management system, it is necessary to bind weight note number with release sheet number. As a result, it's possible to get the tally sheet when weight note is printed. After check-in officer check the truck's pick-up document, the truck could go for yard or shipside for loading. In this way, the time check-in officer searching release sheet in a piles of sheets is removed. Truck stays for 2 min at check-in office, efficiency increasing 150 %. Faster computer is put into use for truck scale, the efficiency of which will raise 100 %. By modifying the corresponding parameter and running the new model again, we can get:

Truck arrival time interval is subject to Poisson distribution, arrival rate per minute

$$\lambda = \frac{1}{12} \approx 0.08$$

service rate per minute

$$\mu = 407 \div (7200 - 407 \times 14) \approx 0.27$$

Plugging them into formula (140.1–140.3), we can get: it takes 1.64 min for a truck to queue for service; it takes 19.33 min for a truck to stay on wharf; and the rate that a truck arrives but have to wait for service is 0.3.

Table 140.4 Handling capacity of model 1

	Stay time	Content	Input	Output
Entry Road	3.83	0.36	684	–
Exit Road	0.25	4.00	–	407

Table 140.5 Vacancy rate of equipment and gantry crane in model 1

	Gantry crane	Jib crane	Fork lift
Equipment in model 1			
Vacancy rate	0.44	0.84	0.83

Gantry crane in model 1

	1	2	3	4	5	6	7	8
Vacancy rate	0.35	0.59	0.34	0.59	0.30	0.65	0.27	0.43

We can see each index is improved. Handling capacity reaches 4884 tons daily (Table 140.4). For a truck carries 60 tons, and the system runs for 5 days, we can come up with throughtput_0 as follows:

$$throughtput_0 = 407 \times 60 \div 5 = 4884$$

The occupying rate of gantry crane, jib crane and fork lift are increasing 60, 240 and 217 % respectively (Table 140.5). So, promoting information technology arguably weakens the resistance from truck scale and check-in service on wharf operation while in the other way, it demands more equipment. If arrival interval of truck and ship are constant, truck can run without any obstacles and reach shipside. More and more trucks arrive at shipside, if the handling of gantry cranes is not effective, traffic jams would come up.

Therefore, we can conclude that model 1 can settle the traffic jams at a period of time, which improves the occupying rate of equipment as well as enlarges wharf throughput. However, when the handling capacity reaches a certain scale, equipments are too occupied. Model 1 is not effective any more. At this time, the planner should arrange more handling equipments so as to meet the demand of larger throughput.

140.3.2 Reengineering Truck Business Process and Improving Wharf Service Quality

(1) When the owner of cargo is applying for release sheet, he or she could apply for an IC card according to their own need. Truck arrives at wharf with IC card. At the truck scale, information of release sheet, weight note and cargo storage position could be called up by swiping IC card. Loading admission notice is printed and the information is also sent to scheduling department,

employees from which would dispatch operators to the corresponding storage position.

(2) After finishing loading, the truck returns to truck scale for loaded weight. Truck scale save the record and print exit admission note as well as tally sheet.

(3) Entrance guard checks the exit note and information on the business management system, if both match, truck can leave, and the truck business process is over.

In this process, it's unnecessary for the truck to check in. IC card is the certificate for picking up cargos. Business system identifies the validation of IC card, and recognizes whether there is stock, which would save the time for truck (Cao et al. 2009). And there is no need for check-in officer to keep record on the paper tally sheet, and then type in the system. Tally sheet is generated automatically. Modifying the parameter, running the new model, we can get:

After truck business process reengineering, there is no queuing phenomenon with throughput of 6252 tons daily (throughtput$_1$). For a truck carries 60 tons, and the system runs for 5 days, we can come up with throughtput$_1$ as follows:

$$throughtput_1 = 521 \times 60 \div 5 = 6252$$

However, the owner of cargo may take the cost of IC card into consideration, and compare it with cargo value, not all the owner choose to buy IC card. For the limit length, this paper discuss situation which is assumed that all the owners would purchase IC cards.

140.3.3 Assigning Wharf Equipments Reasonably and Increasing the Operation Efficiency

Along with upgrading information system, the handling capacity is increasing rapidly. New problems would come up if operation equipments remain the same number as before. For the limit of wharf resource, equipment should be dispatched in a reasonable way. At this time, scheduler can look at the data report of simulation model, and arrange more resource on the weakest link whose occupying rate is high. From report of model 1, the occupying rate of gantry crane 1, gantry crane 3, gantry crane 5, gantry crane 7 and gantry crane 8 are more than 50 % (Table 140.6). It's reasonable to add more gantry crane on the corresponding berth. For there are 13 gantries on the wharf and 5 of them are not taken into use. At this time, they work. Base on the designing of model 1, 5 gantry cranes are added. Modifying the parameter, a new model is designed, by running which for 5 days, we can get Tables 140.7 and 140.8.

By further improvement on Model 1, handling capacity (throughtput$_2$) can reach 6492 tons daily (Table 140.8). For a truck carries 60 tons, and the system runs for 5 days, we can come up with throughtput$_2$ as follows:

Table 140.6 Handling capacity of model 2

	Stay time	Content	Input	Output
Entry road	3.81	0.37	707	707
Exit road	0.28	4.00	521	521

Table 140.7 Handling capacity of model 3

	Stay time	Content	Input	Output
Entry road	3.97	0.38	684	684
Exit road	4.00	0.28	541	541

Table 140.8 Vacancy rate of equipments on model 3

	Gantry crane	Jib crane	Fork lift
Vacancy rate	0.54	0.84	0.83

$$throughtput_2 = 541 \times 60 \div 5 = 6492$$

Efficiency of wharf operation is advanced while the occupying rate of gantry cranes is reduced by 18 %. The road loads near water is decreased, but as handling capacity rises, the road to truck scale is inadequate for the amount of traffic, which makes it hard for truck to reach the shipside area. New problems occur again.

140.3.4 Expanding Wharf Function and Strengthening Regional Cooperation

According to modern logistics philosophy, traditional ports is going to be the center of cargo transport, collecting, appreciation, assembly and distribution, which control the speed cargo circulation (Li et al. 2010). Port logistics service quality does not only depend on the efficiency of handling, but more on the connection with its economical hinterlands. Approaches discussed above can settle wharf operation in a short time. Nevertheless, in order to achieve the long term profit, it‘s insufficient. After all, wharf system content is limited. In the context of constant land area, traffic jams are inevitable along with the increase of throughput.

In the long run, Huangpu Branch Company should seek to expand its wharf function and try to develop multimodal transport and other regional cooperation. Compared with traditional single means of transportation, multimodal transport consists of two or more transportation modes, which plays a vital part in reducing transportation cost and enhancing enterprises' competitiveness (Gao et al. 2010). Further more, in the wake of proposal for constructing and improving comprehensive transportation system, multimodal transport is highly promising. Huangpu

Port should make full use of its advantage from water transport and railway transport, which could reduce the loads of wharf in a wide range and attain cost advantage. It's a good way to strengthen regional cooperation and try to build a strong network connecting with waterway, highway, railway and skyway in order to embrace an encouraging future (Ding et al. 2010). In addition, Huangpu Port should reposition its wharf function. Through the analysis above, we can see that the yard space and yard equipments are not fully utilized. It's considerable to select proper cargo which are strongly connected with the economical hinterlands and offer supply chain service such as transportation between the upstream and downstream, distribution processing on the wharf yard etc.

140.4 Strategy Analysis

According to Model 0, when the throughput is 3444 tons per day, bottlenecks come up in front of the wharf logistics system operation. At this time, invoke model 1. It's a good way to solve traffic jams as well as handling capacity shortage by standardizing business system and reducing manual labor. When the throughput reaches 4884 tons per day, invoke model 2. Model 2 takes advantage from Model 1 and accelerates the handling efficiency in order to meet strong demand. Sources on wharf are so limited, which requires reasonable distribution in dispatch agency. Running the models, we can get indexes of operation, which are helpful to be the guide for distributing more sources to the weak part which index suggests that the vacancy rate is lower. When throughput becomes 6252 tons a day, the system encounters bottleneck again. However, we can still use the model to carry out the latter data analysis.

In this case, 80 % of cargoes are picked up directly from ship side by truck, 20 % of cargoes are picked up at the storage yards. And the utilization rate of storage yard is only 0.05 %. The service function of Huangpu Port remains in traditional handling-loading and uploading, which leads to insufficiency of storage yard and its equipments. The situation will be changed if Huangpu Port extends wharf service function (Hu et al. 2006). It is considerable to take full use of equipments and offer potential logistics service to customers. For example, with the help of source advantage and economic environment superiority, Huangpu port can provide warehousing, transit shipment and distribution, etc. In addition, highly dependency of road transportation is Huangpu's weak point. Assume the port area is constant, traffic jams will be inevitable result. Only when Huangpu Port expands new profit source (Chen et al. 2005), can it solve the congestion fundamentally. Huangpu port can have the aid from goodness on water transportation as well as train transportation and promotes regional cooperation (Huang 2012), which forms a strong system of seaway, road, and train as well as air network in order to make full use of wharf sources.

140.5 Summary and Outlook

The simulation model provided in this paper is helpful for schedule manager to make short-term decision. In the long run, Huangpu Port should make great effort to facilitate the construction of regional transportation network (Tang 2011), and carry out more regional operation. In addition, it should try to expand new service field, for example, make full use of its advantage and offer tailored logistics service for customers, select proper cargo and carry out supply chain service on the wharf area etc.

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Chapter 141
Simulation Design of Piezoelectric Cantilever Beam Applied on Railway Track

Hui Zheng and Fengjing Zheng

Abstract To achieve energy conservation, this paper optimized the size of piezoelectric cantilever applied on railway track. In this paper, by modeling the piezoelectric cantilever through ABAQUS simulation software, author calculated resonant frequency by modal analysis. Considering the characteristic of track vibration, the paper designed four kinds of piezoelectric cantilever beams for absorbing different vibration in various frequency bands.

Keywords Green design · Piezoelectric cantilever beam · Rail · Simulation

141.1 Introduction

In recent years, as wireless sensor networks widely used in rail transport, power supply of wireless sensor network nodes causes for concern. Now wireless sensor network node power supply is battery powered. Because of the limited life of the commonly used chemical batteries, they need regular replacement. So this way will bring a heavy workload, high cost and serious waste. For a large area of wireless sensor networks, such as roadbed monitoring, battery replacement is difficult. Therefore, the power supply and management of the wireless sensor network node problems are urgent to be solved.

At the same time, the train produces a large number of vibration energy during operation and radiant this energy by wheel-rail noise resulting in a lot of energy loss and noise. If we can use this energy for power supply of wireless sensor network nodes, We not only can solve the power supply of wireless network and will be able to achieve the purpose of energy saving and environmental protection.

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E. Qi et al. (eds.), *The 19th International Conference on Industrial Engineering and Engineering Management*, DOI: 10.1007/978-3-642-38391-5_141,

Now with the rapid development of electronic technology, the new ambient vibration energy of a piezoelectric vibration generation came into being. Compared to other micro-generation devices, piezoelectric self-generating device has a simple structure, no heat, no electromagnetic interference. Therefore, piezoelectric power generation device is widely used in different areas. Collecting the rail vibration energy with piezoelectric vibrator will be new ideas to solve this problem for wireless sensor network power.

141.2 The Mechanism of Piezoelectric Device Generator

Based on the piezoelectric effect of piezoelectric materials, piezoelectric materials produce the deformation because of the incentive and its surface will release of absorb charge, achieving the mechanical vibrations to electrical energy. Piezoelectric ceramic is cut into the harmonic oscillator with specific mechanical vibration, known as the piezoelectric vibrator. The core component of the piezoelectric generator is a piezoelectric vibrator, usually the main use of the piezoelectric vibrator first piezoelectric equations (Wang and Su 2011), namely:

$$\begin{cases} D = dT + \varepsilon^T E \\ S = s^E T + d^t E \end{cases}$$

where: D is the electric displacement, d is the piezoelectric constant, T is the stress, ε^T is the dielectric constant, E is the electric field, S is the strain, s^E is the elastic compliance constant, dt is the transpose of d.

Piezoelectric ceramic material shows the piezoelectric effect, when it is polarized. The external force applied to the piezoelectric ceramic material can cause its deformation, resulting in charge. Charge after storage will be able to load acting by circuit. Therefore, piezoelectric power generation device with the rational design will produce repeated deformation through the absorption of vibration energy environment to achieve the mechanical energy to electrical energy conversion. These devices can long-term supply power for the wireless network sensors, micro-power systems.

The piezoelectric generator modes depending on the polarization direction of piezoelectric materials mainly make use of d33 and d31 modes. d33 electricity generation mode stress and voltage direction are in the Z direction. The direction of external force and voltage are the same. Generally, circular piezoelectric vibrator use d33 mode, and d31 power mode collect vibration energy and achieve electrical energy conversion by making use of external incentives. The stress direction is in the X-axis direction, and the voltage is in the Z direction. The direction of external forces and the piezoelectric voltage is perpendicular. Rectangular piezoelectric vibrator use d31 mode, and the model structure are simple. Although d33 piezoelectric mode open circuit voltage is higher than the d31 mode, the d31 mode is much better than the d33 mode on the performance of the collected charge amount. The collection of environmental vibration of the piezoelectric power generation device mainly use in d31-mode (Chu et al. 2008).

141.3 The Theory of Piezoelectric Cantilever Vibration Power

Collection of environmental low-frequency vibration energy usually uses the inertia of the free vibration of cantilever beams piezoelectric oscillator. Cantilever support ways can produce the greatest deflection and supple coefficient with a lower resonant frequency. Cantilever has a very wide frequency range, the resonant frequency is from tens of hertz to several megahertz. Generating capacity of the power generation is weak, but it can generate free vibration. The vibration has longer duration and can be used to absorb the ambient vibration energy, to provide continuous supply of electrical energy. For the cantilever type piezoelectric oscillator, the output voltage U is:

$$U = \frac{3}{16} g_{31} E_p \left(\frac{t}{L}\right)^2 u$$

$$U = \frac{3}{4} g_{31} \left(\frac{L}{tw}\right)^2 F$$

where: g_{31} is the piezoelectric constant of piezoelectric material; E_p is piezoelectric modulus of elasticity; U is displacement of the cantilever free end; L, w, t respectively, the piezoelectric ceramic chip length, width and thickness; F the applied load of the free end.

141.4 The Structure of Piezoelectric Cantilever

The structure of piezoelectric cantilever is shown in Fig. 141.1. Piezoelectric ceramic wafer is affixed to the substrate, and the reduced frequency mass is attached to the free end of cantilever piezoelectric vibrator. The two parts constitute a spring mass system. The role of the mass is to reduce the natural frequency of the cantilever piezoelectric oscillator structure. Substrate acts as the lower electrode at the same time. The top of the piezoelectric ceramic wafer is covered with metal film as upper electrode. When the cantilever fixed end is excited by vibration, the cantilever will produce bending vibration up and down, causing the cantilever deformation and generate the charge and output voltage.

In this model, piezoelectric ceramics is PZT-5H. Substrate material is phosphor bronze. Structural parameters are in Table 141.1.

With the ABAQUS simulation software, through modal analysis, the piezoelectric cantilever structure of the first vibration mode is bending vibration up and

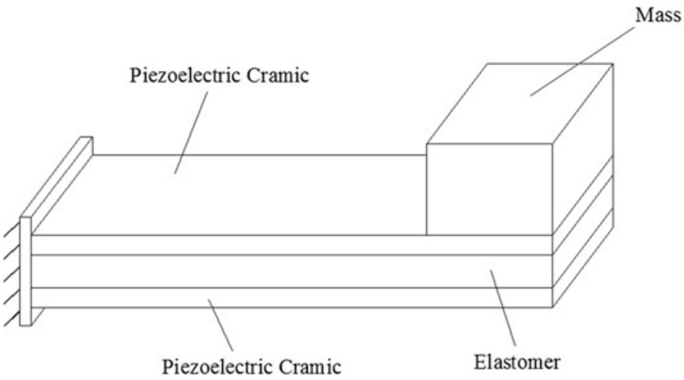


Fig. 141.1 The structure of piezoelectric cantilever

Table 141.1 Geometrical parameters of piezoelectric cantilever

Material	ρ/(kg·m−3)	E/G Pa	Poisson's ratio
Phosphor bronze	8920	106	0.35
PZT-5H	7500	61	0.31

down that meets the piezoelectric vibrator collection of mechanical vibration energy requirements. The author mainly study various natural frequency of piezoelectric cantilever. Though comprehensive consideration of resonance and generate electricity requirement, the author Optimized the structure of piezoelectric cantilever.

141.5 The Analysis of Track Vibration Feature

Track vibration is due to mutual collisions of the wheel and rail, when the train is running. In the propagation of the vibration, the high frequency part decays faster than the low frequency part of the frequency of the vibration which will change over distance. Horizontal vibration attenuates faster than the vertical vibration. Track vibration is complex synthesis of transverse, longitudinal wave, surface wave. Because this kind vibration is affected by a variety of complex factors, it's vibration mechanism and the communication pattern fluctuate. Therefore, only through a large number of measured data for statistical analysis to consider the combined effects of various factors can we get the feature of track vibration. GAO Guang-yun (Gao et al. 2007) tested Qinhuangdao-Shenyang passenger railway tracks vibration. The test results show that: rail vibration frequency is about 100 Hz, and in the 70–130 Hz the amplitude is relatively large. Based on this, this paper installed oscillator on rail base, shown in Fig. 141.2.

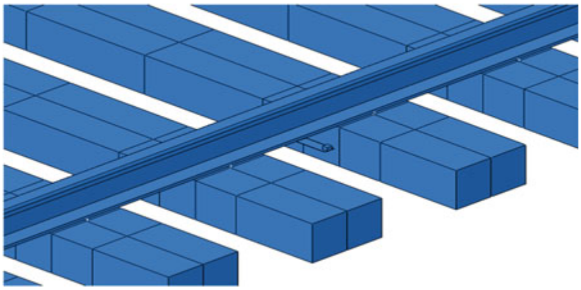


Fig. 141.2 Piezoelectric vibrator installation diagram

141.6 Structural Design

The output current of double crystal parallel piezoelectric oscillator is significantly higher than the output current of the single crystal and double crystal series (Qi et al. 2011), so system selects the parallel double-crystal cantilever piezoelectric oscillator shown in Fig. 141.1. Track vibration has a strong vibration response in a wide frequency range. In order to maximize the absorption of the rail vibration energy, the paper designs four piezoelectric cantilever structures to absorb the vibration energy of the different bands.

As we know that track vibration has relatively large amplitude in frequency range 70–130 Hz. Therefore, the resonant frequency of the cantilever structure preferably falls within this frequency range for the greatest degree of recovery of vibration energy. Frequency may be divided into 70–85, 85–100, 100–115, 115–130 Hz four sections; so we need four cantilevers, and their resonance frequency is just within the four frequency bands. Taking median principle, we get four target frequencies: 77.5, 92.5, 107.5, 122.5 Hz.

According to the structural characteristics of the piezoelectric crystal, thickness of piezoelectric crystal adopted in the paper is 0.1 or 0.2 mm. Taking into account that the track vibration acceleration is very large (about 100 g), the width is 20 mm in order to ensure the strength of the cantilever. According to the research (Liu et al. 2011), output voltage of piezoelectric cantilever beam decreases with increasing the length of the mass. Therefore, mass-length identified as the smaller 10 mm. Now we need to design four kinds of piezoelectricity cantilever with resonant frequency 77.5, 92.5, 107.5, 122.5 Hz. In order to ensure the strength and power requirements, we set the substrate thickness as 0.4, 0.6, 0.8 mm, and length is set between 60 and 80 mm. Mass not greater than 6 g.

(1) Modal Analysis

With ABAQUS simulation software, the paper models the cantilever beam and study the structure modal shown in Fig. 141.3.

By modal analysis, we get a variety of resonant frequency of the cantilever structure. When the thickness of piezoelectric crystal is 0.1 mm, the natural frequency of cantilever beam is shown in Figs. 141.4 and 141.5. (when the length of cantilever is 70 mm, the natural frequency is very low.)

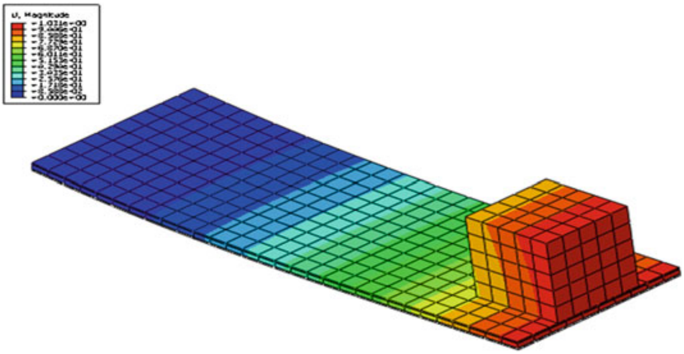


Fig. 141.3 First-order vibration mode diagram of the cantilever structure

Fig. 141.4 Length of piezoelectric oscillator is 50 mm, the cantilever vibration frequency

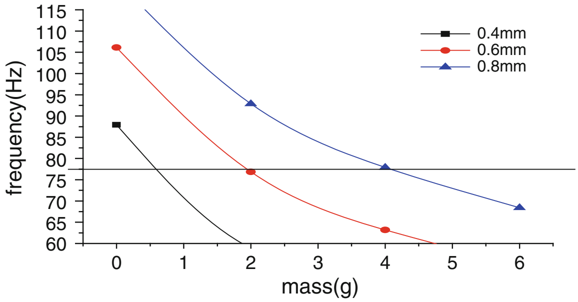
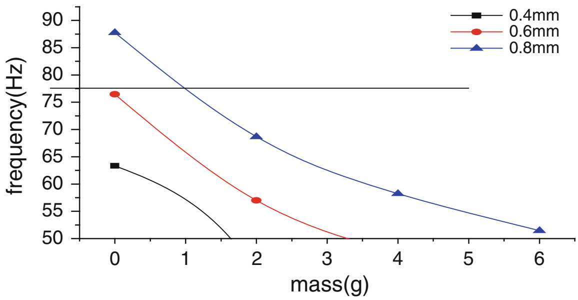


Fig. 141.5 Length of piezoelectric oscillator is 50 mm, the cantilever vibration frequency



When the thickness of piezoelectric crystal is 0.2 mm, the natural frequency of cantilever beam is shown in Figs. 141.6, 141.7 and 141.8.

From the above modal analysis, we can see that with the increasing in the length of the cantilever beam and the mass of mass block, the cantilever's resonant frequency will reduce. Base on this, we design the size of the cantilever.

Now we design a kind of cantilever which has a resonant frequency 77.5 Hz. First, we draw a line along the frequency 62.5 Hz in each map shown in Figs. 141.4, 141.5, 141.6, 141.7 and 141.8, then we get a point of proximity and ten points of intersection shown in Table 141.2.

Fig. 141.6 Length of piezoelectric oscillator is 60 mm, the cantilever vibration frequency

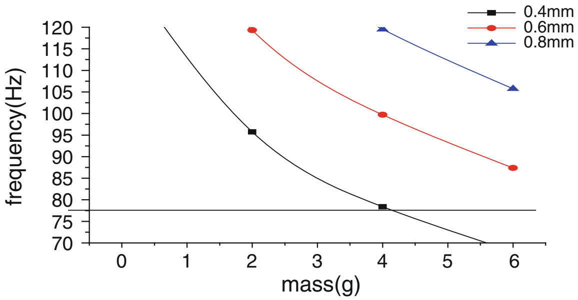


Fig. 141.7 Length of piezoelectric oscillator is 60 mm, the cantilever vibration frequency

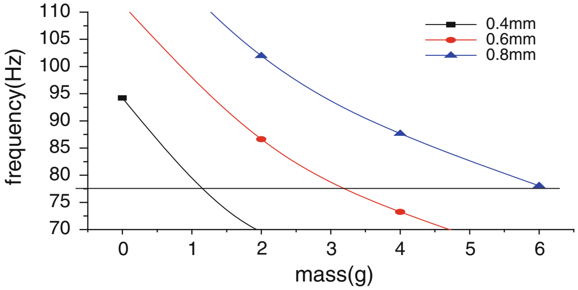
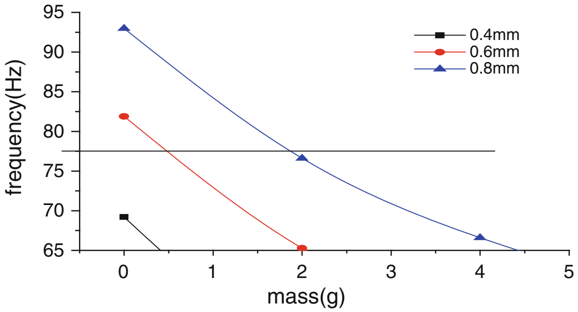


Fig. 141.8 Length of piezoelectric oscillator is 60 mm, the cantilever vibration frequency



According to the study (Shan et al. 2010), the output voltage of the cantilever will increase with the increase of the length of the cantilever. So compare program3 and program4, we choose program4. Compare program2 and program5, we choose program5. Compare program6 and program7, we choose program7. Compare program8 and program10, we choose program10. Compare program9 and program11, we choose program11. At the same time (Liu et al. 2011), the output voltage of the cantilever will increase with the decrease of the thickness of the cantilever. So Compare program4 and program5, we choose program5. Compare program10 and program11, we choose program10. Cantilever substrate material is phosphor bronze, the optimum thickness ratio of about 0.5 (Shan et al. 2010). So the thickness ratio of program5 is 0.33, and the thickness ration of

Table 141.2 Size chart of cantilever

Number	Length	Mass	Thickness of the piezoelectric crystal	Substrate thickness
1	50	0.6	0.1	0.4
2	50	1.9	0.1	0.6
3	50	4.1	0.1	0.8
4	60	0	0.1	0.8
5	60	1	0.1	0.6
6	50	4.2	0.2	0.4
7	60	1.2	0.2	0.4
8	60	3.2	0.2	0.6
9	60	6	0.2	0.8
10	70	0.47	0.2	0.6
11	70	1.8	0.2	0.8

Table 141.3 Size chart of cantilever

Number	Length	Mass	Thickness of the piezoelectric crystal	Substrate thickness
1	50	0.6	0.1	0.4
2	60	1	0.1	0.6
3	70	0.47	0.2	0.6

program7 is 1. Therefore, we choose program5. Finally, we get three programs as following Table 141.3:

For getting the optimal size, we further design of the structure. For getting the maximum output voltage, we assume that the mass is 0 in program1 and 2.

In program1, the mass, thickness of the piezoelectric crystal and Substrate thickness is 0.6 g, 0.1, 0.4 mm respectively. We assume that the mass is 0. The frequency is shown in Fig. 141.9:

From the figure, we can get the maximum length is 54 mm.

In program2, the mass, thickness of the piezoelectric crystal and Substrate thickness is 1 g, 0.1, 0.6 mm respectively. We assume that the mass is 0. The frequency is shown in Fig. 141.10:

From the figure, we can get the maximum length is 59 mm.

So for the cantilever with resonant frequency 77.5 Hz, we have three structures shown Table 141.4.

Now we build this three piezoelectric cantilever models, On condition that the acceleration being 10 m/s^2 and the vibration frequency being 77.5 Hz, ABAQUS simulation is used to conduct simulation. The result is shown in Table 141.5.

It can be seen from Table 141.5 that program3 can output the most voltage. So we choose program3 for absorbing vibration energy with 77.5 Hz.

Apply the same approach, we can find the other three the cantilever structure. Results are summarized in Table 141.6.

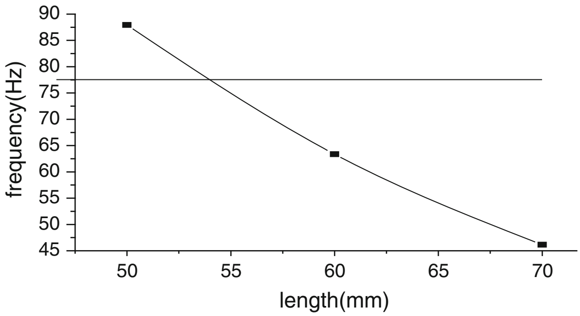


Fig. 141.9 The *curve* of frequency with length

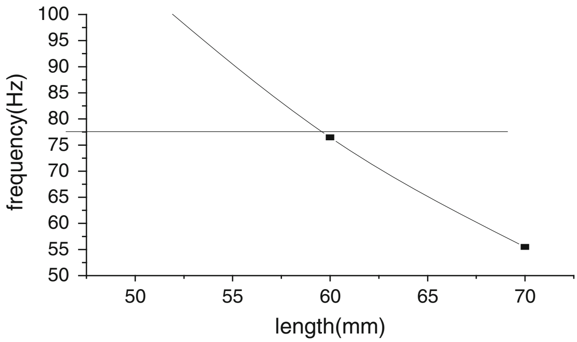


Fig. 141.10 The *curve* of frequency with length

Table 141.4 Size chart of cantilever

Number	Length	Mass	Thickness of the piezoelectric crystal	Substrate thickness
1	54	0	0.1	0.4
2	59	0	0.1	0.6
3	70	0.47	0.2	0.6

Table 141.5 The output voltage of three programs

Program number	Output voltage(V)
1	0.57
2	2.03
3	5.55

Table 141.6 Four kinds of cantilever structure

Length	Mass	Thickness of piezoelectric crystal	Substrate thickness	Resonant frequency
70	0.47	0.2	0.6	77.5
70	0	0.2	0.8	92.5
61	0	0.2	0.6	107.5
61	0	0.2	0.8	122.5

141.7 Conclusion

By modal analysis and orbital vibration characteristics analysis, a new design concept for designing piezoelectric cantilever size is suggested. After a comprehensive analysis, four kinds of cantilever beams matching track vibration characteristics were designed.

Acknowledgments This work was supported by the Natural Science foundation of Tianjin, China, unfer grant 10JCYBJC06800.

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Chapter 142
Simulation of Scenic Spots Dynamic Pricing Based on Revenue Management

Zhi-ping Duan, Shu-lian Yang and Fu-ping Zhang

Abstract The reasonable pricing of the scenic spots ticket involves many aspects, and it is a complicated and changeable process. In this paper, according to the idea of revenue management, scenic spot ticket dynamic pricing model is constructed, simulation calculation is performed by using particle swarm optimization ant colony algorithm. The simulation result shows that the dynamic pricing based on revenue management can bring more profit and this study will provide a scientific means for the scenic spots tickets pricing.

Keywords Ant colony optimization · Dynamic pricing · Particle swarm optimization · Revenue management

142.1 Introduction

At present, the scenic spot ticket pricing is muddledness and lack of scientific basis in China. "Comparison method" or "follow-the-leader method" is the common adopted pricing approaches by scenic operators. In this cases many scenic spots cannot reach the expected passenger flow volume, and economic benefit of scenic spots is influenced seriously (Lu et al. 2008). Revenue management is a set of system management ideas and methods, it makes the scientific forecasting and optimization techniques combine together with the modern computer technology organically and faultlessly, its core is based on market segmentation. Revenue

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E. Qi et al. (eds.), *The 19th International Conference on Industrial Engineering and Engineering Management*, DOI: 10.1007/978-3-642-38391-5_142,

management is to sell the right product to the right customer at the right time for the right price through the right channel, so as to achieve the maximum profit. In other words, revenue management is the art and science of predicting real-time customer demand and optimizing the price and availability of products according to the demand. This paper attempts to build the dynamic pricing model of the scenic tickets based on the idea of revenue management. The simulation calculation carries out by using the particle swarm optimization of ant colony algorithm, these works can provide scientific means for the scenic spot tickets pricing.

142.2 Revenue Management and Pricing Method

The revenue management area encompasses all work related to operational pricing and demand management. This includes traditional problems in the field, such as capacity allocation, overbooking and dynamic pricing, as well as newer areas, such as oligopoly models, negotiated pricing and auctions.

An American airline is considered the main pioneer in this field (Duan et al. 2008). Recent years have seen great successes of revenue management, notably in the airline, hotel, and car rental business. Currently, an increasing number of industries are exploring to adopt similar concepts (Nagae and Akamatsu 2006; Weatherford 1997).

Applying revenue management method to set ticket price is a typical market-oriented pricing. It depends more on the relationship between supply and demand rather than cost. Based on the EMSR (Expected Marginal Seat Revenue) theory, one ticket revenue equals to the ticket price and the probability of being sold if does not consider the cost.

The dynamic pricing method takes tourists willing pay (W_i) as the basis of setting price. We take the single scenic spot for instance, the scenic spot ticket price which the consumers can accept set forth as follows.

$$p_i = w_i = \int_0^{\infty} F(p, z) d_p$$

In the formula: p stands for the costs from the Starting point to the scenic spots, z stands for Socio-economic characteristics of the population. Because there are many consumers, the total revenue TR of the scenic spots is equal to the sum of different price that the consumers can accept.

$$TR = \sum_{i=1}^{n} p_i$$

142.3 Dynamic Pricing Modeling by Revenue Management Theory

Revenue management pricing method is the typical market pricing method, which reflects the game relation of interests of the tourists and the scenic spots in the market

Firstly, we suppose that the capacity of a scenic spots is M. The advance sales cycle is T. The price of each cycle keeps invariability at a period of time. If booking tickets 4 weeks advance and each week as a pricing cycle, then the cycle numbers are 4. Assume that the reserve price of visitors obeys a certain probability distribution $F(p)$ and it is changeless in the whole sales cycle, the sales price is p_t in each sales cycle, only when the reserve price is lower than the current prices tourists will buy the tickets, so the probability of a ticket been bought by an arrived tourist is $1 - F(p_t)$, thereby $D_t(p_t) = M_t[1 - F(p_t)]$ is the demand function of cycle t. Here M_t means the potential market size of the cycle t, the price p_t is the decision variable. The ticket revenue management of scenic spot aims to determine the optimal price for different sale cycle in limited sales cycles of $[0, T - 1]$, so as to make the total revenue of scenic spots tickets maximize. Dynamic pricing model can be expressed as follow.

$$Max \quad TR = \sum_{t=0}^{T-1} p_t D_t(p_t)$$

$$s.t \begin{cases} \sum_{t=0}^{T-1} D_t(p_t) \leq M \quad t = 0, 1, 2, \cdots, T - 1 \\ \alpha\bar{P} \leq p_t \leq \beta\bar{p} \quad t = 0, 1, 2, -1 \\ p_t \geq 0 \quad t = 0, 1, 2, \cdots, T - 1 \\ \alpha \leq \beta \\ \alpha \geq 0 \\ \beta \geq 0 \end{cases}$$

The first restriction shows that the total number of tickets can't exceed the maximum capacity of the scenic spot, and the second says that the price in each cycle cannot exceed a guiding price range providing by the state or department. α and β express the lower limit and upper limit ratio of price change .

142.4 The Solution Model of Particle Group: Ant Colony Algorithm

Because the analytical solution of model is difficult to get, so optimization algorithm are used to obtain the optimal solution. Traditional intelligent algorithm such as genetic algorithms have defects as slow convergence speed, easy to get into local optimal solution with combinatorial optimization decision problems (Tang et al. 2010). This paper adopt particle swarm optimization ant colony algorithm to obtain the solution model.

The ant colony algorithm was first proposed by Italian scholars Dorigo as a bionic intelligent optimization algorithm (Dorigo et al. 1996; Dorigo and Gambardella 1997). It aims to achieve the purpose of optimization by simulates the process of ants looking for the shortest path between food source and their nest and it has been applied to various engineering problems in recent years. It has the properties of distributed computing, strong enlightening, positive feedback, parallelism (Dorigo 1999). However, it is known that the result of ant colony algorithm relies heavily on the selection of algorithm parameters. If the parameter setting is not properly, it is very easy to cause many problems such as increased calculation, the slow solution speed, the long solution time and it is likely cannot obtain the optimal solutions.

It is just because of the shortages of ant colony algorithm, many scholars have proposed a variety of hybrid optimization algorithm for the improvement of the ant colony algorithm, using particle swarm optimization ant colony algorithm is one of them. For example, Li Shiyong and Wang Qing studied the extensive particle swarm ant colony algorithm for continuous space optimization (Shi-yong and Wang 2009), Yu Xue-Cai and Zhang Tian-wen applied multiple colony ant algorithm based on particle swarm optimization to solve the vehicle routing problem with time windows (Yu and Zhang 2010), Ye Rong and Zhao Lingkai studied the Localization Algorithm for Wireless Sensor Network Based on Ant Colony Optimization-Particle Swarm Optimization (ACOPSO) (Rong and Zhao 2011).

Particle swarm optimization ant colony algorithm was first suggested by Kennedy and Eberhart (Kennedy and Eberhart 1995). Compared to other evolutionary algorithms based on heuristics, the advantages of particle swarm optimization ant colony algorithm consist of easy implementation and a smaller number of parameters to be adjusted. Therefore, it has been widely employed for combinatorial optimization problems (Kathiravan and Ganguli 2007; Hetmaniok et al. 2012).

Based on above references, this paper applies the particle swarm optimization ant colony algorithm on the optimization of three control parameters (ξ, ρ, q_0), the solving procedure is as follows.

Step1: Particle swarm initialization, select n (n is the pricing cycle) particles randomly, every particle contains three parameters (ξ, ρ, q_0), here $\xi \in [1, 5]$ randomly, ρ and$q_0 \in [0, 1]$ randomly;

Step2: Ant colony algorithm initialization, place n ants containing only their parameters randomly on n nodes, according their respective variable value to solve fitness function value;

Step3: External loop calculator reset;

Step4: Internal loop calculator reset;

Step5: Perform ant colony algorithm on each ant containing respectively parameters (ξ, ρ, q_0), update pheromone;

Step6: If internal loop conditions are not met loop to step5, otherwise loop to step7;

Step7: Update local pheromone, record the results of each ant, update ξ, ρ, q_0 by ant colony algorithm;

Step8: If external loop conditions are not met loop to step4, otherwise loop to step9;

Step9: Output the optimal solutions.

142.5 Model Simulation

This paper takes QingDao LaoShan JuFeng scenic spot as an example, Laoshan scenic spot's seasonality is very obvious, winter has less tourists, so the present pricing of off-season is different from of busy-season. Assume that every April to October as busy-season, the pricing is 95 yuan/people, every November to next March as off-season, the pricing is 65 yuan/people. Take 4 weeks as a pricing cycle; by using matlab as a simulation tool, simulations are performed for off-season and busy-season respectively. Off-season starts from November and busy-season starts from April, 8 weeks data are used. The benefits of the dynamic pricing and the fixed pricing are compared. Simulation price in integer forms, simulation results show as Tables 142.1 and 142.2.

The simulation results showed that based on revenue management the dynamic pricing revenue are obviously higher than the fixed pricing whether in the off-

Table 142.1 Profit comparison for dynamic pricing and fixed pricing in off-season

Cycle	Fixed price (yuan)	Dynamic price (yuan)	Fixed price profit (yuan)	Dynamic price profit (yuan)	Income increased rate (%)
1	65	57	398580	417353	4.71
2	65	55	384215	402196	4.68
3	65	52	391365	408311	4.33
4	65	50	371280	387691	4.42
5	65	51	380510	396529	4.21
6	65	50	367575	382168	3.97
7	65	52	338000	351114	3.88
8	65	50	295295	306723	3.87

Table 142.2 Profit comparison for dynamic pricing and fixed pricing in peak-season

Cycle	Fixed price (yuan)	Dynamic price (yuan)	Fixed price profit (yuan)	Dynamic price profit (yuan)	Income increased rate (%)
1	95	91	1517340	1619305	6.72
2	95	92	1552965	1658101	6.77
3	95	95	1588495	1690476	6.42
4	95	97	1778780	1913612	7.58
5	95	102	1879480	2023260	7.65
6	95	100	1782675	1916910	7.53
7	95	96	1737835	1866956	7.43
8	95	94	1756930	1887294	7.42

season or in peak -season, and the peak-season revenue is obviously higher than off-season.it is mainly because of the number of visitors to the off-season is a lot less than peak-season, and the dynamic price for off-season are lower than the fixed price, but it is just the reverse for peak-season. The highest tickets price up to 102 yuan, and the time is just corresponding to the May 1 vacation. It denotes that, when there are less visitors one obvious way to win more customers would be to reduce the price. But the reality is the opposite in more tourists' conditions. In this way, the tourists flows have adjusted to a certain extent and the overall income will be always higher than the fixed pricing mode. The whole tourist routes of laoshan scenic spot up to six, the revenue management based dynamic pricing strategy will bring considerable income for scenic spots.

142.6 Conclusion

The revenue management theory is used for building the dynamic pricing model of scenic spots, simulation is performed by using the particle swarm optimization ant colony algorithm, the scenic spots income tends to maximize based on the existing by dynamic adjusting the tickets price. This will provide a scientific means for the scenic spots tickets pricing. However, the scenic spots ticket pricing is a complicated and changeable process, along with the change of ticket price, the consumption behaviour of the tourists will change accordingly. The further researches are very necessary for the more accurate demand forecasting and dynamic pricing.

Acknowledgments Financial support: National social science fund (11BJY121); The education ministry humanities and social science research project (09YA790128); Shandong province soft science research plan (2012RKB01209).

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Chapter 143
Study of Adaptive Noise Cancellation Controller

Cui-jian Zhao and Su-jing Sun

Abstract One important problem in the adaptive noise cancellation controller is responses feedback. This paper studies in the theory and proposes an improved adaptive noise cancellation controller, which is used spectral line enhancement. The simulation provides that the new cancellation controller was more efficient and had robust performance.

Keywords Adaptive · Noise cancellation controller · Responses feedback · Spectral line enhancement

143.1 Introduction

In the application of engineering, the most classical method for eliminating the noise from signals is Wiener filtering (Dai 1994; Shen 2001; Hassoun 1995). But design this filter must know the information of signals and noise. Begin from 60 years, with the developing of adaptive filtering theory, this problem becomes not so important (He 2002). Adaptive filter can set apart the signals and noises without information of them. Then, this technology was applied in many fields (Wu 2001). However, there are still two concern questions—interfered reference channel and responses feedback. These problems are both not solved satisfied (Haykin 1994; Zhang and Feng 2003; Jiang et al. 2001). This paper is mostly work over the question of responses feedback, and proposed a new improved adaptive noise cancellation controller.

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E. Qi et al. (eds.), *The 19th International Conference on Industrial Engineering and Engineering Management*, DOI: 10.1007/978-3-642-38391-5_143,

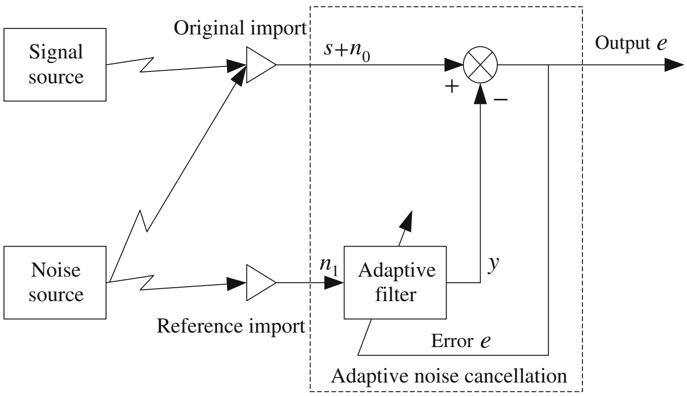

Fig. 143.1 Normal adaptive noise cancellation controller

143.2 Theory of Adaptive Noise Cancellation

Figure 143.1 is a normal adaptive noise cancellation controller (Yang and Zhou 1998; Larimore et al. 1978; Evinson 1946). It has two sensors. The signal will be add irrelevance noise n_0 when it was transported to the first sensor. Incorporate signal $s + n_0$ were transmitted to noise cancellation controller from “original import”. The second sensor accepted the noise signal n_1, which is irrelevant to signal but is relevant to noise n_0 with some way. The signal out from second sensor was called “reference import” (Doherty and Porayath 1997).

Suppose s, n_0, n_1, y are fixed in statistic. Their average values all are 0. s and n_0, n_1 are irrelevant, but n_1 and n_0 are relevant. The error of output is:

$$e = s + n_0 - y \tag{143.1}$$

If square formula (143.1) and get mathematic expectation. s and n_0, $n_1$are irrelevant, so:

$$\begin{aligned} E\left[e^2\right] &= E\left[s^2\right] + E\left[(n_0 - y)^2\right] + 2E[s(n_0 - y)] \\ &= E\left[s^2\right] + E\left[(n_0 - y)^2\right] \end{aligned} \tag{143.2}$$

Adjust the adaptive filter let $E[e^2]$ achieve the least. Because the power of signal $E[s^2]$ is not affected, $E[(n_0 - y)^2]$ will be the least. Ideal instance, $E[(n_0 - y)^2] = 0$. Then $y = n_0$, $e = s$, it indicate that the least power of output make output no any noise.

143.3 The Reasons of Responses Feedback and Solved Project

143.3.1 Reasons of Responses Feedback

In Fig. 143.1, the method of adjusting parameters of adaptive filter is similar to the steepest descent method, which is a kind of optimization algorithms. Actually, this method is use instantaneous gradient $\hat{\nabla}(k)$ instead of factual gradient $\nabla(k)$, namely:

$$\begin{aligned}\nabla(k) &= -2E[e(k)X(k)] \\ &= -2E\{[n_0(k) - W(k)^T X(k)]X(k)\}\end{aligned} \tag{143.3}$$

$$\begin{aligned}\hat{\nabla}(k) &= -2e(k)X(k) \\ &= -2s(k)X(k) - 2\{[n_0(k) - W(k)^T X(k)]X(k)\}\end{aligned} \tag{143.4}$$

While the formula of iterating weight is:

$$\begin{aligned}W(k+1) &= W(k) + \mu\hat{\nabla}(k) \\ &= W(k) - 2\mu e(k)X(k)\end{aligned} \tag{143.5}$$

When the adaptive filter converges to steady state, system output signal e(k) will be equal to the signal s(k). Then the weight will be changed based on the signal s(k). So it can said that the signal s(k) have feedback through adaptive filter. The next system output signal is affected by the frontal one. The formula (143.4) indicated that the instantaneous gradient $\hat{\nabla}(k)$ is added an error vector:−2 s(k)X(k), which should be equal zero. This will bring on surplus mean square error. Thereby, system output signal e(k) will different from input useful signal s(k). This will bring to distortion of signal, namely, responses feedback phenomenon.

143.3.2 Solved Project

The former Refs. (Zhen-ya He et al. 2000; Cichocki and Unbehauen 1996; Miller et al. 1990), adopted the method of variable step size algorithm commonly to counteract responses feedback phenomenon. This paper is based on another opinion to improve the iterating weight. Sequentially, it will weaken or eliminate the effect of responses feedback.

From (143.3)–(143.5) we can see that the surplus mean square error is accretion because of error vector −2 s(k)X(k), which exist in instantaneous gradient. Then the formula of iterating weight (143.5) will be rewrite:

$$W(k+1) = W(k) - 2\mu[e(k) - \hat{s}(k)]X(k) \tag{143.6}$$

where, $\hat{s}$(k) is the estimate value of input useful signal s(k). In ideal condition, $\hat{s}$(k) = s(k). Then the error vector will be eliminated completely from instantaneous gradient. Based on this theory, we designed another adaptive noise cancellation controller in the following text.

143.4 Improved Adaptive Noise Cancellation Controller

Based on the idea of above and adaptive spectral line enhancement, propose a new adaptive noise cancellation controller show in Fig. 143.2. It is composed of two parts, one is high frequency noise cancellation the other is low frequency noise cancellation.

In the first part high frequency noise cancellation, by the theory of adaptive spectral line enhancement we know, when the mixed signal get across the delay $z^{-\triangle}$, the output of adaptive filter 1 is only contain narrowband weight, if delay time is longer than the reciprocal of broadband bandwidth while shorter than that of narrowband. The cause is the continuance of narrowband autocorrelation is longer than that of broadband.

Then the reference input can be regarded as predictive estimate signal of error e_1. Use the difference e_2 to adjust adaptive filter 1 in order to cancellation high frequency noise.

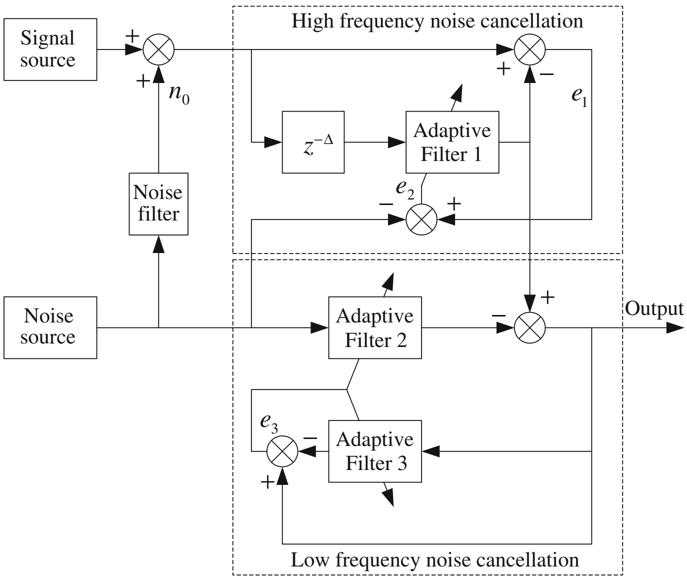

Fig. 143.2 Adaptive noise cancellation

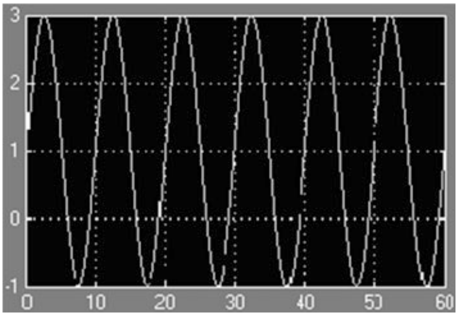

Fig. 143.3 Input signal

143.5 Simulation

In order to validate the validity of adaptive noise cancellation controller proposed in this paper, the following is simulation of it.

Input signal show in Fig. 143.3. It is composed of direct current signal and low frequency alternate current signal:

$$s(t) = 1 + 2sin(0.1t)$$

Noise signal is consisted of low frequency alternate current (narrowband) signal and stochastic (broadband) signal:

$$n(t) = 2sin(2t) + 0.5P(t)$$

In original import, the additive correlative noise n_0 is brought by noise source n, which is through a noise filter. Here we use nonlinear IIR filter (Zhang and Feng 2003), namely:

$$n_0(k) = n(k) + f(n_0(k-1))$$

Here:

$$f(n_0(k-1)) = exp\left(-(n_0(k-1)-1)^2/2\sigma^2\right)/2 \\ -exp\left(-(n_0(k-1)+1)^2/2\sigma^2\right)/2$$

Figure 143.4 shows this noise filter. σ^2 is 3. The mixed signal was shown in Fig. 143.5.

The result of common adaptive noise cancellation controller is show in Fig. 143.6. It effect is not so perfect. Figure 143.7 is the result of adaptive noise cancellation controller proposed in this paper. Compare Fig. 143.6 with Fig. 143.7, we can see that the improved adaptive noise cancellation controller is better than common one obviously. Its wave is much smoother, there are lesser burrs and their amplitudes are very small.

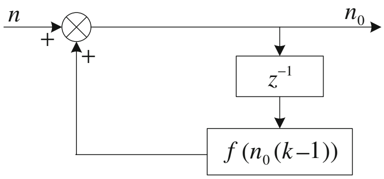

Fig. 143.4 Noise filter

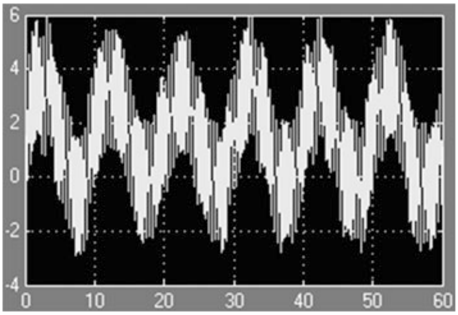

Fig. 143.5 Mixed signal

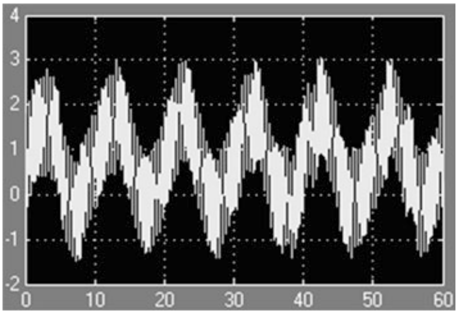

Fig. 143.6 Effect of common cancellation controller

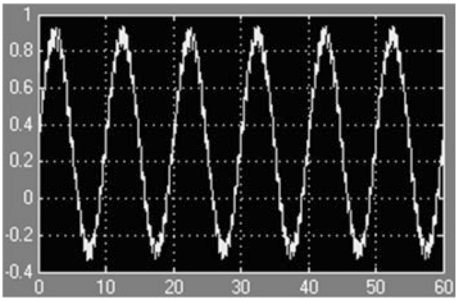

Fig. 143.7 Effect of cancellation controller in this paper

From the simulation we can see that the adaptive noise cancellation controller proposed in this paper can wipe off noise effectively, and the result is better than the common.

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Chapter 144
Study of Cost-Time-Quality in Project Failure Risk Assessment Based on Monte Carlo Simulation

Xing Pan and Zi-ling Xin

Abstract In order to analyze project failure risk, the quality factor, added on the basis of cost-time joint risk assessment, are showed by the degree of deviation and expressed by 2-norm firstly. Secondly, considering the cost-time-quality factors jointly, the joint distribution model of cost-time based on the Monte Carlo model is established; meanwhile, the definition of project failure risk value is given. Last, an example is given based on Program Evaluation Review Technique (PERT) to simulate and analyse project failure risk through Monte Carlo Simulation (MCS).

Keywords Cost-time-quality · Engineering project failure risk · Monte Carlo Simulation · The degree of deviation

144.1 Introduction

Management of project typically includes the three aspects: cost, time and quality (Oisen 1971). Project's goal is to achieve the expected quality performance requirement within the specified time and the approved budget. Cost, time and quality influence each other.

In 1996, Babu and Suresh adapted the continuous scale from Zero to One to specify quality attained at each activity. They developed the optimization models and presented an illustrative example (in press) (Babu and Suresh 1996). In 2006, Xu, Wu and Wang determined the conditional percentile ranking of the schedule (or cost) values with the integration method, which combined Monte Carlo multiple simulation analysis technique, regression analysis and statistical analysis (in press) (Xu et al. 2006). Gao, Hu Cheng and Zhong built the mathematics model of their

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E. Qi et al. (eds.), *The 19th International Conference on Industrial Engineering and Engineering Management*, DOI: 10.1007/978-3-642-38391-5_144,

synthesis optimization considering time, cost and quality (in press) (Gao et al. 2007). In 2009, XU Zhe, WU Jin-jin and JIA Zi-jun formed the marginal p probability distribution functions and the conditional p probability distribution functions about cost and schedule and analyzed the simulation outputs (in press) (Xu et al. 2009). In 2012, Kim, Kang and Hwang proposed a mixed integer linear programming model that considers the PQLC for excessive crashing activities (in press) (Kim et al. 2012). The main idea of Monte Carlo Simulation is to estimate the amount people interested in through simulating system reliability and risk behaviors randomly (Dubi 1998, 2000; Yang and Sheng 1990; Marseguerra and Zio 2000).

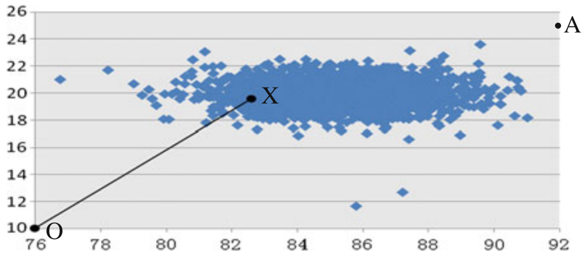
This paper builds the model with Arena the software and analyses the results with Excel to calculate the value of project failure risk, which relates to the knowledge of probability theory and MCS.

144.2 Quality Assessment of a Project

Quality has an important influence on the risk of project. In this paper, the author proposes a method to quantify the quality. The corresponding quality will gradually increase when cost and time are increasing, and vice versa reduced. The failure risk reaches the maximum when cost and time are smallest, which led to the minimum of project's quality. On the contrary, the failure risk reaches the minimum when cost and time are biggest, which led to the maximum of project's quality.

Figure 144.1 is a scatter plot of the cost and time data. Horizontal and vertical axes are the dimensionless cost C and time T, which are shown in the figure. $X(C_X, T_X)$ is a cost-time point of the project, $O(C_O, T_O)$ is the minimum value of all the data points, while $A(C_A, T_A)$ is the maximum. It shows that O and A defines the scope of cost and time value. Therefore, the quality of the project is defined as: the degree of deviation from the value point of project relative to the minimum of cost and time. Within the definition of deviation from the farther, the higher the quality of the project; deviation from the closer, the lower the quality of the project. The formula of any quality values in Fig. 144.1 are defined as follows:

Fig. 144.1 Cost and time scatter plot



$$Q_X = \frac{\|OX\|_2}{\|OX\|_2 + \|XA\|_2} \tag{144.1}$$

$\|OX\|_2$ and $\|XA\|_2$ are 2-norm, namely distance, of OX and XA, defined respectively as follows:

$$\|OX\|_2 = \sqrt{(C_X - C_O)^2 + (T_X - T_O)^2} \tag{144.2}$$

$$\|XA\|_2 = \sqrt{(C_A - C_X)^2 + (T_A - T_X)^2} \tag{144.3}$$

As seen above, quality of the project is quantitated with the numeral from 0 to 1.

144.3 Project Failure Risk Assessment

144.3.1 Cost-Time Joint Failure Risk Assessment Model

Assume simulation times $k = 1, 2, \ldots N$, $C^{(1)}, C^{(2)}, \ldots, C^{(N)}$ and $T^{(1)}, T^{(2)}, \ldots, T^{(N)}$ are the output results of the total cost C and time T from N times simulation. a_{ij} is the frequency of results which fall into the shaded area in 0. Then the joint probability distribution of the project in the region $\begin{bmatrix} C_1, & C_i \\ T_1, & T_j \end{pmatrix}$ is as follow:

$$F(C_i, T_j) = P(C \le C_i \cap T \le T_j) = \sum_{g=1}^{i-1} \sum_{h=1}^{j-1} a_{gh}/N \tag{144.4}$$

$\sum_{g=1}^{i-1} \sum_{h=1}^{j-1} a_{gh}$ is the cumulative frequency of shaded area in Fig. 144.2. So the joint failure risk probability is as follow:

$$P_{CT} = P(C_i, T_j) = P(C > C_i \cup T > T_j) = 1 - F(C_i, T_j) \tag{144.5}$$

144.3.2 Project Failure Risk Value

In this paper, considering the three factors of cost, time and quality, the failure risk value of the project is given by the following formula:

$$R_i = P_{CT_i} * Q_i \tag{144.6}$$

R_i is the failure risk value from the ith time of simulation, P_{CT_i} is the joint failure risk probability of cost and time from the ith time of simulation and Q_i is the quality value from the ith time of simulation.

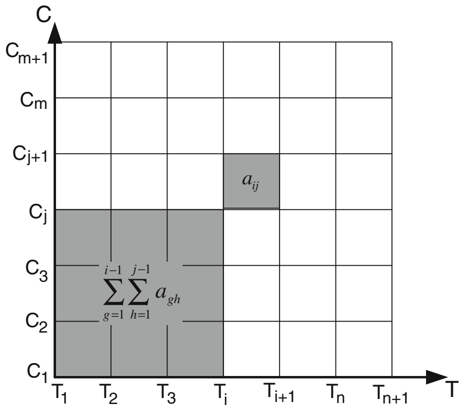


Fig. 144.2 Joint frequency statistics schematic of cost and time

144.3.3 Example of a Network Plan

(1) Example of Network Plan

This paper will combine a project network plan with nine activities (including a virtual activities) to analyze. Figure 144.3 is the network plan for the project.

0 is the data of cost and time from the activities of network plan. Assuming that the cost, duration and quality of the estimates from each activity are random variables, which subject to the triangular probability distribution $TRIA(a, m, b)$. A is the most optimistic value; m is the most likely value; b is the most pessimistic value (Table 144.1).

(2) Assessment of Project Failure Risk Value

Cost and time joint failure risk probability. The 2500 groups of output data from project cost and schedule simulation can be got through 2500 independent repeated simulation by software Arena.

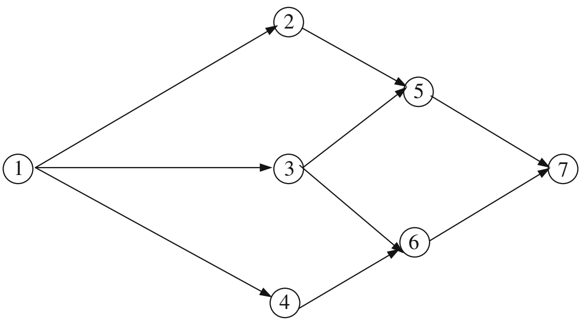


Fig. 144.3 Example of a network plan

Table 144.1 Network plan

Activity	Cost of activity			Time of activity		
	Good	Mode	Bad	Good	Mode	Bad
Begin node①	–	–	–	–	–	–
① → ②	5.1	6	8.4	2.55	3	4.2
① → ③	3.15	4.5	5.4	1.4	2	2.4
① →④	8	10	12.5	4	5	6.25
② → ⑤	7.65	9	11.7	4.25	5	6.5
② →⑤	0	0	0	0	0	0
③ → ⑥	10.88	16	19.2	4.76	7	8.4
④ → ⑥	13.87	19	25.65	5.84	8	10.8
⑤ → ⑦	11.68	16	21.6	5.84	8	10.8
⑥ → ⑦	3	4	5.2	4.95	6.6	8.58
End node ⑦	–			–		

0 is the results of data (Table 144.2).

The sample mean and standard deviation of cost and time can be got by statistical analysis. Both the frequency distribution for normality goodness of fit test, the test results show that the cost and time values follow a normal distribution. 0 is the frequency histogram of the results of cost and schedule outputs (Fig. 144.4).

The joint failure risk probability table can be got through statistics and computing, as shown in 0. Values in the table are the probability of project cost and time failure risk (Table 144.3).

Analysis of quality factor. According to formula (144.7) and formula (144.8), the dimensionless cost and time value are as follows:

$$C_i' = \frac{C_i}{\mu_c}, \quad i = 1, 2 \ldots n \tag{144.7}$$

Table 144.2 Simulation results

Results	Cost of activity			Time of activity		
	Good	Mode	Bad	Good	Mode	Bad
1 → 2	5.107	6.486	8.377	2.554	3.247	4.19
1 → 3	3.157	4.345	5.394	1.401	1.933	2.395
1 → 4	8.005	10.157	12.477	4.009	5.076	6.242
2 → 5	7.670	9.434	11.697	4.259	5.239	6.496
3 → 5	0	0	0	0	0	0
3 → 6	10.926	15.268	19.158	4.782	6.702	8.391
4 → 6	13.935	19.212	25.584	0	8.132	10.745
5 → 7	11.729	16.264	21.546	5.863	8.133	10.754
6 → 7	3.013	4.050	5.185	4.968	6.661	8.5642
Sum	63.541	85.216	109.418	27.836	45.122	57.778

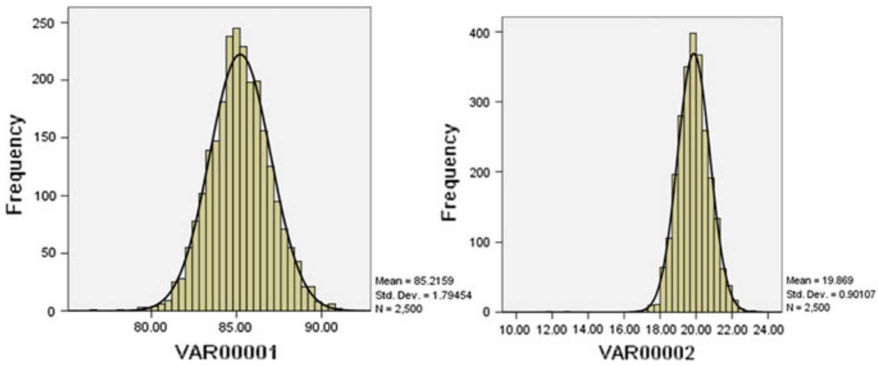


Fig. 144.4 The frequency histogram of the results of cost and time

Table 144.3 Joint failure risk probability

Total time value (M)	Total cost value					
	76	77	…	87	…	92
12	1	1	…	0.9996	…	0.9996
13	1	1	…	0.9996	…	0.9992
⋮	⋮	⋮	⋮	⋮	⋮	⋮
19	1	1	…	0.866	…	0.842
20	1	1	…	0.5132	…	0.4308
⋮	⋮	⋮	⋮	⋮	⋮	⋮
23	1	0.9996	…	0.154	…	0.0012
24	1	0.9996	…	0.1536	…	0

$$T_j' = \frac{T_j}{\mu_t}, \quad j = 1, 2 \ldots n \tag{144.8}$$

C_i and T_j are the cost and time value of the i and j groups of data. C_i' and T_j' are the dimensionless data. According to formula (144.1) to (144.3), the quality value of each group can be got. In this paper $C_O = 0.90$, $T_O = 0.59$, $C_A = 1.07$, $T_A = 1.19$.

Then we can get the ordinal position of each data after sorting the joint failure risk probability values from small to large. According to the formula (144.9), the location of the corresponding failure risk probability of the p-th confidence percentile value is determined, while the estimation of joint failure risk probability of corresponding confidence percentile can be got.

$$k = \text{int}\left[\left(\frac{p}{100}\right) * 2500\right] \tag{144.9}$$

For example, the 95th of confidence percentile data is located on k = 2375 order and the cost is 870,508 yuan with the time of 20.7264 months. The joint failure risk probability is 0.1568. 0 shows the 80th, 85th, 90th, 95th confidence

Table 144.4 Results of percentile estimates

Percentile estimates	Failure risk probability	Cost	Time	Quality
80th	0.39	85.02	20.11	0.70
85th	0.33	85.93	21.66	0.82
90th	0.23	86.72	20.81	0.76
95th	0.16	87.05	20.73	0.76

Table 144.5 Results of percentile estimates

	Cost	Time	Quality	C–T joint failure risk probability	Project failure risk value
1	81.17	23.06	0.83	0.9676	0.8021
2	81.67	22.01	0.79	0.968	0.7687
3	81.17	21.90	0.79	0.9688	0.7581
4	78.22	21.70	0.74	0.9988	0.7384
5	80.58	21.24	0.74	0.9908	0.7321
6	83.00	22.06	0.82	0.8968	0.7285
7	81.95	21.19	0.75	0.9688	0.7259
8	81.98	21.16	0.75	0.9688	0.7245
9	81.80	21.00	0.74	0.9688	0.7131
10	82.77	21.76	0.80	0.898	0.7118

percentile of the joint failure risk probability of cost and time, as well as the corresponding cost and time values (Table 144.4).

Project failure risk value. According to the formula (144.6), the project failure risk value of 2500 groups of data can be calculated.

0 shows the statistics results of randomly selected 10 groups of data (Table 144.5).

It can be seen from the above data that the quality factor, which has a direct impact on the failure risk of a project, cannot be simply ignored.

144.4 Conclusion and Discussion

Study of "risk" or "failure" but not "success" is a common method today. Project failure risk in engineering can be as low as possible to minimize losses by estimation of failure risk value.

This paper establishes a quantitative method of quality factors and gets the quality formula. Cost and time joint failure risk probability is estimated by Monte Carlo Simulation, statistical analysis and confidence estimation methods. Finally the project failure risk value can be calculated and analyzed by adding quality value.

The improvement of this paper is given as follows.

The quantification of the quality factor. As we know quality factor in the actual situation is very complex, whether which can be estimated by the formula is not known. The author tries to find a better quantitative method for quality.

The project failure risk value of cost, time and quality is not the joint probability value. So the next step is to study the joint risk assessment methods for the three factors of a project to better predict the actual situation.

Acknowledgments This work is supported by the National Natural Science Foundation of China under Grants No. 70901004/71171008 and the Fundamental Research Funds for the Central Universities.

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Chapter 145
Study on Innovation and Practice of Independent Auto Companies Lean Digital Factory Building

Yu-chun Wang, Li-fang Wang, Ze-yong Xu, Zhen-kui Li and Feng-qi Wang

Abstract Lean Thinking extracted on the basis of the lean production is a theory suitable for all industries, can prompt managers to rethink the business process, to eliminate waste and to create value. It has entered the various fields of design, manufacturing, logistics, procurement, sales and operations management so far. The digital technology is a key technology to realize the knowledge-based, automated, flexible enterprises and their rapid response of the market. It has now achieved good economic benefits in optimize the design, fault diagnosis, intelligent detection, system management, scheduling optimization, resource allocation and other aspects in various industries. In this paper, lean digital factory solutions is proposed, on the base of analyzing the problems of multi-production line, multi-plant, multi-brand, short cycle, low-cost and so on in a domestic independent car manufacturer, lean digital manufacturing framework model is built based on applications of the information technology and digital technology, advantages of lean digital manufacturing in creating value, improving resource utilization, enhancing the competitiveness of enterprises are verified through case studies, experience and effective measures of developing enterprises' lean digital manufacturing are prompted ultimately.

Keywords Lean · Virtual manufacturing · Simulation modeling · Structure model

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E. Qi et al. (eds.), *The 19th International Conference on Industrial Engineering and Engineering Management*, DOI: 10.1007/978-3-642-38391-5_145,

145.1 Purpose, Meaning and Research Status

The core of Lean Thinking is to reduce costs by completely rule out the waste. The lean, that is, be concise and economic, do not invest the extra factors of production, just at the right time to produce the necessary number of market need for product (or the next process urgently needed products) but all business activities must be beneficial and effective. Automotive manufacturing digital is a general term of applying digital technology to factory design and building, product process planning and actual manufacturing and management processes, increase manufacturing efficiency and product quality, reducing manufacturing costs, optimizing design and improving manufacturing processes through information modeling, simulation, analysis and information processing. It includes digital product definition (Product), digital process planning (Process), digital factory layout planning (Plan), workshop production of digital management (Production) and digital technology manufacturing resource (the Resource, including digital equipment (CNC machining centers, robots, etc.), tools, tooling and operators). Factories carry out a comprehensive digital activities are called Digital Factory. Factory lean digital is applying lean thinking to digital factory construction and operation, thereby creating products that meet user requirements: the right product, right time, right price, the right to meet user requirements. Lean digital manufacturing to achieve the overall upgrade in T, Q and C, T (Time) refers to the enterprises to continuously adapt to the international advanced enterprise product development speed to bring the fierce competition; Q (Quality) refers to quality improvements of the whole process from drawings to physical vehicles. C (Cost) refers to advancing late product design to the product development process, thus avoiding late design changes, repeated transformation and production preparation caused massive waste of the cost.

Research shows that digital technology has been widely used in many advanced domestic and foreign enterprises so far. Many research institutes and enterprises have adopted the digital factory program within different ranges like: CIM Institute of Shanghai Jiaotong University applied EM-plant and Deneb virtual factory simulation software in the technological transformation projects in the engine factory production line of Shanghai Volkswagen Automotive Co., Ltd.; digital factory platform is used as the digital base for aviation manufacturing enterprises in Modern Design and Integrated Manufacturing Technology Laboratory of the Northwestern Polytechnical University; In the aspect of production engineering and manufacturing process management, Tecnomatix company, a world leader, applied eMPower series of their software products including the industry's leading virtual factory simulation software eM-Plant (SIMPLE++) in factories of all sizes (and even large-scale multinational corporations) and the production line modeling, simulation and optimization of production systems; products' processes are verified by EM-Assemble software in the simulation assembly process of the early product development; U.S. Dassault has designed and built a car production line, cut in half than in the past with traditional CAD technology cycle; GM has applied

DENEB software to the luxury car factory assembly optimization design. These digitization projects have very good economic benefits (Liu 2002; Li et al. 2008; Zhai et al. 2004; Tecnomatrix Corporation Website (2013); http://www.longsea-tech.com/eMPower.htm; Liao et al. 2004; Beit-On 2002). Many domestic enterprises on the understanding and application of digital still at primary stage, the realization of digital manufacturing also need to invest a lot of time, personnel funding and more scientific, comprehensive planning (Shao et al. 2000; Pi 2002).

145.2 Digital Manufacturing Problems Faced by Autonomous Enterprises

FAW Car Co., Ltd. (hereinafter referred to as FAW Car) is one of the important independent enterprises, in “the 12th development strategy” implementation process, it is facing multiple challenges and pressures: (1) a number of production line and factories, including local factories, remote factories and overseas factories and so on; (2) Development and production of multi-brand (both co-branded and own brand) vehicle models; (3) short cycle-market competition requires companies to achieve rapid product development and mass production; (4) low cost - requires companies to fully identify the manufacturability of the product before the manufacturing, to avoid design changes at the later stage. With the development of the company, products are gradually updating and developing, market competition is requiring the company to adjust the structure, change the mode of production, change from manual to automatic, reduce design changes, respond to abnormal situations and solve resource waste and project tardiness problems.

145.3 Framework Model of Lean Digital Factory in Independent Auto Enterprises

In order to be able to survive in the intense global competition in the market and development, FAW Car have identified the strategic objectives of building a digital manufacturing system and have made the decision of changing original extensive growth mode: in early production preparation, extensively use virtual manufacturing software simulation and provide a reliable technology program basis for late production preparation; extensively use information network technology to construct multi-functional information systems to provide tools for the factory management and office automation, to ensure quality, schedule and cost optimization of the production preparation and volume manufacturing. Established a framework of lean digital factory model composed by one goal, two mains and two basics (as shown in Fig. 145.1).

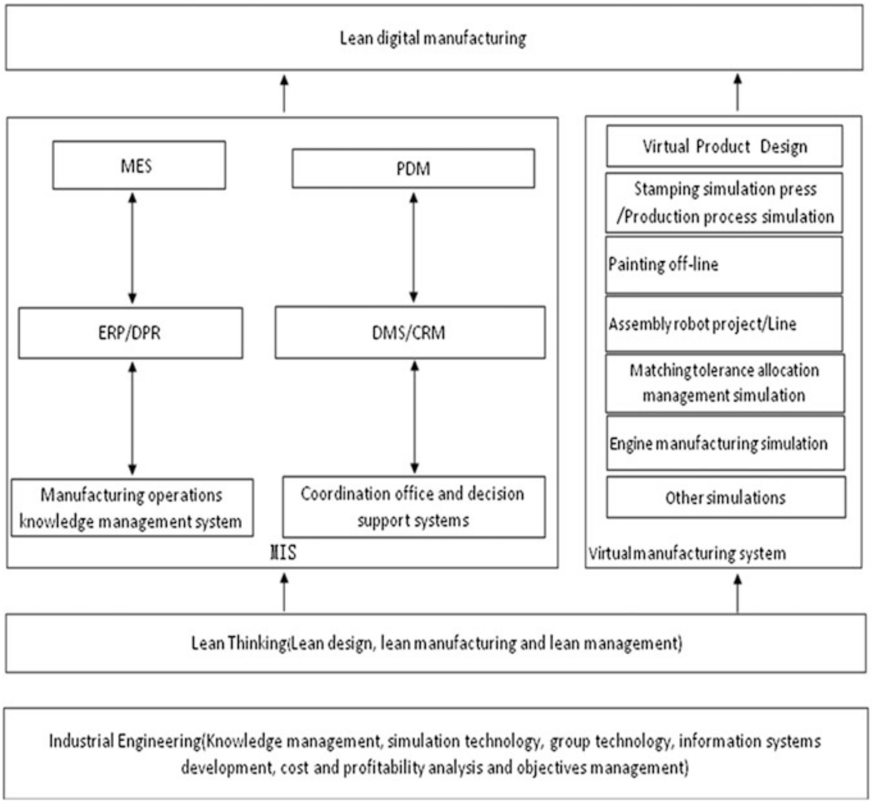

Fig. 145.1 Framework model of lean digital manufacturing

The one goal is to build lean digital manufacturing system for the overall objective to completely exclude the unreasonable waste; the two mains are management information system and virtual design and manufacturing system, they can achieve and enhance Lean Thinking and industrial engineering, including: (1) digital Lean design and manufacturing (include 1, virtual product design the process is Product Design-CAE Engineering Analysis-CAE Process Analysis—virtual product testing; 2, process virtual evaluation and simulation, includes process simulation of stamping, welding robot simulation with the logistics simulation, painting and offline programming, assembly ergonomics and the logistics simulation, matching tolerance allocation management simulation engine machining and manufacturing simulation; etc.), (2) informational lean management and manufacturing (the development of management information systems, such as MES production control systems, ERP/DRP Enterprise Resource Management system, PDM collaborative development and management system, the DMS/CRM dealer customer relationship management systems, production operations, knowledge management systems, collaboration and decision support systems, realized the informationalization, networking and platform) make lean, IE and IT able to penetrate and throughout the corporate culture, management and operational process. The two basics are Lean Production and Industrial Engineering, they are the guiding ideology for the two main's formation and enhancement, they can be deeply applied in various fields to form the lean design, lean manufacturing and lean management. The core of the industrial engineering is the TQC, it is theory methods, tools and means of Scientific, rational planning and management of manufacturing systems, the technologies usually used are the study of methods, plant layout, knowledge management, simulation technology, digital, group technology, information systems development, cost and profit analysis, organizational studies, matching production, inventory control and analysis, the planned network technology, value analysis, work measurement, objectives management and so on.

145.4 Lean Digital Manufacturing Cases

To ensure effective establishment of lean digital manufacturing systems, FAW Car has researched the latest technology in terms of enterprise information management, product design, manufacturing technology, logistics management and quality management at home and abroad the latest technology research, deeply used CAE, database, network technology, information technology and virtual simulation technology in various fields and has achieved remarkable results. There are many successful cases in the product design, stamping, and welding technology, and logistics planning (Fig. 145.2).

145.4.1 The Application Case of Information System in Stamping Operation

The main production materials of mass production of stamping are the mold, equipment and plates, production process embodies the salient features of the downtime, causes and data volume. Since 2010, FAW Car stamping plant started building the production and operation of information technology knowledge management system model (Fig. 145.3) based on lean thinking, knowledge management methods and production operations management experience accumulated over the years. The model is divided into three levels: data management, information management knowledge management, specifically divided into building "working platform", forming "business experts" and "management consultant". The stamping operation of knowledge management system information platform including daily management of production, management of production data statistical analysis, mold management, problem management,

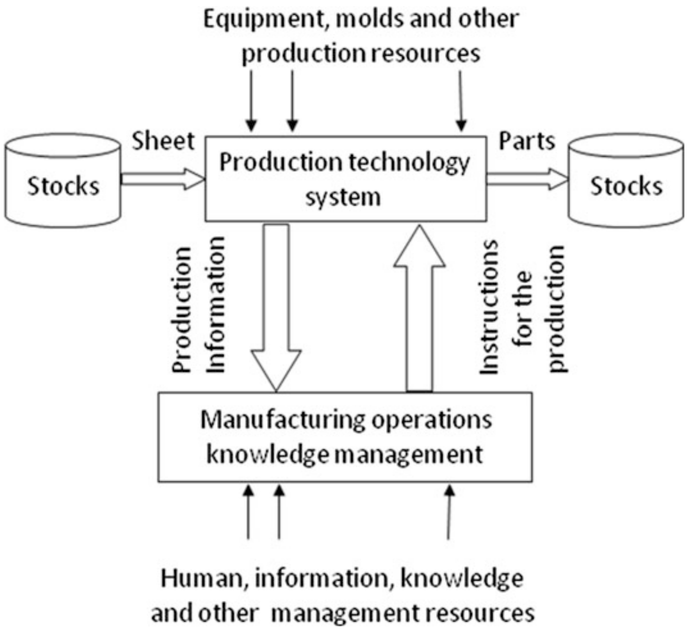

Fig. 145.2 Stamping plant production information system built schematic

Fig. 145.3 The first program plan of floor hand-line

production planning and inventory management and other information management modules integrated the business and management processes in stamping plants has been completed and used.

Since the use of information systems, mold downtime has decreased by 3.3 % in 2010–2012, comprehensive and effective stroke has enhanced 0.4 times/min, monthly reduced by an average waste 80.

In the process of development and use of the information platform, trained workers in workshops for using the system 40 times, improved the management process, optimized, cured the process more than 50 simultaneously, standardized shutdown description, analysis, and measures more than 500 languages, accumulated mold problems, downtime analysis more than 1,000, determined the core business of the stamping plant, provided a platform for business accumulation and inheritance of the workshop, provided support for the workshop Lean Production Management.

This case illustrates that using means of information in the manufacturing of the product management process can effectively improve work efficiency, reduce waste, the accumulation of the core business, improve the quality of staff to ensure the high efficiency and low-cost of the production run.

145.4.2 *The Application Case of Digital Manufacturing in Welding Technology and Logistics Planning*

FAW Car began to apply digital simulation technology to welding technology and logistics planning, the software included ProcessDesigner (process planning) module, ProcessSimulate (process simulation) module, Plant (Logistics Simulation) module and RobCAD (simulation and offline programming) module. Planning 2 factory welding shop production capacity of 200,000/year, continuously and randomly product more than four models. So, digitally simulate various welding technology programs. The typical case is floor welding logistics simulation and verification.

Process plan improved by technology personnel is shown in Fig. 145.3, A and B are front and rear floor cache areas, the simulation showed that if the location appliances are manually dragged to D area, workers' work load is moderate (balanced production of 50–70 %, the limit case in 70–85 %), the plan is reasonable (Fig. 145.4).

This case illustrates that, if digital factory technology is applied to welding technology and logistics design, the process and logistics design could be optimized, labor efficiency could be improved and the waste of workshop's reform in production could be reduced.

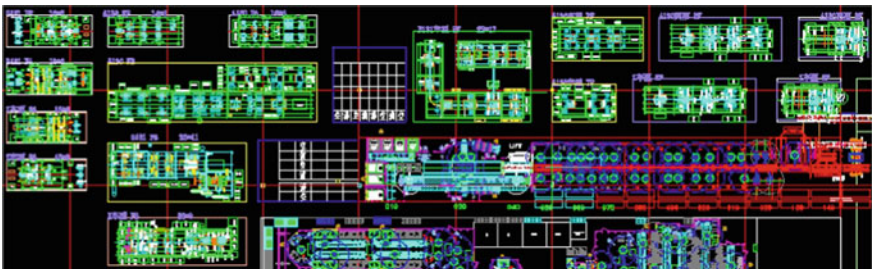

Fig. 145.4 The developed program plan of floor hand-line

145.5 Effective Way to Construction and Innovation of Lean Digital Manufacturing System

145.5.1 Lean Thinking is the Basis of Lean Digital Manufacturing System

FAW Car's rapid development process, first of all, is the process of learning and developing lean thinking, it established a philosophy of "to be correct at the first time", pursued "zero defect", took "customers first" as the origin and manufactured first-class products. Companies to make a profit, must have a long-term strategic vision, focus on investing in new technology and talent training, thereby, could reduce design, manufacturing defects and thoroughly eliminate wasteful aspects, guarantee mutual benefit among businesses, employees and partners. FAW Car takes lean thinking and digital factory building as part of the strategy "to create one million international passenger cars business units", enhances independent innovation and system capacity, shifts from extensive management to fine management, shifts from "Fuzzy management" and "chaos management" into a "precision management".

145.5.2 Integrated Innovation is the Only Way to Achieve Lean Digital Manufacturing

FAW Car's principle is "self-development, open and cooperative", Began to build self-management mode—Red production system (that is, of HPS, the Hongqi Production System) from 2007, lean thinking was extended from the production management to all areas of product development, quality control, procurement, technology, logistics, and production organization, therefore, all parts played a synergistic effect, the brand premium and the ability to support the one million-scale system are enhanced continuously. FAW Car belongs to the main body of the international auto market, only to constantly summarize and analyze its own deficiencies and problems, capacity and conditions it should have, speed and objective to fill the gaps, to unify ideas, to open minds and to strive to build lean digital factory, in an open competitive environment, to develop self-development on the road, can it achieve survival, be solid, stronger and bigger.

145.5.3 Step Implementation is the Effective Guarantee of Realizing Lean Digital Manufacturing

The FAW Car did not have a digital plant technology capability before and could only rely on products partners the MAZDA to complete large-scale production line process planning (such as welding and assembling the M1, M2 production line planning), controlled technology resulted in very high manufacturing costs. "Independent" determine the characteristics of the FAW Car can not completely copy the digital factory technology of advanced foreign enterprises, therefore, the "Digital manufacturing" could only be divided into different areas, different stages and different degrees to be planned, implemented, and ultimately to achieve the generalization and integration of various fields of information transmission, use and management of the manufacturing system. The TECNOMATIX/eMPower body planning systems and logistics planning systems were introduced, completed modeling of the "digital manufacturing", establishment of work ideas, technology library architecture design, repository architecture design and other preliminary works in the first stage; The second stage was the "digital manufacturing" island style applications, gradually improved the "digital manufacturing" system functions and processes to create the conditions and lay the foundation for realizing the following "digital" planned projects. These two stages have been completed. In the third stage, data management platform will be unified, the digital factory software applications proficiency, through technology of island and network technology in all areas will be strengthened, accordingly, will the interfaces and sharing will be realized.

145.6 Conclusion and Prospect

In this paper, the importance of FAW Car Digital Manufacturing System is illustrated on the basis of the model and cases, useful lessons are provided for other auto manufacturers: (1) lean ideas, information and digital technology is an important means for the auto enterprises to promote product updates, develop production and improve the international competitiveness; (2) lean digital manufacturing system is the effective guarantee to ensure multiple production lines, multi-plant, multi-brand, short cycle and low-cost production; (3) if independent auto enterprises carry out comprehensive lean digital factories, it will continuously promote the enterprise economic growth mode to transfer from extensive and technology-introduction type to intensive and innovation type; (4) enable enterprises to achieve 4 development through lean digital manufacturing system: efficiency is continuously increased, cost is continuously reduced; quality is continuously improved; ability is continuously increased; the system's core ability is enhanced, the core competitiveness of enterprises is formed, its own excellent is built.

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Chapter 146
The Application of Kernel Estimation in Analysis of Crime Hot Spots

Yan-yan Wang, Zhi-hong Sun, Lu Pan, Ting Wang and Da-hu Zhang

Abstract In order to analyze crime hot spots, we use Kernel estimation. The choice of Kernel function and Band-width is critical in kernel density estimation, which decides the accuracy of the estimation. We choose Gauss kernel and further obtain the optimal Band-width in the sense of square error MISE. Using Kernel estimation, not only can we calculate the density of crime in the region, but also accurately show the areas with the relative high-crime density and get the maximum point according to the information about the previous criminal spots. Last we use Kernel estimation to predict Peter Sutcliffe "the Yorkshire Ripper" 11th criminal location based on the previous criminal locations in the Serial murders. Finally we can get the range of the criminal hot zone: Longitude: 53.6875–53.8125 N; Altitude: 1.775–1.815 W. In fact, the coordinate of Peter's 11th criminal location is (53.817 N, 1.784 W). From this, it can be seen that our estimation is relatively accurate.

Keywords Band-width · Crime hot spots · Kernel estimation · Kernel function · MISE

146.1 Introduction

In space, the phenomenon of high concentration of crime naturally will be related to the expression of crime hot spots in the map (Rossmo 2000). In the process of crime mapping, the text address of crime hot spots by geo-coding can be changed

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E. Qi et al. (eds.), *The 19th International Conference on Industrial Engineering and Engineering Management*, DOI: 10.1007/978-3-642-38391-5_146,

into the coordinate point. Criminologists observe the spatial distribution of crime, such as gregariously, regularly, discretely or randomly. Through the analysis of crime hot spots, we can look for the gather place of Point group and the identifiable range, further understanding the formation reasons and its possible impact. The commonly analysis methods in the crime hotspots are Grid-counting Method, nearest neighbor distance Method and Moran's I way. The advantage of Kernel estimation method is to regard crime space as a core site. Not only can we calculate the density of crime in the region, but also accurately show the areas with the relative high-crime density.

146.2 Model

Rosenblatt and Parzen proposed a very important estimation—Kernel Density Estimation, which is a kind of non-parametric density estimations (Chen 1989). The characteristic is that there is not a definite function form and we cannot calculate density function without parameter. In the K-means, a kernel function (probability density function) (Venables and Ripley 2002), used to indicate the spot distribution in the neighborhood, is set at each data point. The density function of the point in the spot can be regarded as the total contributions of known point's kernel density, which is made by all the given points to the point (Lai 1996). Therefore, for any point X, the contribution law made by the given point X_i not only depends on the distance from X to X_i but also on the shape and the span of the kernel density (Band-width) (Worton 1989).

Definition 1 Suppose $X_{1,}X_2, \cdots, X_n$ are the samples of X, which are subject to $f(x)$. Let us define the function as

$$\underset{h_n}{\hat{f}}(x) = \frac{1}{nh_n}\sum_{i=1}^{n} K\left(\frac{x - x_i}{h_n}\right) \tag{146.1}$$

It is called K-means of the density function $f(x)$.

$K(.)$ Kernel function is a preset probability density function, in which the Bandwidth is h_n and n is sample size.

146.2.1 Selecting Kernel Function

In estimating the density function about X, let us suppose each sample, just like a small irradiative light bulb, serves X, the function of which is related to the distance in a certain sense (situation) from sample X_1 to X_n, i.e., the farther the distance, the weaker the light intensity. When it is taken into the consideration, the kernel function should be chosen according to the distance from X to each sample X_i, which decreases with the growing distance. The kernel function $K(x)$ is insensible to $\hat{f}_{h_n}(x)$, therefore each kernel function with satisfying conditions is suitable. Kernel function is symmetrical about the origin and satisfies $\int k(\mu)d\mu = 1$. Epanechnikov kernel, Bisquare kernel and Gauss kernel are in common use (Silverman 1986). We might as well suppose

$$K(x) = \frac{1}{\sqrt{2\pi}}\exp\left(-\frac{x^2}{2}\right) \tag{146.2}$$

Then $\hat{f}_{h_n}(x) = \frac{1}{h_n n}\sum_{i=1}^{n}\frac{1}{\sqrt{2\pi}}\exp\left[\frac{(x-x_i)^2}{2h_n^2}\right]$.

146.2.2 Selecting Band-Width

The choice of Band-width is critical in kernel density estimation, which decides the slipperiness of density shape, i.e. it has an effect on the accuracy of the estimation.

Generally, the coefficient of the Band-width h_n diminishes with the augment of the sample size n. When the kernel function $K(x)$ is fixed, the generated shape intends to be smooth only to cover up the density structure if the Band-width is oversize. And the generated shape intends to be sharp which cannot indicate the internal regularity. In addition, the density should be considered in deciding h_n. In data compact district, h_n tends to be small and in data rare faction, $h_n$to be large. Only after many experimental investigations can the Band-width be determined.

As the density is continuous theoretically, we usually obtain the optimal Band-width in the sense of square error MISE (Sheather and Jones 1991).

$$\begin{aligned}\text{MISE} &= \text{E}\int_{-\infty}^{+\infty}\{f_n(x) - f(x)\}^2dx \\ &\approx \frac{1}{4}\left\{\int_{-\infty}^{+\infty}\mu^2k(\mu)d\mu\right\}^2\int_{-\infty}^{+\infty}\{f''(x)\}^2dxh_n^4 + \int_{-\infty}^{+\infty}k^2(\mu)d\mu\frac{1}{nh_n}\end{aligned} \tag{146.3}$$

We adjust the parameters to minimize MISE and get Band-width h_n estimation

$$h_n = \left[\frac{\int_{-\infty}^{+\infty}k^2(\mu)d\mu}{n\int_{-\infty}^{+\infty}\{f''(x)\}^2dx\cdot\{\int_{-\infty}^{+\infty}\mu^2k(\mu)d\mu\}^2}\right]^{1/5}.$$

We use sample standard deviation S_n to replace unknown parameter σ in order to get normal reference Band-width. Then substituting $\hat{f}_{h_n}(x)$ for $f(x)$, we obtain

$$h_n = 1.06S_n\cdot n^{-\frac{1}{5}} \tag{146.4}$$

Finally we can get the kernel function

$$\mathop{\hat{f}}_{h_n}(x) = \frac{1}{1.06\,S_n\,n^{\frac{4}{5}}}\sum_{i=1}^{n}\frac{1}{\sqrt{2\pi}}\exp\left[\frac{(x-x_i)^2}{1.1236\,S_n^2\,n^{-\frac{2}{5}}}\right] \tag{146.5}$$

Using this function, we can get the maximum point X_{n+1} according to $\{X_i\}_{i=1}^{n}$ the information about the previous criminal spots. And spot represented by the maximum point is just the most probable criminal location.

146.3 The Application of Kernel Estimation

Serial murders have serious social impact and make people in great horror. So it is extremely critical to predict the offender's hideout by the offender's crimes in solving the case.

Peter Sutcliffe was born in Bingley, West Riding of Yorkshire on 2nd June in 1946. He was a ferocious serial killer and committed over 20 crimes just within 6 years, including 13 murders and a series of vicious attacks. He was nicknamed "the Yorkshire Ripper" because of his vicious criminal means.

The victims' information is listed below (Table 146.1).

We can predict Peter's eleventh criminal location through the Eq. (146.5) based on the previous criminal locations. And we get the coordinate of the 11th location (53.7975 N, 1.5652 W). Actually, we can get the range of the criminal hot zone:

Longitude: 53.7620–53.8125 N
Altitude: 1.5124–1.5876 W

In fact, the coordinate of Peter's 11th criminal location is (53.7997 N, 1.54917 W). From this, it can be seen that our estimation is relatively accurate (Fig. 146.1).

Table 146.1 The victims' information

Data	Name	Location	
		Latitude	Longitude
5 July 1975	Anna Rogulskyj	53.867	−1.911
August 1975	Olive Smelt	53.725	−1.863
27 August 1975	Tracy Browne	53.914	−1.937
30 October 1975	Wilma McCann	53.816	−1.531
January 1976	Emily Jackson	53.808333	−1.53333
9 May 1976	Marcella Claxton	53.841667	−1.4925
5 February 1977	Irene Richardson	53.841667	−1.4925
23 April 1977	Bradford	53.8	−1.75206
26 June 1977	Jayne MacDonald	53.64932	−2.43999
1 October 1977	Jean Jordan	53.4286	−2.2582
14 December 1977	Marilyn Moore	53.799722	−1.54917

Source http://en.wikipedia.org/wiki/Peter_Sutcliffe

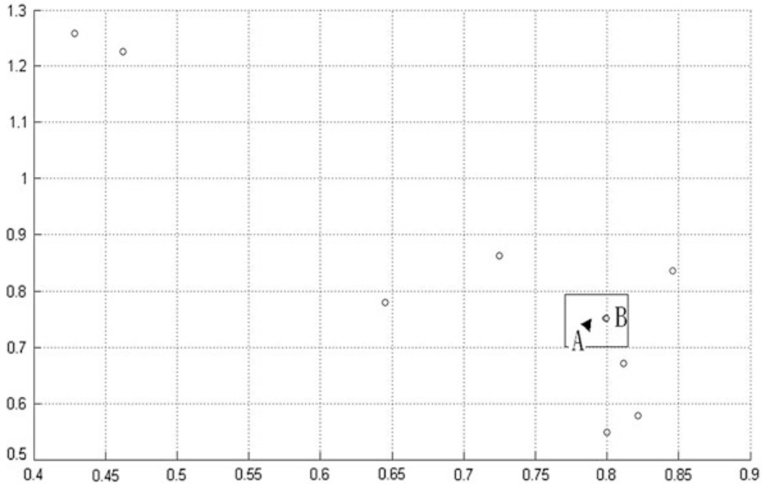

Fig. 146.1 Peter's predicted next possible criminal spot based on Kernel Density Estimation

146.4 The Application of Kernel Estimation Grid-Counting Method

We take the crimes which Peter committed in Bingley (West Riding of Yorkshire), his former hideout, from 1975 to 1977 as example.

Peter is one of the Marauder offenders. His criminal spots, centered on his stable hideout, were scattered around. Also it is found that his criminal spots were not regularly distributed but focused on some area.

From Fig. 146.2, we find that more crimes were committed in the elliptic region, up to 5 (2 crimes committed in one certain point), which coincide with the criminologist David Canter's opinion that the criminal chooses his familiar location to commit the crimes. The offender repeated committing his crimes in the small area, which reflects that he desired to gain control over the criminal spots. Once he succeeded in committing, the offender would become confident in his scheme and repeat his crime at the same spot (Becker et al. 1988). So, more police force should be laid out in this area.

146.5 Further Research Trend

The police agency is much interested in finding out the next criminal spot of the offender in serial criminal cases.

Given a series of crimes at the locations $X_1, X_2, \ldots, X_n$ committed by a single serial offender, we are to estimate the probability $P\left(X_{next}|X_{1,}X_2, \ldots X_n\right)$of the next

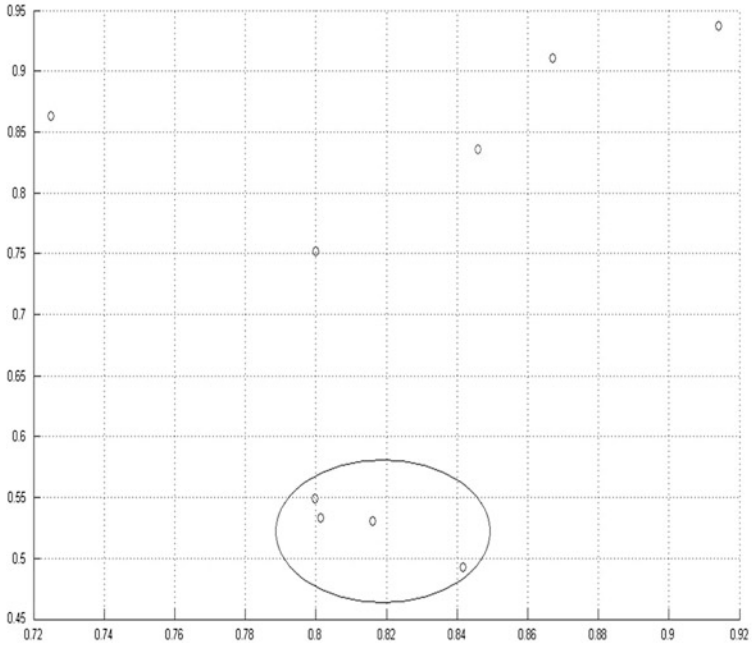

Fig. 146.2 Peter's clustered criminal spots

criminal spot X_{next}. Based on Bayesian Model from Mike O'Leave (Levine and Block 2011). Once again, we can use Bayes' Theorem get the expression formula

$$P\left(X_{next}|X_{1,}X_{2},\ldots X_{n}\right) \propto \iiint P(X_{next}|z,\alpha)P(X_{1}|z,\alpha)P(X_{2}|z,\alpha)(X_{n}|z,\alpha)H(z)\pi(\alpha)dz^{(1)}dz^{(2)}d\alpha.$$

In reality, it is not easy to estimate the value of $H(z)$and the value of $\pi(\alpha)$. Moreover, even the estimation values of $H(z)$and $\pi(\alpha)$has been given, it is still not so easy for us to get the result of the triple integral (Scott 1992).

In solving the problem, we aim to discretize the continuous process and then use the numerical method to get the probability $P\left(X_{next}|X_{1,}X_{2},\ldots X_{n}\right)$.

146.6 Conclusions

Through the grid mesh and refinement of the area, we set up an optimization model and Bayesian Model to construct "Geographic profiling" pointing to search the offender's hideout.

In Bayesian Model, by using “maximum likelihood estimation method” to estimate parameter Z, we can obtain the longitude and altitude of Peter’s hideout (53.8063 N,1.77044 W), which is also close to his actual hideout.

We can use the internal relation among the criminal spots in serial cases to predict the offender’s next probable criminal location after predicting his hideout.

First, we can use the Bayesian Model to predict the criminal probability in any spot X and further $P(X|Z,\alpha) = \frac{1}{4\alpha^2} EXP\,(-\frac{\pi}{4\alpha^2}|X-Z|^2)$to identify the function on distance and criminal frequency as negative exponential decay function. This function reflects the characteristic, i.e., the farther the spot is away from the offender’s hideout, the smaller the criminal probability is.

The prediction obtained by using the Bayesian Model, a conceptual model, is inaccurate. Compared with the former, the prediction obtained by using the Kernel Density Estimation Model is more accurate. Furthermore, the model is established on the actual criminal spots which can induce higher accuracy. In Peter’s cases, the coordinate of the predicted criminal spot is (53.7375 N, 1.795 W) and the coordinate of the actual criminal spot is (53.817 N, 1.784 W). From this, it can be seen that the prediction obtained by using the Kernel Density Estimation Model is more accurate and credible.

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Chapter 147
The Research of Full-Bridge and Current Double Rectifier Switched-Mode Power Supply for Vehicle

Yi-lin Yin, Rui-peng Chen and Xi-ming Cheng

Abstract The switched-mode power supply (SMPS) has many advantages, for instance high efficiency of transformation, small volume and etc. As the most directive and effective way to decrease the size of the switching converter, high frequency, however, increases the switching wastage. Therefore, the soft-switching technology has been invented and developed to reduce switching wastage. This paper presents the high frequency of full-bridge switching converter using zero-voltage switching technology and current double rectifier technology. The steady state model and small signal model are built by PWM switching technology. Peaking-current control mode is adopted as the control strategy. The simulation circuit of full-bridge and current double rectifier switch power is designed on PSIM platform, and the simulation is finished. The simulation proves that the model is right and the control strategy is effective.

Keywords The switched-mode power supply · Current double rectifier · ZVS soft-switching · PSIM

147.1 Introduction

Electric vehicles have become an important topic throughout the automotive industry and are developing at a high speed. As the main part of DC switching power supply, DC/DC SMPS will be widely applied in electric vehicles.

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E. Qi et al. (eds.), *The 19th International Conference on Industrial Engineering and Engineering Management*, DOI: 10.1007/978-3-642-38391-5_147,

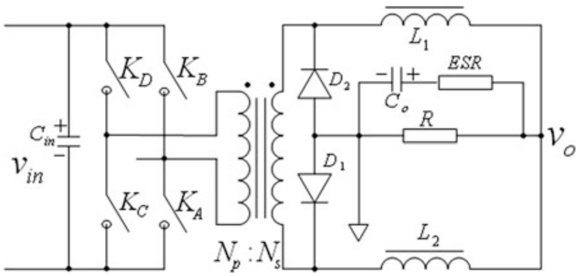

Fig. 147.1 The structure of the full-bridge and current double rectifier SMPS

Nowadays the switching power supply development tendency is: high efficiency, low loss, miniaturization, integration, intellectualization, redundant reliability (Middlebrook and Cuk 1977; Hua and Lee 1993)· In order to reduce switch losses, noises and improve power density, soft-switching technology under the principle of zero-current switching (ZCS) and zero-voltage switching (ZVS) is widely used in many applications (Liu et al. 1987; Theron and Ferreira 1995; Canesin and Barbi 1997; Dudrik et al. 2006; Liu and Lee 1990).

The SMPS consists of three basic topological structures: buck converter, boost converter and buck-boost converter. In this paper, the full-bridge and current double rectifier SMPS is designed on the basis of buck converter and adopts current double rectifier in the secondary side of pulse transformer. The structure of the full-bridge and current double rectifier SMPS is shown in Fig. 147.1.

147.1.1 Modeling of the SMPS

The models of SMPS are built for steady state analysis, transient analysis and designing of SMPS. There are many modeling methodologies of SMPS, including method of state-space averaging, the model of PWM switch and so on (Hua and Lee 1995; Smith and Smedley 1997; Chen et al. 1991).

As in the case of continuous conduction mode (CCM), the model of the PWM switch in DCM represents the dc and small-signal characteristics of the nonlinear part of the converter which consists of the active and passive switch pair (Vorperian 1990). The dc and small-signal characteristics of a PWM converter are then obtained by replacing the PWM switch with its equivalent circuit model in a manner similar to obtaining the small-signal characteristics of linear amplifiers whereby the transistor is replaced by its equivalent circuit model.

Thus this paper adopts the model of PWM switch to build the steady state model and small signal model of full-bridge and current double rectifier SMPS. The simplified equivalent circuit structure by the model of PWM switch is shown in Fig. 147.2.

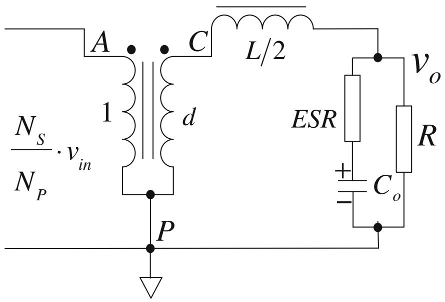

Fig. 147.2 The simplified equivalent circuit structure

The model of simplified equivalent circuit is obtained as

$$\begin{cases} \frac{N_S}{N_P} \cdot d \cdot v_{in} = \frac{L}{2} \cdot \frac{di_L}{dt} + v_o \\ v_o = v_C + \mathrm{ESR} \cdot C_o \cdot \frac{dv_C}{dt} \\ i_L = C_o \cdot \frac{dv_C}{dt} + \frac{v_o}{R} \end{cases} \tag{147.1}$$

After adding disturbance, the model of steady state can be derived as

$$\begin{cases} \frac{N_S}{N_P} \cdot D \cdot V_{in} = V_o \\ V_o = V_C \\ I_L = \frac{V_o}{R} \end{cases} \tag{147.2}$$

The small signal model in complex frequency domain is needed to design the compensation network and the model will be different on the basis of different control mode. This paper adopts the peak-value current control mode which includes voltage and current dual close-loop feedback system. In the peak-value current control mode, the circuit includes current detecting circuit and ramp compensation circuit which are shown in Fig. 147.3

The ramp compensation voltage v_{CT} is supplied by oscillation circuit and v_e is supplied by feedback compensate network.

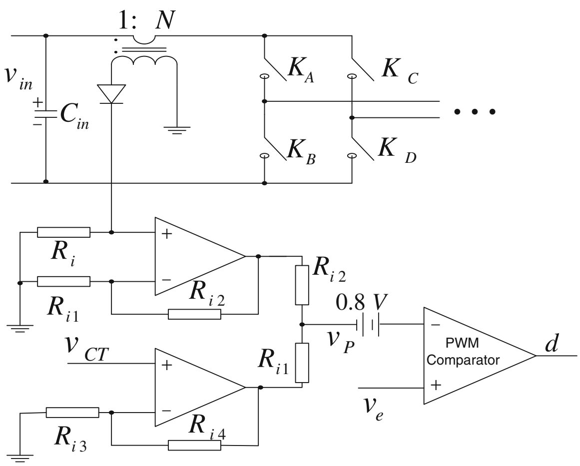

Fig. 147.3 current detecting circuit and ramp compensation circuit

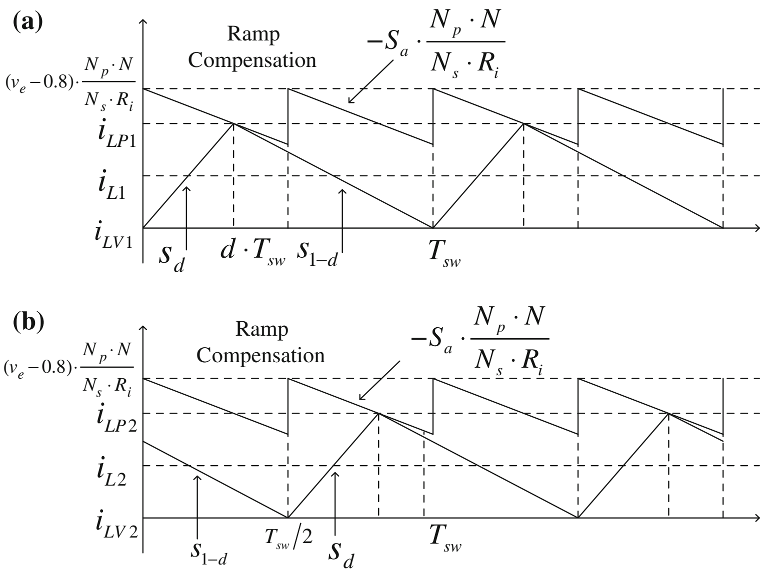

Fig. 147.4 The current waveform of two filter inductors. **a** Current waveform of L_1, **b** current waveform of L_2

The current waveform of two filter inductors in the circuit is shown in Fig. 147.4.

The upward slope of current of filter inductor is s_d and the downward slope is s_{1-d}. Therefore, the transfer function of the peak-value current control mode can be derived from Fig. 147.3

$$H_1(S) = \frac{R}{R_i'} \cdot \frac{1}{1 + \frac{R \cdot T_{sw} \cdot \pi}{L'} \cdot Q_p} \cdot F_p(S) \cdot F_h(S) \tag{147.3}$$

where

$$\begin{cases} F_p(S) = \dfrac{1 + \frac{S}{\omega_{Z1}}}{1 + \frac{S}{\omega_{P1}}} \\ F_h(S) = \dfrac{1}{1 + \frac{S}{\omega_n \cdot Q_p} + \frac{S^2}{\omega_n^2}} \\ R_i' = \dfrac{N_s}{2N_p \cdot N} \cdot R_i \\ S_d' = \dfrac{\frac{N_s}{N_p} \cdot V_{in} - V_o}{\frac{L}{2}} \\ Q_p = \dfrac{1}{\pi \cdot \left[(1 - D) \cdot \left(1 + \frac{S_a / R_i'}{S_d'} \right) - \frac{1}{2} \right]} \end{cases} \tag{147.4}$$

Table 147.1 The technical indicators of SMPS for vehicle

Technical indicator	Value
Input voltage (V)	60–90
Output voltage (V)	14
Output ripple voltage (V)	≤100
Output power range (W)	100–800
Transformer turns ratio	3:2
Switching frequency (kHz)	50
Minimal output power in CCM (W)	200

147.2 Designing of the SMPS

The first step of designing SMPS, including power circuit and control circuit, is to choose the right structure of SMPS, control method and related SMPS technology according to the technical indicators of SMPS. The technical indicators of this paper are illustrated in Table 147.1

147.2.1 Designing of Power Circuit

The designing of Power circuit of SMPS based on the technical indicators mainly includes the choosing of output capacitors and filter inductors, designing of parameters of soft-switching.

Essentially, full-bridge and current double rectifier SMPS is the derivation of BUCK converter. The minimum of filter inductors L_m must be obtained, using the model of steady state in (147.2)

$$L_m = R_M \cdot T_{sw} \cdot \left(1 - \frac{V_o}{V_{inM}} \cdot \frac{N_p}{N_s}\right) \tag{147.5}$$

where V_{inM} stands for maximum input voltage of SMPS and R_M stands for load impedance of SMPS in discontinuous current mode (DCM) and can be derived as follows:

$$R_M = \frac{V_o^2}{P_m} \tag{147.6}$$

where P_m is the minimum output power in CCM.

Finally, inductor with inductance $L = 15$ μH is selected as the filter inductor.

The key parameter of choosing output capacitor is equivalent series resistance (ESR) rather than capacitance, because ESR of output capacitor has a much bigger impact on the ripple of output voltage than the capacitance. Thus, the ESR of output capacitor is obtained firstly according to the ripple of output voltage and the output capacitor is selected according to obtained ESR and manufacturer's data specification sheets.

The capacitance C_o can be ignored only when C_o satisfies the following relationship:

$$C_o \geq \frac{1}{f_c \cdot \mathrm{ESR}} \tag{147.7}$$

where f_c is the operating frequency of output capacitor.

The ripple of output voltage cannot exceed the maximum value ΔV_M when the ESR satisfies the following relationship:

$$\mathrm{ESR} \leq \frac{\Delta V_M}{\Delta I_{CM}} \tag{147.8}$$

where ΔI_{CM} is the maximum ripple voltage through the output capacitor C_o.

The f_c and ΔI_{CM} can be derived as follows:

$$\begin{cases} f_c = \frac{2}{T_{sw}} \\ \Delta I_{CM} = \frac{V_o}{L} \cdot T_{sw} \cdot \left(1 - \frac{2V_o}{V_{inM}} \cdot \frac{N_p}{N_s}\right) \end{cases} \tag{147.9}$$

Combining Eqs. (147.7), (147.8), and (147.9), yields

$$\begin{cases} \mathrm{ESR} \leq \frac{\Delta V_M \cdot L \cdot V_{inM} \cdot N_s}{V_o \cdot T_{sw} \cdot \left(V_{inM} \cdot N_s - 2V_o \cdot N_p\right)} \\ C_o \geq \frac{V_o \cdot T_{sw}^2 \cdot \left(V_{inM} \cdot N_s - 2V_o \cdot N_p\right)}{2\Delta V_M \cdot L \cdot V_{inM} \cdot N_s} \end{cases} \tag{147.10}$$

The initial value of ESR and C_o can be obtained, using expression (147.10) and Table 147.1.

$$\mathrm{ESR} \leq 40.1\,\mathrm{m}\Omega \quad C_o \geq 63\,\mu\mathrm{F}$$

When choosing capacitors, it is necessary to take into consideration the loss factor $\tan\delta$ which is provided in manufacturer's data specification sheets because the ESR of capacitor decreases with the increasing of capacitance.

$$\tan\delta = 2\pi f_c \cdot C \cdot \mathrm{ESR} \tag{147.11}$$

Thus, two capacitors with withstand voltage 63 V and capacitance 1500 µF are selected as the output capacitor.

147.2.2 Designing of Soft-Switching

Soft-switching technology can effectively improve work environment of power converter and greatly decrease its power consumption (Hua et al. 1994; Cho et al. 1994; Jiang et al. 2003; Schutten and Torrey 2003). Soft switching includes ZVS and ZCS. Since using MOSFET as the switch, this paper adopts ZVS.

The power circuit of full-bridge and current double rectifier SMPS using MOSFET is shown in Fig. 147.5.

When the voltage drop of diode is ignored, the total time t_{CD} of charging or discharging of the capacitor C_{CD} in the leading leg can be derived as follows:

$$t_{CD} \approx 2C_{CD} \cdot \frac{v_{in}}{i_{pk}} \tag{147.12}$$

where i_{PK} is the peak current though the primary winding of transformer. To make sure the soft switching of leading leg is achieved, t_{CD} must be less than commutation dead time t_{deadCD}.

$$t_{CD} \le t_{deadCD} = 5 \times 10^{-11} \cdot \frac{R_{DELCD}}{1.5(v_{CS} - v_{ADS}) + 1} \tag{147.13}$$

During switching of lagging leg, the transformer is not impacted but only the resonant inductance L_r is impacted. Therefore, to make sure the capacitor C_{AB} in the lagging leg is fully charged or discharged, the resonant inductance L_r must satisfies the following expression.

$$\begin{cases} L_r \ge \frac{2C_{AB} \cdot v_{in}^2}{i_{AB}^2} \\ i_{AB} \approx i_{pk} - \frac{N_s}{N_p} \cdot \frac{(0.5-d) \cdot T_{sw} \cdot v_o}{L} \end{cases} \tag{147.14}$$

The total time t_{AB} of charging or discharging of the capacitor C_{AB} in the lagging leg can be derived as follows:

$$t_{AB} = \sqrt{2L_r \cdot C_{AB}} \cdot \arcsin\left(\sqrt{\frac{2C_{AB}}{L_r}} \cdot \frac{v_{in}}{i_{AB}}\right) \tag{147.15}$$

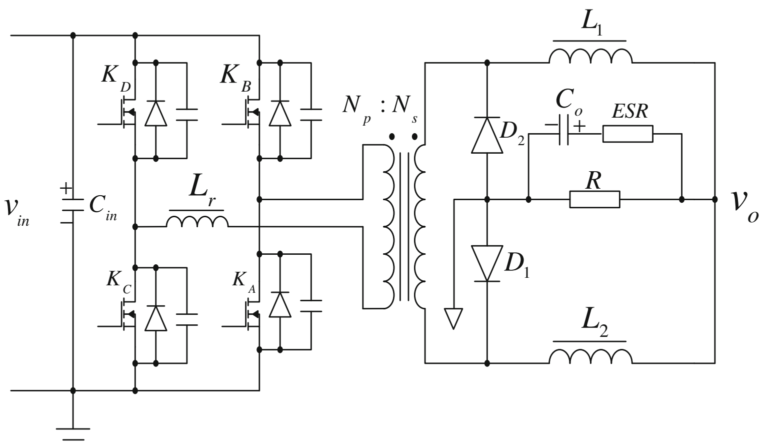

Fig. 147.5 The power circuit of SMPS

To make sure the soft switching of lagging leg is achieved, t_{AB} and t_{deadCD} must satisfies the following expression.

$$\begin{cases} t_{AB} \leq t_{deadAB} \leq t_{AB} + t_r \\ t_{deadAB} = 5 \times 10^{-11} \cdot \frac{R_{DELAB}}{1.5(v_{CS} - v_{ADS}) + 1} \end{cases} \tag{147.16}$$

147.2.3 Designing of Control Circuit

The designing of control circuit mainly includes type selection of control chip and designing of its outside circuits. UCC3895 is selected as the control ship and the peak-value current control mode is selected as the control mode. The control circuit is shown in Fig. 147.6.

The feedback compensate network can be designed as

$$\begin{cases} \frac{1}{R_1 \cdot C_2} = \frac{1}{R \cdot C_o} + \frac{T_{sw}}{L' \cdot C_o} \cdot \left[(1 - D)\left(1 + \frac{S_a / R_i'}{S_d'}\right) - \frac{1}{2} \right] \\ R_4 \cdot C_4 = \mathrm{ESR} \cdot C_o \\ \omega_{cross} = \frac{CTR \cdot R_4}{R_1 \cdot R_3 \cdot C_2} \cdot \left(1 + \frac{R_5}{R_6}\right) \cdot H_1(0) \\ H_1(0) = \frac{R}{R_i'} \cdot \frac{1}{1 + \frac{R \cdot T_{sw}}{L'}\left[(1-D)\left(1 + \frac{S_a / R_i'}{S_d'}\right) - \frac{1}{2}\right]} \end{cases} \tag{147.17}$$

147.3 Simulation Results

The whole simulation circuit construction of the designed full-bridge and current double rectifier SMPS is shown in Fig. 147.7.

The circuit is designed with power outputs ranging from 100 to 800 W. The designed SMPS is simulated in PSIM and the simulated waveforms are illustrated in Figs. 147.8, 147.9, 147.10 and 147.11.

When the output power is 100 W, the crossover frequency f_{cross} of the open loop transfer function and the dominant pole of slope compensation network are set about 63 kHz. Thus, when the output power is below 100 W, the phase margin will decline and even become negative because the crossover frequency f_{cross} moves to higher frequency, which will lead to system instability, as is shown in Fig. 147.8. The current sensor is designed when the output power is 800 W. If the output power exceeds 800 W, current limiter and protecting circuit will start to work and then the output power will be limited by limiting input peak current and the duty ratio of controller, so the output voltage will be below 14 V, as can be seen in Fig. 147.11

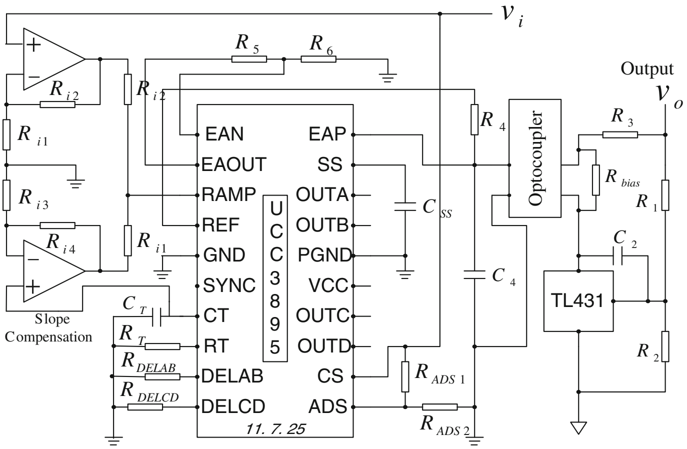

Fig. 147.6 The control circuit

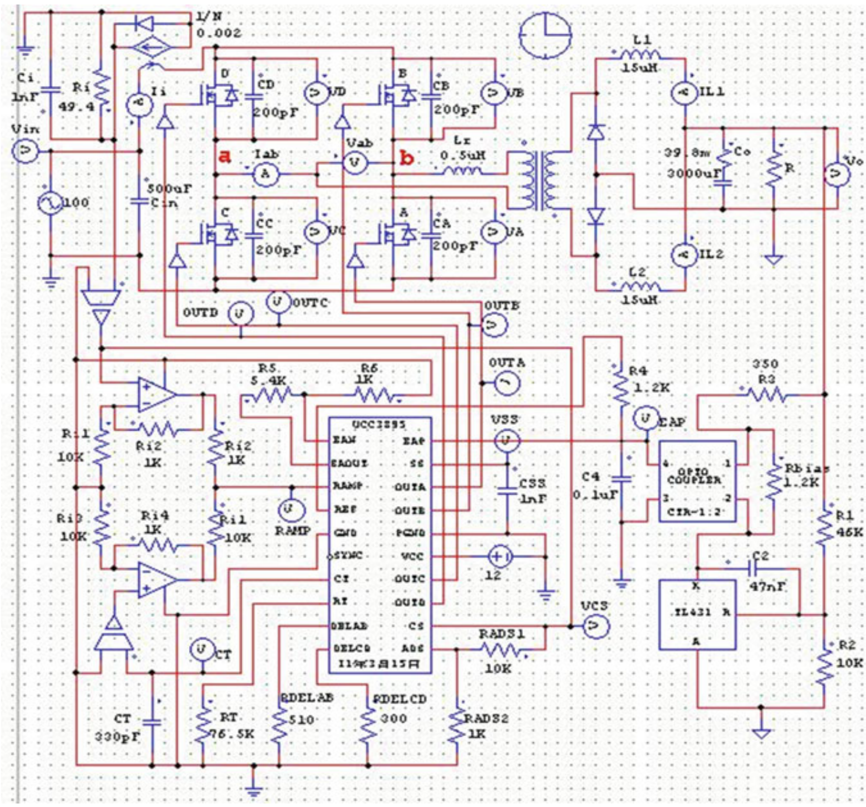

Fig. 147.7 The whole simulation circuit construction

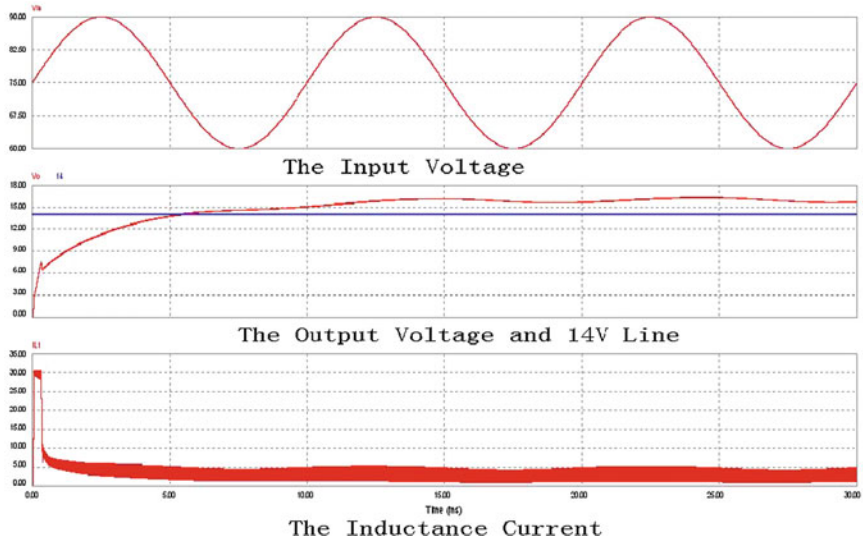

Fig. 147.8 $P_o = 70$ W, $R = 2.8\ \Omega$

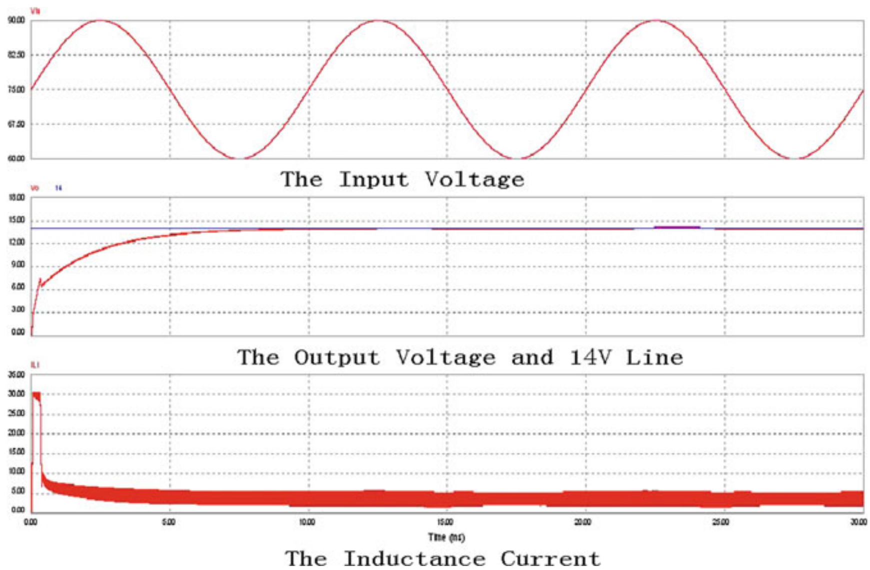

Fig. 147.9 $P_o = 100$ W, $R = 1.96\ \Omega$

The ripple of output voltage is mainly determined by the ESR of output capacitor C_o.

Figure 147.12 shows the ripple of output voltage. The ripple of output voltage is always below 100 mV in a period of input voltage v_{in}, so the selection of output

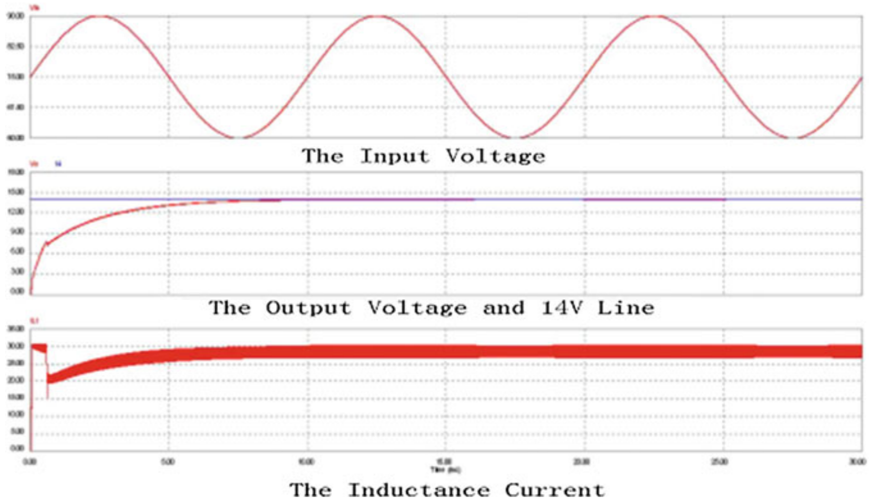

Fig. 147.10 $P_o = 800$ W, $R = 0.254\ \Omega$

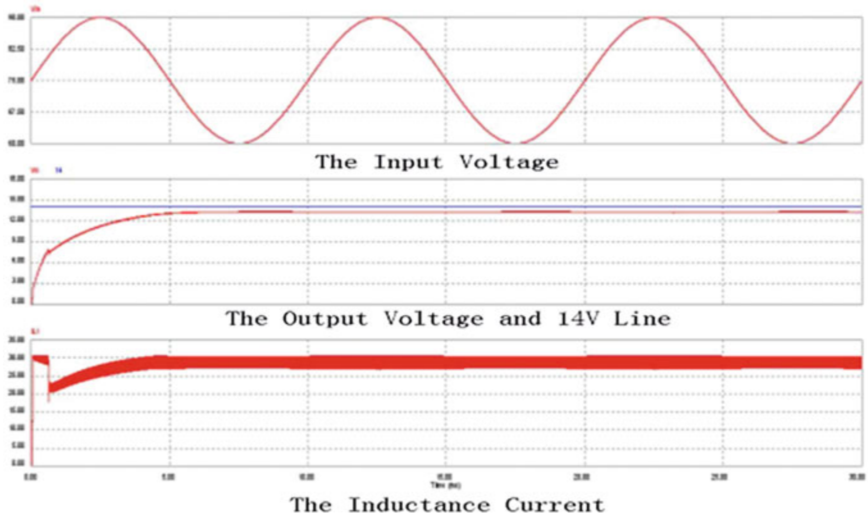

Fig. 147.11 $P_o = 852$ W, $R = 0.23\ \Omega$

capacitor C_o is right. The ripple of output voltage is the biggest under the maximum input voltage, as is shown in Fig. 147.12.

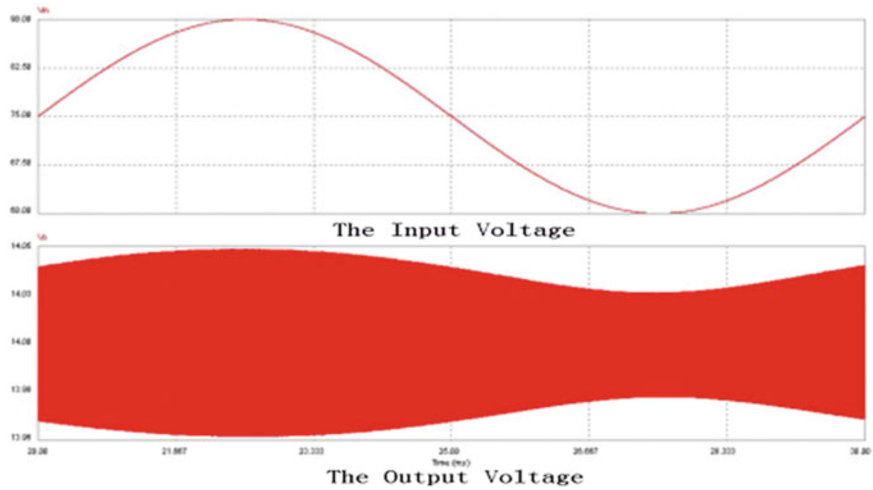

Fig. 147.12 The ripple of output voltage

147.4 Conclusion

In this paper, a kind of full-bridge and current double rectifier SMPS for vehicle is analyzed and modeled. Based on the models, the circuit of the SMPS is designed and soft-switching technology is also used to reduce the switching losses. By simulation in PSIM, the models and designed circuits are validated. The result shows that the models have very high accuracy and the designed circuit is right.

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Chapter 148
The Research of Industrial Optimization of Beijing CBD Ribbon Based on Fitness Function Mode

Youliang Zhang and Gang Zong

Abstract Beijing CBD, guided by modern service industry, is international business areas with international finance as the leading role. By fitness function model, it researches the scale-free characteristics of industrial network of CBD Ribbon, on the basis of analyzing its network node by cluster analysis. The results show that the modern service industry is closely linked to the traditional leading industries, and the stimulative correlation relationship with the rest of the industry, which will promote the continuous optimization of regional industrial structure.

Keywords CBD ribbon · Cluster analysis · Fitness function model

148.1 Introduction

There are numerous nodes in the urban industrial system, the generation of pillar industry and leading industry and the evolvement of forerunner industry and sunset industry have certain rules. To analyze urban industrial clustering structure by means of fitness function model in order to discover its rules in evolvement and features can accelerate the development of urban industrial structure as well as promote the optimization of urban industry.

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E. Qi et al. (eds.), *The 19th International Conference on Industrial Engineering and Engineering Management*, DOI: 10.1007/978-3-642-38391-5_148,

148.1.1 Fitness Function Model

There are few abnormal nodes in many realistic networks. These nodes' growth rate of degree depends on not the age of nodes but their competitive capacity. Moreover, they don't acquire new sides complying with the principle of degree preferential attachments. They may connect to only a few sides in the early evolution of time step for these nodes (Population Division, Department of Economic and Social Affairs, United Nations 2010). According to the principle of degree preferential attachments, the probability that they may obtain new sides should be very small. Because of some other reasons, however, they have a greater probability to get new sides. This phenomenon reflects the fitness is becoming rich. As a result, people put forward fitness function model based on this phenomenon.

The following is the evolutionary pattern of its network model (Gomez-Gardenes et al. 2006):

1. Increase: Begin with a network included nodes, bring in one new node each time and connect it to existing nodes, fitness of each node is selected in accordance with probability distribution.
2. Preferential connection: The probability of connection between a new node and an existing node, the node's degree, the node's degree and fitness meet the following relationship:

$$\prod_i = \frac{\eta_i k_i}{\sum_j \eta_j k_j} \tag{148.1}$$

More specifically, utilize fitness function model in the optimal development of urban area industry:

1. Increase: In initial process, after years of development, it has formed industrial system which is comprised of m_i relative independent industries. These industries may be in the position of forerunner industry, leading industry, pillar industry and sunset industry respectively in the present industrial structure.
2. Preferential connection: In the next time step, there will be a new industry in urban area industrial system. The new industry will demonstrate a strong ability to adapt. A great deal of social resource will concentrate on this new industry due to general optimism and particular attention about it. As a result, this industry will develop rapidly in the short term and establish extensive contact with other industries; in the following time step, all evolvement of urban area industrial system will comply with this industrial increasing principle.

148.1.2 Evolutionary Analysis of the Model

Evolving in accordance with fitness function model, the prominent feature of urban area industry is not only able to establish relevance with the original

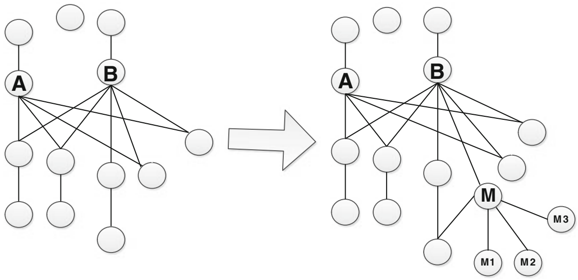

Fig. 148.1 The increase of industrial network based on fitness function model

industry but derive the new industry rapidly, and even become the new leading industry and pillar industry (Mo et al. 2008; Wang et al. 2006). It increases the proportion of it in the national economy, and promotes optimization of urban area industrial structure and increase of overall economy constantly, as shown in Fig. 148.1.

A, B represent leading industry, pillar industry, and M represents emerging industry and its derivative industry. In the long term, the industrial optimization based on the fitness function model confirms to the stream and principle of industrial development. But under the effect on path dependence, urban area has already formed several industries so this process will be limited. There is a constant gambling process between emerging industry and original industry (Liu 2009). If they have no mutual promoting relationship, participation of the emerging industry must squeeze the other's living space and emerge competitive relationship. Meanwhile, the original and relative outdated industries are not willing to withdraw from the market. Consequently, the government needs to give enough initial support before the maturity of emerging industries; as the maturing of the emerging industry, its relevant industry enters into market gradually and the industrial structure will be optimized constantly.

Certainly, the participation of emerging industry has limit. The new participants, comparing with other industries, have to invest on numerous personnel, resources and capital in order to obtain greater competitive advantages (Luo 2005). Or else the emerging industry may abort so as to make adverse effect on long term development.

148.2 Methodology

148.2.1 The Network Analysis of Industrial Optimization in CBD Ribbon

We can get Table 148.1 through classifying and disposing the date of Beijing CBD Ribbon's node relation. Utilizing Ucinet software, we can generate corresponding network relation figure (viz. Fig. 148.2). The node represents the industry's

Table 148.1 The list of network node of industries in CBD ribbon

No.	Node name
Bb2	Manufacturing
Bb3	Electric power, fuel gas and water production and supply industry
Bb4	Construction industry
Bc1	Transportation, storage and postal industry
Bc2	Information transmission, computer services and software industry
Bc3	Wholesale and retail industry
Bc4	Accommodation and catering industry
Bc5	Financial industry
Bc6	Real estate industry
Bc7	Lease and business services industry
Bc8	Scientific research, technology services and geological exploration industry
Bc9	Water conservancy, environment and public facilities management industry
Bc10	Resident services and other services industry
Bc11	Education
Bc12	Health, social security and social welfare industry
Bc13	Culture, sport and recreation

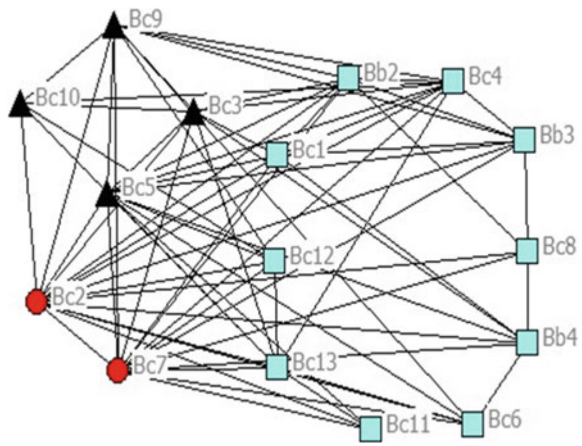

Fig. 148.2 The industrial network construction figure of olympic ribbon

designation and the line represents the relations among industries. The scale of network represents quantity of total participants; therefore the scale of industrial network in this Ribbon is 16.

As shown in the Fig. 148.1, we can see clearly that this network has significant scale-free network characteristic that the connection situation (number of degrees) among each node has asymmetrical distributivity, and most of nodes have relative less number of degrees and only few of them have higher number of degrees. In the CBD Ribbon industrial structure, retail business and traditional service

	Bb2	Bb3	Bb4	Bc1	Bc2	Bc3	Bc4	Bc5	Bc6	Bc7	Bc8	Bc9	Bc10	Bc11	Bc12	Bc13
Bb2	1.00	0.87	0.49	0.61	0.21	0.31	0.59	0.15	0.11	0.38	0.28	0.31	0.11	0.18	0.11	-0.11
Bb3	0.87	1.00	0.34	0.47	0.19	0.47	0.48	0.09	0.22	0.33	0.36	0.21	-0.05	0.26	0.22	-0.22
Bb4	0.49	0.34	1.00	0.34	0.16	0.11	0.09	0.03	0.31	0.29	0.16	0.09	-0.22	0.34	0.05	0.22
Bc1	0.61	0.47	0.34	1.00	0.19	0.48	0.48	0.45	0.22	0.33	0.66	0.47	-0.05	0.26	-0.05	0.05
Bc2	0.21	0.19	0.16	0.19	1.00	0.24	0.24	0.42	0.14	0.56	0.12	0.24	0.14	0.10	0.14	0.21
Bc3	0.31	0.47	0.11	0.48	0.24	1.00	0.71	0.22	0.58	-0.02	0.20	0.14	0.29	0.43	0.58	0.03
Bc4	0.59	0.48	0.09	0.48	0.24	0.71	1.00	0.22	0.29	-0.02	0.20	0.43	0.29	0.43	0.58	0.03
Bc5	0.15	0.09	0.03	0.45	0.42	0.22	0.22	1.00	0.34	0.75	0.28	0.22	0.32	0.25	-0.03	0.15
Bc6	0.11	0.22	0.31	0.22	0.14	0.58	0.29	0.34	1.00	0.25	0.29	0.00	0.17	0.74	0.72	0.11
Bc7	0.38	0.33	0.29	0.33	0.56	-0.02	-0.02	0.75	0.25	1.00	0.22	-0.02	0.22	0.18	-0.21	-0.07
Bc8	0.28	0.36	0.16	0.66	0.12	0.20	0.20	0.28	0.29	0.22	1.00	0.20	-0.29	0.21	0.00	-0.29
Bc9	0.31	0.21	0.09	0.47	0.24	0.14	0.43	0.22	0.00	-0.02	0.20	1.00	0.29	0.11	0.29	0.58
Bc10	0.11	-0.05	-0.22	-0.05	0.14	0.29	0.29	0.32	0.17	0.22	-0.29	0.29	1.00	0.12	0.43	0.39
Bc11	0.18	0.26	0.34	0.26	0.10	0.43	0.43	0.25	0.74	0.18	0.21	0.11	0.12	1.00	0.74	0.48
Bc12	0.11	0.22	0.05	-0.05	0.14	0.58	0.58	-0.03	0.72	-0.21	0.00	0.29	0.43	0.74	1.00	0.39
Bc13	-0.11	-0.22	0.22	0.05	0.21	0.03	0.03	0.15	0.11	-0.07	-0.29	0.58	0.39	0.48	0.39	1.00

Fig. 148.3 The network node's correlation matrix of each industry in CBD ribbon

industry still have relative higher number of degrees, but the proportion of CBD Ribbon's modern service industry grows constantly in national economy, and its industrial correlation degree has significant improvement, emerging a trend to become the leading industry gradually (Newman 2001; Barabási 2001; Liljeros et al. 2001).

148.2.2 The Structural Analysis of Complicated Network of CBD Ribbon Industry

According to the relationship matrix of CBD Ribbon's each industry, we can generate corresponding network node's correlation matrix (Table 148.1) and each industrial network node's cluster analysis tree (Fig. 148.3) by utilizing Uncinet software. According to the correlation coefficient of the modern service industry (Bc7, Bc2) and related industries, we can figure out that the correlation coefficient of Bc7 and Bc5 is 0.75, similarly, the correlation coefficient of Bc2 and Bc5 is 0.42. It shows that the correlation between modern service industry and financial industry is the most significant due to the higher correlation coefficient (Refiner 1998; Yook and Jeong 2002). As shown in the each industrial network node's cluster analysis tree (Fig. 148.4), we can clearly see that modern service industry has intimate relation with traditional leading industry and mutual promoting

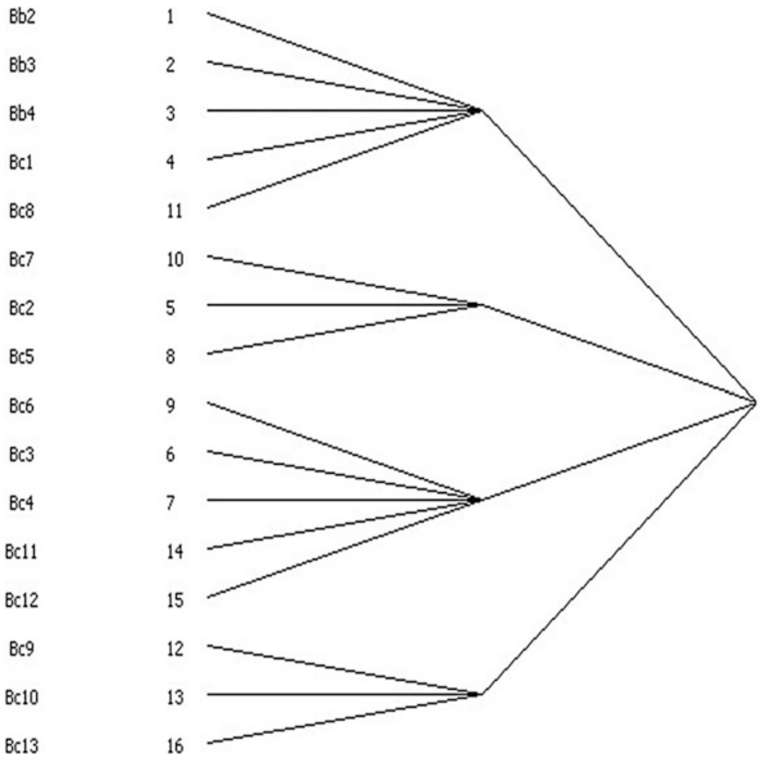

Fig. 148.4 The network node's cluster analysis tree of each industry in CBD ribbon

relation with other industries. Therefore modern service industry shows strong adaptive capacity and will optimize the regional industrial structure constantly.

148.3 Conclusions

This article carries on evolutionary analysis which analyzed 16 industries of Beijing CBD Ribbon on fitness function model supported by the construction of urban industry. As a result, it verifies the scale-free characteristic of inner industrial relation. In the CBD Ribbon, traditional industries like the retail and traditional services have greater centrality. However there is a gradual increasing trend in the relevancy of modern service industry. Moreover it has a tight connection with traditional leading industry as well as other industries.

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Chapter 149
A Study on the User Acceptance Model of SNS Websites Based TAM

Dan Jin and Mei-mei Zhou

Abstract Based on Davis's TAM, combining with the user satisfaction theory in information system and motivation theory, and the SNS user behavior characteristics, this study proposed the user acceptance model on SNS websites. In this model, Perceived Usefulness and Perceived Ease-of-Use were retained, and Perceived Enjoyment and Perceived Connectivity were added. In addition, the external variables affecting these key factors were subdivided. The questionnaire was designed and Structural Equation was used to validate the empirical hypothesis. The results showed that TAM could apply to user acceptance on SNS website basically, and Perceived Enjoyment and Perceived Connectivity were all positively correlated with Willingness, also, the subdivision of external variable reflected the importance of user activity.

KeyWords Activity level · Perceived enjoyment · SNS websites · Technology acceptance model

149.1 Introduction

SNS websites is a booming Internet applications, based on the theory of "Six Degrees of Separation", taking the customer relationship as the core, designed to help people build social networks. The large number of Internet users makes a great contribution to the rapid development of SNS sites. Various SNS websites rise rapidly after 2006, and competition is fierce, causing serious phenomenon of homogeneity.

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E. Qi et al. (eds.), *The 19th International Conference on Industrial Engineering and Engineering Management*, DOI: 10.1007/978-3-642-38391-5_149,

MicroBlog, a Twitter-like service, has been rapidly developed, and the registered users have increased dramatically.SNS websites users are coincident with those of MicroBlog to a great extent. Double pressures of homogenous competition and MicroBlog' rising, makes SNS websites face a great challenge. SNS websites need to absorb new users continuously and retain old ones. SNS websites are facing with the problem of user acceptance.

149.2 Literature Review

The user acceptance problem of SNS websites belongs to information technology acceptance. The user's act in accepting technology is regarded as one of the most mature research field of information systems (Davis 1989). The most representative theories are theory of rational act (TRA), theory of planning behavior (TPB), and technology acceptance model (TAM).

149.2.1 Technology Acceptance Model

Based on rational behavior theory, Davis (1986) put forward TAM. TAM adopts the well-established causal chain of beliefs →attitude → intention → behavior which has become known as the Theory of Reasoned Action (TRA). Based on certain beliefs, a person forms an attitude about a certain object, on the basis of which he or she forms an intention to behave with respect to that object. The intention to behave is the sole determinant of actual behavior (Fig. 149.1). In TAM applications, two key factors, Perceived Usefulness and Perceived Ease-of-Use, can effectively explain users' behavior intention.

149.2.2 Other Related Theory

Papacharissi and Rubin (2000) summarized motivation of Internet usage in the following: interpersonal communication, killing time, achieving information,

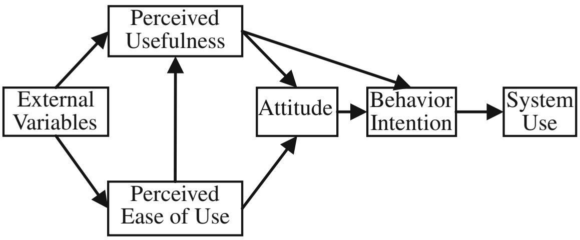

Fig. 149.1 Technology acceptance model

convenience and entertainment. Through the online questionnaire survey in a German SNS website, Schaefer (2008) discussed participating motivation and running mode, considered the participating motivation includes keeping in touch, searching for information, entertainment, communicating, managing existing relationship and so on. From these motivations, some other factors may also affect SNS websites usage, apart from Perceived Usefulness and Perceived Ease-of-Use.

Wixom and Todd (2005) proposed that the user satisfaction of information system could be united with Davis's TAM. Information quality and system quality influence information satisfaction and system satisfaction respectively, and information satisfaction and system satisfaction exert influence on Perceived Usefulness and Perceived Ease-of-Use respectively. Delone and Mclean (2003) added service quality in the improved D&M information system success model, and proposed that the SERVQUA scale in marketing field could be referred to measure service quality. As studying the relationship between intimate degree and diving behavior, Patrick Rau (2008) and others measured the member behavior of participating in SNS websites with member activity level. These theories could provide a foundation for further study on external variables subdivision in TAM.

149.3 Model and Hypothesis

149.3.1 User Acceptance Model of SNS Websites

In TAM, the external variables have not been fractionized, which will make against further analysis the influencing factors on user acceptance to SNS websites.SNS websites provide an interactive platform for friends, on which integrates basic Internet applications, such as log, photo, video, community and game, and meet users' sociality demands through online interactive among friends, information sharing, participating in activities and other ways. Webster and Martocchio (1995) thought entertainment was an intrinsic motivation using computers in workplaces. Scholars put forward Perceived Enjoyment as doing Internet empirical study, which refers to entertainment degree by using SNS websites. Moreover, Perceived Connectivity refers to being connected with friends in passions and is not confined by time or location. During using SNS websites, users may have the feeling of satisfaction or happiness, which makes users to accept SNS websites in further (Shin 2008).

Based on TAM, the user acceptance model for SNS websites is shown in Fig. 149.2. Perceived Usefulness and Perceived Ease-of-Use are retained in the model, and Perceived Enjoyment and Perceived Connectivity are added as another two key factors affecting users to accept SNS websites. In addition, external variables of the above factors are further divided into the information quality, quality system, active degree and the service quality and related factors.

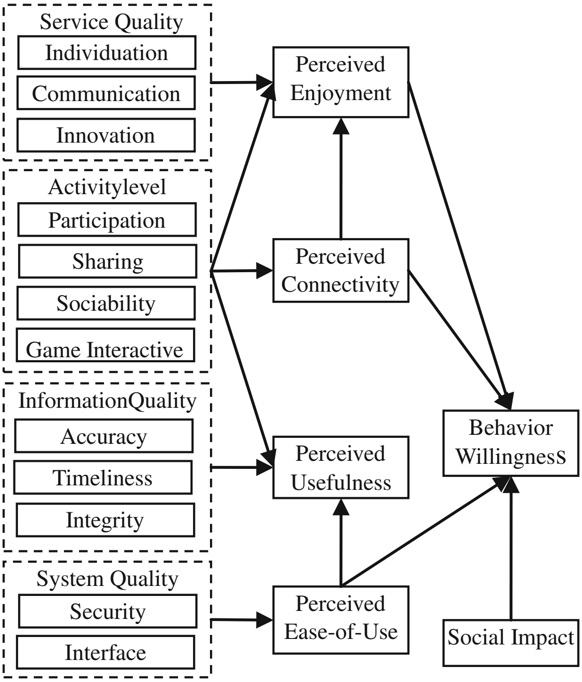

Fig. 149.2 Prototype of user acceptance model for SNS websites

149.3.2 Assumptions of Model

The related assumptions in TAM are still established in this model. And new assumptions about Perceived Enjoyment and Perceived Connectivity are proposed.

(1) Perceived Ease-of-Use and related assumptions.
Based on customer satisfaction theory and with the previous empirical data support, (Seddon 1997) also confirmed that system quality has a positive effect on Perceived Ease-of-Use. In addition, the system security is much important to users, which means to promise personal information safety. Moreover, both user interface and interactive process will affect users to accept SNS websites.

H1: System quality positive effect on this term
H1a: Security positive effect on it
H1b: Interface positive effect on it
H2: Perceived Ease-of-Use positive effect on this item
(2) Perceived Usefulness and related assumptions
H3: Information Quality positive effect on this item
H3a: Accuracy positive effect on it
H3b: Timeliness positive effect on it
H3c: Integrity positive effect on it
H4: Activity level positive effect on this item
H4a: Participation positive effect on it

H4b: Sharing positive effect on it
H4c: Sociability positive effect on it
H4d: Game interactive positive effect on it
H5: Perceived Ease-of-Use positive effect on this item
H6: Perceived Usefulness positive effect on this item
(3) Perceived Connectivity and related assumptions
H7: Activity level positive effect on this item
H7a: Participation positive effect on it
H7b: Sharing positive effect on it
H7c: Sociability positive effect on it
H7d: Game interactive positive effect on it
H8: Perceived Connectivity positive effect on this item
(4) Perceived Enjoyment and related assumptions.
As a community website where users' activities are based on group, SNS website should pay much attention to users' activity involvement, which can tell the influence of Perceived Connectivity to Perceived Enjoyment.
H9: Service quality positive effect on this item
H9a: Individuality positive effect on it
H9b: Communication positive effect on it
H9c: Innovation positive effect on it
H10: Activity level positive effect on this item
H10a: Participation positive effect on it
H10b: Sharing positive effect on it
H10c: Sociability positive effect on it
H10d: Game interactive positive effect on it
H11: Perceived Connectivity positive effect on this item
H12: Perceived Enjoyment positive effect on this item
(5) Social impact and related assumptions
Social impact refers to others influence on individual for using SNS websites. Similar to the TRA subjective enorms, people are very conscious of others view about their particular behavior willing. Whether individual uses SNS websites would be influenced by others recommendation or evaluation.
H13: Social impact positive effect on this item

149.4 Research Methods

149.4.1 Survey Questionnaire Design

In order to verify the model assumptions, a questionnaire is used to collect data. The questionnaire uses a standard 7-point Likert-typescale. The 7 point are "completely disagree", "relatively disagree", "some disagree", "not sure"," some agree", "relatively agree" and "completely agree". According to actual situation, respondent shave the right to choose from 1 (completely disagree) to 7 (completely agree). As the final questionnaire data is analyzed and tested by using structural equation model, it need to meet the requirements that structural equation model to observed variables and characteristics of measuring factors, so three or more items are used to measure each factor. All the measure items use the mature scales which have been used in empirical study by researchers at home and abroad, and are adjusted according to SNS websites characteristics and questionnaire's semantic environment. The questionnaire has 18 variables to measure, including 13 external variables, such as accuracy, timeliness, integrity, security, interface, individuality, innovation, communication, participation, sociability, sharing, game interactive and social impact, and 5 internal variables, as Perceived Usefulness, Perceived Ease-of-Use, Perceived Enjoyment and Perceived Connectivity and Willingness. Above all, the total number to be measured is 58.

149.4.2 Pre-test Questionnaire

In order to ensure the effectiveness of the survey questionnaire, it is necessary to pretest it before actually using it. This paper uses SPSS 18 to do reliability and validity analysis on the test results. The reliability analysis results showed that Cronbach's Alpha value of every measured factor was greater than 0.5, while the overall questionnaire reliability was 0.959, indicating the internal consistency of the questionnaire was acceptable. In the validity analysis, separate factor analysis was made on corresponding measured items of independent variables, mediating variables and dependent variables. The factor analysis result showed that other factors were all better classified in the corresponding dimension apart from two factors measured items, sociability and social impact of the independent variables. So sociability factor and social impact factor were deleted.

149.4.3 Data Collection

According to the pre-test results, the questionnaire were modified in final two ways, electronic and paper questionnaire. On the principle of simple random sampling, questionnaires were distributed. 170 electronic questionnaires and 68 paper questionnaire were distributed, altogether 202 questionnaires were returned. After moving the data obviously not meeting the requirements, 153 valid questionnaires were remained.

149.5 Model Analysis

149.5.1 Second Order Confirmatory Factor Analysis

Second order confirmatory factor analysis (CFA) is put forward as there is high degree relevance among original first order factors in the first order CFA, and the first order CFA can be in agreement with sample data. In the model, information quality, system quality, service quality and activity level are measured with the multidimensional method, so AMOS 17 would be used respectively during their second order factor analysis. The analysis results show, all the first order factors to second order factors of information quality, system quality, service quality, and activity level, the load capacity value lie between 0.5 and 0.95, and the Significance Probability and C.R. are greater than 1.96, and decision criteria is achieved totally. Meanwhile, compared with the goodness-of-fit standard, the whole goodness-of-fit reaches the basic standard. So we can conclude that the first order factors of information quality, system quality, service quality and activity level would measure these second order factors well.

149.5.2 Model Analysis and Revision

According to the validity inspection and analysis results of second order CFA above, social impact and sociality factors are removed from the original hypothesis model, the goodness-of-fit indexes of the model are summarized as Table 149.1. The ratio Chi-square/freedom degree of the model is $1.828 < 2$, RMSEA is $0.074 < 0.080$, two goodness-of-fit indexes meet the standard. But other goodness-of-fit indexes, such as GFI ($0.658 < 0.9$), AGFI ($0.62 < 0.8$), CFI ($0.828 < 0.9$), TLI ($0.816 < 0.9$) and NFI ($0.689 < 0.8$), are not up to the standards, thus the model need to be modified and optimized.

AMOS offers two model modification indexes, in which modification index MI is used for model expanding, and the critical ratio C.R. is used for model restricting. According to the value of critical ratio and modification indexes, following the principle of modifying one parameter once, the final revised model is shown in Fig. 149.3.

The path of regression coefficients of each factor of the revised full model has increased, the value of C.R. is larger than 1.96, some of the path of significant probability are larger than 0.05 that are sufficiently close to the standard, which shows the modification effect well. Table 149.2 is the path coefficient of the revised model for the first time.

Table 149.1 Goodness-of-fit indexes of full model

Absolute goodness-of-fit index				Relative goodness-of-fit index		
χ^2/df	*GFI*	*AGFI*	*RMSEA*	*CFI*	*NFI*	*TLI*
(1, 5)	>=0.9	>=0.8	<0.08	>=0.9	>=0.8	>=0.9
1.828	0.658	0.621	0.074	0.828	0.689	0.816

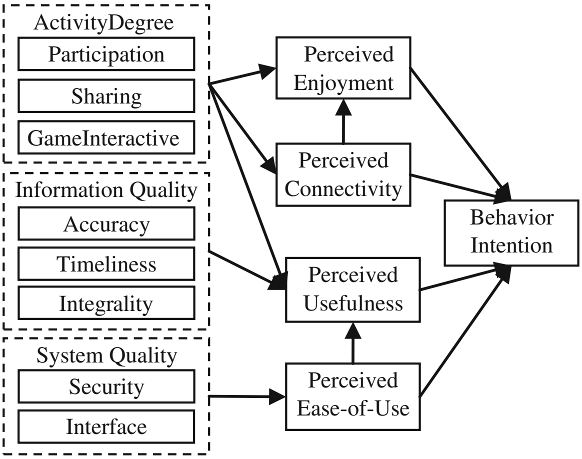

Fig. 149.3 SNS websites user acceptance model based on TAM

The goodness-of-fit of the revised model is shown as Table 149.3. The value of Chi square (1468.758) and freedom (835) improve markedly than the preceding ones. The ratio Chi-square/degree of freedom ($1.759 < 2$) and the value of RMSEA ($0.071 < 0.08$) reach the standard both. Several other goodness-of-fit indexes meet the standard basically. For numbers of latent variables exist in the model, the relationship between factors is relatively complex and some indexes may be influenced greatly by the sample size, the revised model can be regarded as the final model.

149.5.3 Test Results of Model Hypothesis

The model set up in this study originally uses 13 level 1 hypothesis from H1 to H13. As system quality, information quality, service quality, and activity level use multidimensional measure method, H1–H6 each exists level 2 hypothesis. The data analysis results support the rest hypothesis apart from H4c, H5, H7c, H9, H9a, H9b, H9c, H10c and H13.

Table 149.2 The path coefficient of revised full model

Path	Estimated coefficient	Standard deviation (S.E.)	Critical ratio (C.R.)	Significant probability (p)	Standard coefficient
connectedness <— activity	0.562	0.121	4.627	***	0.535
usefulness <— information	0.913	0.232	3.940	***	0.641
easiness <— system	0.702	0.111	6.340	***	0.735
entertainment <— activity	0.758	0.120	6.311	***	0.620
usefulness <— activity	0.343	0.137	2.492	0.013	0.315
entertainment <— connectedness	0.322	0.102	3.147	0.002	0.277
willingness <— usefulness	0.229	0.084	2.731	0.006	0.221
willingness <— entertainment	0.340	0.084	4.070	***	0.368
willingness <— easiness	0.213	0.084	2.530	0.011	0.177
willingness <— connectedness	0.307	0.096	3.205	0.001	0.285
easiness4 <— easiness	1.342	0.121	11.089	***	0.919
easiness3 <— easiness	1.411	0.125	11.283	***	0.942
easiness2 <— easiness	1.000				0.717
easiness1 <— easiness	1.128	0.099	11.415	***	0.790
willingness4 <— willingness	1.034	0.076	13.592	***	0.850
willingness3 <— willingness	0.981	0.068	14.359	***	0.876
willingness2 <— willingness	0.880	0.070	12.591	***	0.813
willingness1 <— willingness	1.000				0.864
usefulness4 <— usefulness	0.944	0.100	9.440	***	0.729
usefulness3 <— usefulness	0.946	0.103	9.225	***	0.716
usefulness2 <— usefulness	1.000				0.803
usefulness1 <— usefulness	1.193	0.117	10.235	***	0.779
entertainment4 <— entertainment	1.000				0.870
entertainment3 <— entertainment	1.147	0.061	18.711	***	0.966
entertainment2 <— entertainment	1.016	0.060	16.805	***	0.918

(continued)

Table 149.2 (continued)

Path	Estimated coefficient	Standard deviation(S.E.)	Critical ratio(C.R.)	Significant probability(p)	Standard coefficient
entertainment1 <— entertainment	0.923	0.078	11.784	***	0.762
connectedness3 <— connectedness	1.214	0.183	6.651	***	0.811
connectedness2 <— connectedness	1.000				0.685
connectedness1 <— connectedness	0.473	0.149	3.171	0.002	0.296

Where *** $p < 0.001$

Table 149.3 Revised goodness-of-fit index of full model

Absolute goodness-of-fit Index				Relative goodness-of-fit Index		
x^2/df	GFI	AGFI	RMSEA	CFI	NFI	TLI
(1, 5)	>=0.9	>=0.8	<0.08	>=0.9	>=0.8	>=0.9
1.759	0.717	0.680	0.071	0.863	0.734	0.852

149.6 Conclusion and Prospect

This study constructs SNS websites user acceptance model based on TAM, and model hypothesis is verified by the structure equation model. The conclusion can be drawn as follows: (1) TAM is basically suitable to SNS websites user acceptance study, but no evidence supports the causality between Perceived Usefulness and Perceived Ease-of-Use. (2) Both Perceived Enjoyment and Perceived Connectivity have a positive correlation with Usage Willingness, and Perceived Connectivity further affects Perceived Enjoyment. (3) The subdivision of external variables reflects the importance of user activity, the activity level influences Perceived Usefulness, Perceived Connectivity and Perceived Enjoyment simultaneously, while the influence of service quality to Perceived Enjoyment is deleted for path of regression coefficients is too little.

Based on above study, some constructive suggestions are proposed to SNS service providers: perfect amusement and e-commerce functions to enhance user' viscidity, pay attention to interface operation to optimize user' experience; provide service in information filtering, sorting and pushing, study deeply on promoting user' activity level.

Acknowledgments Supported by National Natural Science Foundation of China (No. 70802008), Beijing Municipal Natural Science Foundation (No. 9112011).

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Chapter 150
Augmented Reality Based Factory Model Comparison Method

Wei-wei Sun, Jian-feng Lu and De-zhong Li

Abstract Through factory digital mock-up, Digital Factory (DF) technology can save enormous time and cost in factory planning. A problem of the digital factory mock-up maintenance is checking the digital models with the real factory. This paper introduces a method using Augmented Reality (AR) technology to compare the 3D models with the real object in real time. Compared to other measures, this method have the benefit of the cost saving. An experiment demonstrates the proposed method is given at the end of the paper.

Keywords Digital factory mock-up · Model comparison · Augmented Reality · ARToolKit

150.1 Introduction

The factory digital mock-up creates a visual simulation platform for product design and processes planning which has been the key point to optimize processes and offer optimal production scheme (Bracht and Masurat 2005). It works as the foundation of Digital Factory (DF) technology which is widely used in many fields such as aviation, automobile manufacturing, chemical industry and electronic products. Model calibration is a significant issue in the application of factory

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E. Qi et al. (eds.), *The 19th International Conference on Industrial Engineering and Engineering Management*, DOI: 10.1007/978-3-642-38391-5_150,

digital mock-up. Previous methods of model comparison perform inefficient and high-cost, which result in a deep impact on the development of DF. With the expectation of seeking a cost-effective way, Augmented Reality (AR) is proposed to be used in factory digital model comparison (Azuma 1997; Azuma et al. 2001).

150.2 Factory Digital Mock-Up

Factory digital mock-up is a complex of digital archive for the whole life-cycle of a factory. It includes not only 3D model of the factory, but also all the design documents, construction documents, and maintenance information. DF technology, the company to meet the challenges of the twenty-first century an effective means (Liu 2009), which integrates techniques of computer, virtualization, emulation, and networks, plays a significant role in keeping competitive advantage for enterprises. It operates in a collaborative way under 3-D visualization environment and interactive interface. Based on the actual data and models the planned products and production processes can be improved using virtual models until the processes are fully developed and extensively tested for their use in the real factory. DF is a comprehensive approach in factory layout planning, which consists of the 3-D model design of plant (that contains workshop structure, equipments and facilities, material flow and other resources for production) and processes optimization (Zhang et al. 2006). And Factory digital mock-up acts as the prerequisite for operative information concerned.

Factory digital mock-up shows its advantages: engineers make assessment by optimizing the plant layout and resolving conflicts between different parts, then avoid loss due to irrational design, and make data and information of equipments and process flow optimum coordinate with the factory building (Yu et al. 2003). When applied in the aspect of automobile industry, it coordinates materials resource (components and modules of automobile), equipment (machine tools and facilities), workshop (area), and process flow (automobile manufacturing processes) into an IT system. While in the field of pharmaceutical and chemical industry, factory digital mock-up makes it possible to increase product innovation and flexibility.

150.3 Methodology

150.3.1 Method of Factory Digital Mock-Up Comparison

One of the most basic problems currently limiting factory digital mock-up applications is updating. Regular calibrating factory models taking real factory for reference is necessary. There are several model comparison methods prevailed: laser scanning, laser ranging, photograph-visual inspection comparison.

Laser scanner firstly gets the outline integrated data of the object rapidly by Omni-directional scanning, and then generates point cloud records after precisely construction, editing, and modification by computer. Accurate as the data is, the method cannot be widely used because of the high cost. Furthermore, the instrument is unable to display data instantly.

Another approach for updating factory digital mock-up is laser ranging. People can easily obtain elevation and other information of the object, relative position, for example, using the hand-held laser distance meter. However, this kind of method is not appropriate for objects which are precise and complicated.

Photograph-visual inspection means to make a comparison between real factory and the photograph of the factory. It is feasible, however, not accurate.

These methods above are commonly used at present. However, more efforts should be paid to explore new resort which is inexpensive and accurate. Therefore, Augmented Reality based factory model comparison method has been proposed. AR system can present a view of blended scene of real factory environment and digital mock-up. Then the information files can be easily changed to correct the model without complicated manual operation.

150.3.2 Augmented Reality and ARToolKit

Augmented Reality (AR) technology can enhance user's perception of the real world by providing information from computer system. It has the following three characteristics: combine real and virtual, interactive in real time, and registered in 3-D (Azuma 1997; Azuma et al. 2001). AR system has been applied in medical, manufacturing, visualization, path planning, entertainment, military and many other aspect (Quan et al. 2008).

ARToolKit is an AR application development tool kit based on C/C++ language. It has successfully developed indoor registration technology with fiducial mark pattern tracking system. On the condition of controlled environment, it has achieved a fine tracking result. The kit includes camera calibration and mark making tool which can compound Direct3D, OpenGL graphics and VRML scenes into the video stream and support a variety of display devices.

150.3.3 Augmented Reality Based Factory Model Comparison Method

Augmented Reality based factory model comparison method is put forward on the foundation of model-loaded procedure in ARToolKit to blend virtual objects seamlessly with a real factory environment in 3-D. The mainly work flow is shown in Fig. 150.1.

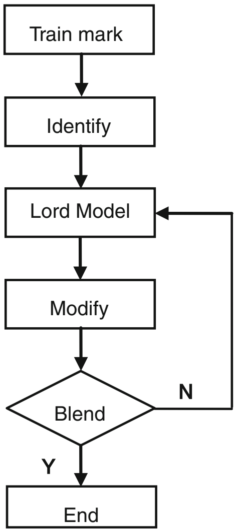

Fig. 150.1 AR based model comparison method work process

Take the case of a section of a cross fire fighting sprinkler and a pipe support in a classroom (as Fig. 150.2 shows) which is too high to measure, just meet the requirements of the experiment object selection.

The operating system is Windows XP with Microsoft Visual studio 2008 development environment. An ordinary CMOS camera (pixels 320 × 240) with 2.0 USB interface and a printed fiducial mark is enough.

Besides provided mark patterns, other patterns also can be designed and trained according with the instruction in ARToolKit. There are some limitations to purely computer vision based AR systems. The larger the physical pattern, the further away the pattern can be detected. What's more, the simple pattern is better. Taking the height of experimental subject into account, a proper coordinate axis offset should be set to get a clearly vision. The mark was fixed in the bottom right-hand corner of the object which is also shown in Fig. 150.2.

DAT files contain the name, size display, rotation and other information of the models. Some new models can be matched with modifying the data as well as model updating. When multiple patterns tracked associate with different 3D object needed, DAT files also can be easily fixed to load more than one pattern.

The virtual model of the classroom was created by Microstation in real proportion and converted into WRL by 3DSMAX. The mark shown in Fig. 150.2 has been trained to match the digital model. The initial vision of the blending scene was rendered as soon as the camera identified the mark, which is shown in Fig. 150.3.

The model and the vision of real object can be rotated synchronously when the camera moved. While immersed in a view of real world, some subtle changes in DAT files can make the model get closer to the object. Then the position can be determined with acceptable precision and accuracy in real time. The modified model was shown in Fig. 150.4.

Fig. 150.2 The real object scanning

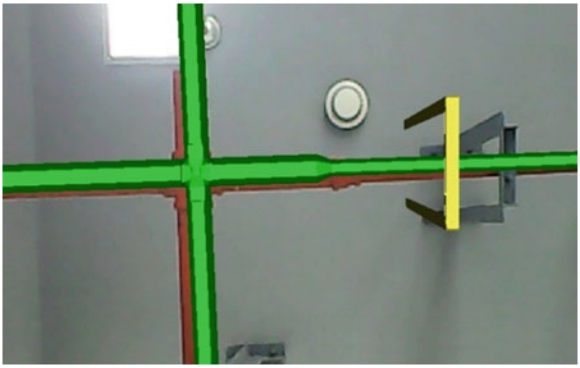

Fig. 150.3 The initial vision of blending

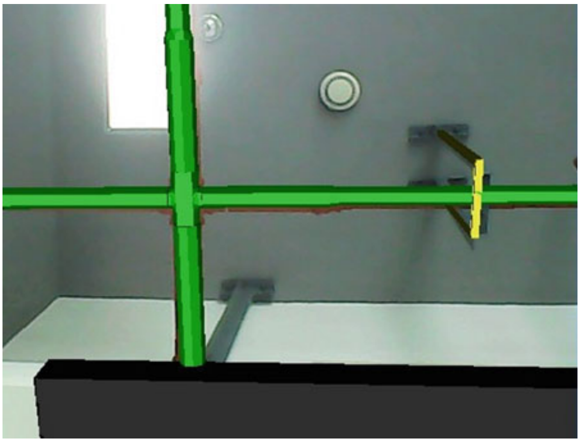

Fig. 150.4 The modified vision of blending

150.4 Conclusion and Future Work

From the conclusions drawn from experiment above, Augmented Reality based factory model comparison method has the following advantages over the existing methods:

(1) Flexibility. The method operated in a direct way which has avoided laser scanning, ranging, or other manual work.
(2) Low-cost. It can do the work well without professional instrument and also result in time-saving.
(3) Accuracy. The real object was blended with the virtual model seamlessly, that lead to errorless result.
(4) Real-time. The real world and the digital model were rendered and combined in real time, and it is possible to reduce time with the use of the method by working more efficiently.

Certainly, there are also some limitations. The method cannot work without document database of the object, while Laser scanning is better. And Laser ranging does well in presenting data like elevation and relative position for some big facilities. It is more efficiently to make a proper combination of these approaches in the real factory.

Since visual interface has advanced the performance, more effort needed to perfect the AR system, which includes tracking visible natural features without prepared marks (Neumann and You 1999), model loaded automatically, project of the controller interface with CAD and so on. The author will do further study in this area to support the factory digital modeling techniques in future.

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Chapter 151
An Evaluation Method Based on Cloud Model for the Credit of High-Tech SMEs

Guo-qiang Zhou, Xue-qing Wang, Rui Liu and Li-guo Sun

Abstract In the process of resolving financing difficulties of high-tech small and medium enterprises (SMEs) in China, the evaluation of credit risk of high-tech SMEs becomes a very challenging problem for the bank. This paper proposes a novel evaluation method based on cloud model to measure the credit risk of Chinese listed high-tech SMEs. Finally, an example is provided for illustrative purpose, and the indexes system of credit evaluation is established of 25 key factors, embedded within five broad categories: credit quality, organizational level, operation level, R&D level and network position. This research shows that it is a better way to use this method to realize transforming qualitative terms described in a natural language to distribution patterns of quantitative values, especially for high-tech SMEs.

Keywords Cloud model · Credit evaluation · Credit risk · Credit scoring · High-tech SMEs

151.1 Introduction

In recent years, the credit of high-tech small and medium enterprises (SMEs) has been gaining much more importance according to their high growth in financial world (Derelioglu and Gürgen 2011). However, the credit guarantee risk is very

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E. Qi et al. (eds.), *The 19th International Conference on Industrial Engineering and Engineering Management*, DOI: 10.1007/978-3-642-38391-5_151,

high in SMEs due to their particular characteristics, which lead to a low credit scoring in general (Chen et al. 2006, 2010). The evaluation of credit risk of high-tech SMEs becomes a very challenging problem for the bank. Therefore, it is essential to develop an accurate credit scoring model for high-tech SMEs for the efficient management of bank.

Most well-known evaluation models use probability or fuzzy set theory to hold randomness or fuzziness respectively, such as the decision trees (Frydman et al. 1985), artificial neural networks (Jensen 1992), genetic algorithm (Walker et al. 1995), etc. Among all of these methods, only cloud model based models consider both aspects of uncertainty. Cloud model is the innovation and development of membership function in fuzzy theory (Di et al. 1999), which transforms qualitative terms described in a natural language to distribution patterns of quantitative values (Deyi et al. 1995). It is successfully used in spatial analysis (Haijun and Yu 2007), target recognition (Fang et al. 2007), intelligent algorithm improvement (Yunfang et al. 2005) and so on.

Therefore, in this paper, we propose an evaluation method based on cloud model for the credit of high-tech SMEs. As credit evaluation is a typical multi-attribute evaluation problem, it is more significant in applying this novel approach to credit evaluation so as to demonstrate its usefulness.

151.2 Methodology

151.2.1 Basic Concepts of Cloud Model

Suppose that r is the language value of domain U, and mapping $Cr(x) : U \rightarrow [0, 1]$, $\forall x \in X(X \subseteq U)$, $x \rightarrow Cr(x)$, then the distribution of $Cr(x)$ in U is called the membership cloud of r, or cloud in short, and each projection is called a cloud drop in the distribution. If the distribution of $Cr(x)$ is normal, it is named normal cloud model.

151.2.2 Numerical Characteristics of the Cloud Model

The normal cloud model is determined by the following three parameters: expectation Ex, entropy En, and hyper entropy He.

Expectation Ex represents the values that mostly stand for this qualitative concept, generally it is the value x that corresponds to the gravity center of the cloud, it should belongs to this qualitative concept hundred percent.

Entropy En is the measurement of the qualitative concept fuzzy degree, it determines the range of the cloud and about 99.74 % cloud drops fall within the

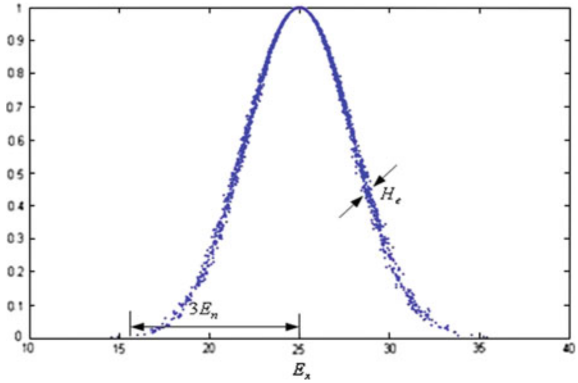

Fig. 151.1 Numerical characteristics of the cloud model

range between $[Ex - 3En, Ex + 3En]$, and it reflects the numerical value range acceptable by concept and represents the margin with double-sided property.

Hyper entropy *He* is the entropy of entropy, it reflects the dispersion degree of the entropy of concept (Lv et al. 2009).

A cloud model can be denoted with vector $C(Ex, En, He)$. The numerical characteristics of the cloud Model are shown in Fig. 151.1.

151.2.3 Normal Cloud Model

Let U be a quantitative universal set and r be the qualitative concept related to U. If $x \in U$, which is a random realization of the concept r, and x satisfies $x \sim N(Ex, En'^2)$, where $En' \sim N(En, He^2)$, and the certainty degree of x on r is

$$\mu = e^{-\frac{(x-Ex)^2}{2(En')^2}} \tag{151.1}$$

Then the distribution of x on U is a normal cloud (Li et al. 2009), and every x is defined as a cloud drop. Given the three parameters *Ex*, *En*, *He*, the normal cloud model can be generated (Deyi and Yi 2005).

Input: *Ex*, *En*, *He*, and the number of the cloud drops n.

Output: n of cloud drops x and their degree μ.

Step 1. Generate a normally distributed random number En'_i with expectation *En* and variance He^2, i.e., $En'_i = NORM(En, He^2)$.

Step 2. Generate a normally distributed random number x_i with expectation *Ex* and variance En'^2_i, i.e., $x_i = NORM(Ex, En'^2_i)$.

Step 3. Calculate

$$\mu_i = e^{-\frac{(x_i-Ex)^2}{2En'^2_i}} \tag{151.2}$$

Step 4. x_i with certainty degree of μ_i becomes one cloud drop in the domain.

Step 5. Repeat Steps 1 to 4 until n cloud drops are generated.

151.2.4 Cloud Model-Based Credit Evaluation Algorithm

In the evaluation method based on cloud model, gravity center of cloud can be denoted as:

$$T = a \times b \tag{151.3}$$

In the type, a means the position of gravity center of cloud, depicting with the expectation value Ex, then if the expectation value Ex changes, the position of gravity center of cloud also corresponds of change; b means the height of gravity center of cloud, depicting with the heavy value of power, which takes often value (0.371).

Therefore, the variety that passes gravity center of cloud can reflect the variety of system information status, the concrete step of the evaluation method based on cloud model is as follows:

Step 1: Confirming index system and index power weight.

Step 2: Denoting the cloud model of each index. Denotation of accurate-number type and language-description type are different in cloud model. Withdraw a set of sample n to constitute to make policy matrix, so the index of accurate-number type can be denoted as follow:

$$Ex = \frac{Ex_1 + Ex_2 + \cdots + Ex_n}{n} \tag{151.4}$$

$$En = \frac{\max(Ex_1, Ex_2, \ldots, Ex_n) - \min(Ex_1, Ex_2, \ldots, Ex_n)}{6} \tag{151.5}$$

And the index of language-description type can be denoted as follow:

$$Ex = \frac{Ex_1En_1 + Ex_2En_2 + \cdots + Ex_nEn_n}{En_1 + En_2 + \cdots + En_n} \tag{151.6}$$

$$En = En_1 + En_2 + \cdots + En_n \tag{151.7}$$

Step 3: Denoting status of the system. n indexes can be depicted with n cloud models, therefore the evaluation system containing n indexes can be denoted with n dimension comprehensive cloud, $T = (T_1, T_2, \ldots, T_n)$, $T_i = a_i \times b_i(i = 1, 2, \ldots, n)$, and when the status of evaluation system occurrences variety, the gravity center changes to $T' = (T'_1, T'_2, \ldots, T'_n)$.

Step 4: Measuring the variety of cloud gravity center based on power-added deviation degree. Suppose that each index of the ideal status of a system is given, then the vector of cloud gravity center can be depicted as $T^0 = a \times b^T = (T^0_1, T^0_2, \ldots, T^0_n)$, $a = (Ex^0_1, Ex^0_2, \ldots, Ex^0_n)$, $b = (b_1, b_2, \ldots, b_n)$, $b_i = w_i \times 0.371$, and the normal status of vector of n dimension comprehensive cloud gravity center is denoted as $T = (T_1, T_2, \ldots, T_n)$.

Generally power-added deviation degree can be used to measure the variety of cloud gravity center between ideal status and normal status. The vector of

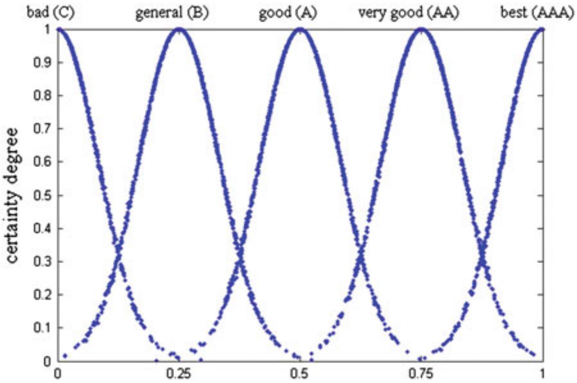

Fig. 151.2 Five-scale evaluation set based on cloud model

n dimension comprehensive cloud gravity under normal status is normalized to $T^G = (T_1^G, T_2^G, \ldots, T_n^G)$, among them,

$$T_i^G = \begin{cases} (T_i - T_i^0)/T_i^0, T_i < T_i^0 \\ (T_i - T_i^0)/T_i, T_i \geq T_i^0 \end{cases} \quad (i = 1, 2, \ldots, n) \tag{151.8}$$

Therefore, power-added deviation degree $\theta (0 \leq \theta \leq 1)$ is denoted as:

$$\theta = \sum_{i=1}^{n} \left(w_i T_i^G \right) \tag{151.9}$$

Under the ideal status, $\theta = 0$.

Step 5: Confirming the evaluation set based on cloud model. Generally, the more numbers of evaluation scales, the more accurate of the evaluation results. According to the feature of high-tech SMEs, five-scale evaluation set is adopted (see Fig. 151.2):

$$\begin{aligned} V &= (v_1, v_2, v_3, v_4, v_5) \\ &= (bad(C), general(B), good(A), verygood(AA), best(AAA)) \end{aligned}$$

151.3 Application Example

151.3.1 Confirming Index System and Sample Data

The index system of credit evaluation of high-tech SMEs includes total 25 indexes, 5 major type as follows: credit quality U_1—register capital U_{11}, history credit condition U_{12}, equipment level U_{13} and guarantee U_{14}; Organizational level U_2—business strategy U_{21}, organization system U_{22}, stability of management team U_{23}, stability of R&D team U_{24}, business proposal U_{25}; Operation level U_3—turnover ratio of accounts receivable U_{31}, turnover ratio of total assets U_{32}, return on total assets ratio U_{33}, operating profit ratio U_{34}, income growth ratio U_{35}, profit growth ratio U_{36}, liquidity ratio U_{37}, debt asset ratio U_{38}, after-sales service U_{39}; R&D level U_4—R&D input U_{41}, intellectual property rights U_{42}, R&D character U_{43}; Network position U_5—market share U_{51}, public relations U_{52}, industry trend U_{53}, geography position U_{54}.

Select ten high-tech SMEs in the second-board Market in China as test sample set $S = \{S_i | i = 1, 2, \ldots, 10\}$, including electronics information, medical apparatus, biological pharmacy, etc. Finance data comes from database in CSMAR Solution (2012), and other qualitative indexes are descripted by the expert evaluation languish. Take company S_1 (NO. 300002) in the test sample set as example, the status of each credit evaluation index are shown in Tables 151.1, 151.2, 151.3, 151.4 and 151.5.

Table 151.1 Status of credit quality U_1

Status	U_{11}	U_{12}	U_{13}	U_{14}
1	37920	33470815	General	Good
2	37920	33470815	General	Good
3	37920	33470815	Good	Good
4	37920	252764848	Good	Very good
Ideal	100000	300000000	Best	Best

Table 151.2 Status of organizational level U_2

Status	U_{21}	U_{22}	U_{23}	U_{24}	U_{25}
1	1.701	Good	Very good	Good	Good
2	1.789	Good	Good	Good	Good
3	1.660	General	Good	Good	Good
4	1.912	Good	Very good	General	Very good
Ideal	2.000	Best	Best	Best	Best

Table 151.3 Status of operation level U_3

Status	U_{31}	U_{32}	U_{33}	U_{34}	U_{35}	U_{36}	U_{37}	U_{38}	U_{39}
1	2.450	0.307	0.121	0.420	0.545	0.266	12.400	0.069	Good
2	0.436	0.073	0.028	0.378	–0.267	–0.245	11.178	0.068	General
3	0.776	0.188	0.075	0.407	0.613	0.816	11.305	0.067	Good
4	1.563	0.255	0.091	0.358	–0.277	–0.577	6.884	0.095	Good
Ideal	1.000	0.100	0.030	0.500	0.200	0.100	10.000	0.050	Best

Table 151.4 Status of R&D level U_4

Status	U_{41}	U_{42}	U_{43}
1	19435331	66500	General
2	29018320	76110	Bad
3	38857798	1076920	Bad
4	12724180	49268370	Bad
Ideal	50000000	50000000	Best

Table 151.5 Status of network position U_5

Status	U_{51}	U_{52}	U_{53}	U_{54}
1	General	Very good	Very good	Best
2	General	Good	Best	Best
3	Bad	Very good	Very good	Best
4	General	Good	Very good	Best
Ideal	Best	Best	Best	Best

151.3.2 Denoting the Cloud Model of Each Index

Normalize the evaluation languish set (bad, general, good, very good, best) to (0, 0.25, 0.50, 0.75, 1), and thus the policy matrix A_1–A_5 is constituted as follow:

$$A_1 = \begin{bmatrix} 37920 & 33470815 & 0.25 & 0.50 \\ 37920 & 33470815 & 0.25 & 0.50 \\ 37920 & 33470815 & 0.50 & 0.50 \\ 37920 & 252764848 & 0.50 & 0.75 \end{bmatrix}$$

$$A_2 = \begin{bmatrix} 1.701 & 0.50 & 0.75 & 0.50 & 0.50 \\ 1.789 & 0.50 & 0.50 & 0.50 & 0.50 \\ 1.660 & 0.25 & 0.50 & 0.50 & 0.50 \\ 1.912 & 0.50 & 0.75 & 0.25 & 0.75 \end{bmatrix}$$

$$A_3 = \begin{bmatrix} 2.450 & 0.307 & 0.121 & 0.420 & 0.545 & 0.266 & 12.400 & 0.069 & 0.50 \\ 0.436 & 0.073 & 0.028 & 0.378 & -0.267 & -0.245 & 11.178 & 0.068 & 0.25 \\ 0.776 & 0.188 & 0.075 & 0.407 & 0.613 & 0.816 & 11.305 & 0.067 & 0.50 \\ 1.563 & 0.255 & 0.091 & 0.358 & -0.277 & -0.577 & 6.884 & 0.095 & 0.50 \end{bmatrix}$$

$$A_4 = \begin{bmatrix} 19435331 & 66500 & 0.25 \\ 29018320 & 76110 & 0 \\ 38857798 & 1076920 & 0 \\ 12724180 & 49268370 & 0 \end{bmatrix} \quad A_5 = \begin{bmatrix} 0.25 & 0.75 & 0.75 & 1 \\ 0.25 & 0.50 & 1 & 1 \\ 0 & 0.75 & 0.75 & 1 \\ 0.25 & 0.50 & 0.75 & 1 \end{bmatrix}$$

Expectation *Ex* and entropy *En* of each index cloud model are calculated by the above policy matrixes (see Tables 151.6, 151.7, 151.8, 151.9 and 151.10).

Table 151.6 Expectation *Ex* and entropy *En* of credit quality U_1

Parameter	U_{11}	U_{12}	U_{13}	U_{14}
Ex	37920	88294323.3	0.375	0.563
En	0	36549005.5	0.042	0.042

Table 151.7 Expectation *Ex* and entropy *En* of organizational level U_2

Parameter	U_{21}	U_{22}	U_{23}	U_{24}	U_{25}
Ex	1.766	0.438	0.625	0.438	0.563
En	0.042	0.042	0.042	0.042	0.042

Table 151.8 Expectation *Ex* and entropy *En* of operation level U_3

Parameter	U_{31}	U_{32}	U_{33}	U_{34}	U_{35}	U_{36}	U_{37}	U_{38}	U_{39}
Ex	1.306	0.206	0.079	0.391	0.154	0.065	10.442	0.075	0.438
En	0.336	0.039	0.016	0.010	0.148	0.232	0.919	0.005	0.042

Table 151.9 Expectation *Ex* and entropy *En* of R&D level U_4

Parameter	U_{41}	U_{42}	U_{43}
Ex	25008907.25	12621975	0.063
En	4355603	8200311.667	0.042

Table 151.10 Expectation *Ex* and entropy *En* network position U_5

Parameter	U_{51}	U_{52}	U_{53}	U_{54}
Ex	0.188	0.625	0.813	1
En	0.042	0.042	0.042	0

Table 151.11 The power weights of indexes

w_i	w_{i1}	w_{i2}	w_{i3}	w_{i4}	w_{i5}	w_{i6}	w_{i7}	w_{i8}	w_{i9}
0.36	0.58	0.14	0.07	0.21	–	–	–	–	–
0.16	0.11	0.19	0.19	0.19	0.33	–	–	–	–
0.23	0.17	0.17	0.07	0.07	0.09	0.09	0.12	0.12	0.11
0.13	0.25	0.59	0.17	–	–	–	–	–	–
0.12	0.56	0.11	0.26	0.07	–	–	–	–	–

151.3.3 Confirming the Power Weight of Indexes

The power weights of indexes are shown in Table 151.11.

151.3.4 Result and Analysis

Through cloud model computation, the credit evaluation value of high-tech SMEs:

$$P_{S_1} = \sum_{i=1}^{5} (w_i P_{U_i}) = 0.487$$

Then the credit evaluation value is input into the five-scale evaluation set based on cloud model (see Fig. 151.3). It will activate two cloud objects: A and B, but the activation degree of A is far larger than B, so the credit evaluation of company S_1 (NO. 300002) obtains A.

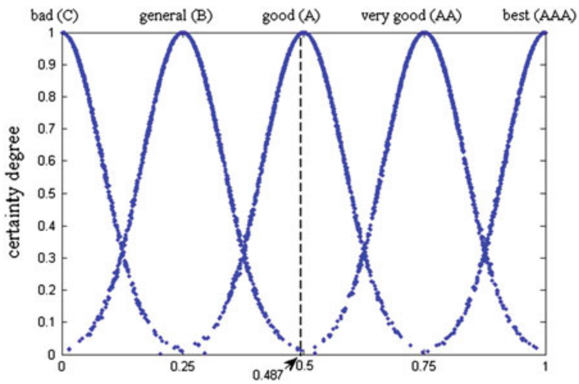

Fig. 151.3 Result of credit evaluation of company S_1

151.4 Conclusion

In this paper, credit evaluation applications in high-tech SMEs are discussed, and an evaluation method based on cloud model is formulated. The application of this model is also illustrated. After this research, we find that it is a better way to use this method to realize transforming qualitative terms described in a natural language to distribution patterns of quantitative values, especially for high-tech SMEs.

Acknowledgments This work was partially supported by the National Natural Science Foundation of China (Grants No. 71172148) and Soft Science Research Projects of the Ministry of Housing and Urban-Rural Construction (Grants No. 2011-R3-18). The authors are also grateful to the referees for their helpful comments and valuable suggestions for improving the earlier version of the paper.

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Chapter 152
The Structural Optimum Design of Erected Circular Medicine-Chest Based on Non-Intervention Motion

Zhi-qiang Zhang, Chao Yun, Xiang-quan Liu and Li-yong Wang

Abstract In this paper, the following studies are completed, including the analysis of the mechanical structure of the erected circular medicine-chest as well as its working principle, discussion of the non-intervention motion conditions of drug containers according to their different motion phases, establishment of the optimum functions of the chain transmission based on the conditions of the non-intervention motion of the containers, obtention of the minimum circular radius of drug containers by application of Matlab as well as the obtention of the design parameters of chain transmission, the simulation model building with UG and ADAMS, and the accomplishment of the motion simulation to prove the success of optimum design based on the non-intervention motion condition of drug containers.

Keywords Erected circular medicine-chest · Optimum functions · Non-intervention motion conditions · Motion simulation

152.1 Introduction

Currently, with the limitation regarding technology, the drug storing system in a hospital pharmacy mainly consists of ordinary shelves, unable to realize the dense storage. In most of the hospital pharmacy, the facilities are old, working environment poor and pharmacists' working intensity high. In addition, there are other problems such as storage complexity, space waste, low working efficiency, etc.

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E. Qi et al. (eds.), *The 19th International Conference on Industrial Engineering and Engineering Management*, DOI: 10.1007/978-3-642-38391-5_152,

The introduction of automated pharmacy system may help to make a better overall plan for the pharmacy, including reducing the drug storage area, effectively carrying out the standardized and automated management of the pharmacy, thus improving drug dispensing and reducing patients' waiting time. The automated pharmacy system may be connected to HIS, putting all the working process of the working staff under the supervision (Li et al. 2007; Liu et al. 2009; Zhao 2009).

The typical equipment is erected circular Medicine-chest, which is originated from the digital-controlled erected circular inventory for the management and storage of accessories and tools in large factories. Basing on the stereoscopic inventory, when adding safety security, humanization design and connecting with the HIS system of hospital, it can be sued for the pharmacy management in the hospital. This is a semi-automatic system, in which the drug dispensary works should be done artificially. This type of automatic system is adaptable to the package of drugs, and can be used as the supplementary equipment to the drug dispensing machine for box-packed drugs as effective assisting (Zhao et al. 2008).

152.2 The Working Principle of the Erected Circular Medicine-Chest

In operation, after two rate reductions, one by reducer, the other by the first chain transmission, the motor of the erected circular medicine-chest drives the two driving chain wheels on the synchronizing shaft, connected to which are two driven wheels fixed on the two half axles accordingly. Driven by the chains, the support rods and balance bars fixed on them make all the drug containers move circularly. Drugs in the movable containers, after receiving the dispensing order, are conveyed along the shortest path and reached the outlets within the shortest time.

152.3 The Analysis of the Conditions in Regard to Non-Intervention Motion of Neighbouring Drug Containers

As shown in Fig. 152.1, the pitch of chain 084 A: 12.7 mm; the span between the two support rods connected to the same container: 18 pitches; the span between the support rods respectively connected to the neighbouring containers: 4 pitches; the number of containers (evenly arranged along the chains): 12.

The pitch radiuses of both driving wheels and driven wheels: *r*; the overhang of the support rods: *c*; the width and height of the containers *W*: and *h*, respectively; the space between the centers of the pivots of the two neighbouring drug

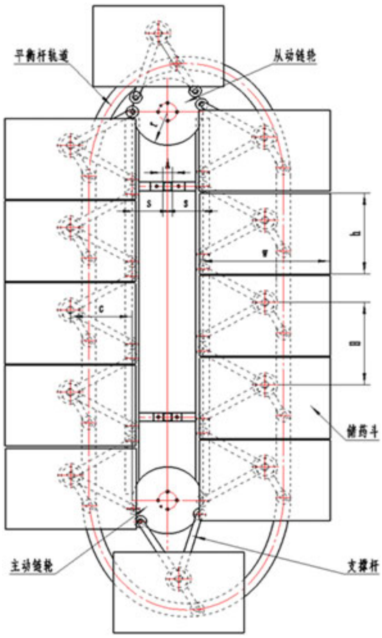

Fig. 152.1 The structure of the erected circular medicine-chest

containers: H; the fixation range for the connection beam: A; the safety space between the connection beam and the drug container: S.

As shown in Fig. 152.2, with the center of driven wheel as the origin of coordinate, the reference coordinate is built; O_1, O_2, O_3, O_4 are, respectively, the joint points of the transmission chain with the Supporting Rods No. 1, 2, 3 and 4 for the Drug Containers A_1, A_2, whose coordinates are (x_1, y_1), (x_2, y_2), (x_3, y_3), (x_4, y_4) accordingly. A_1 is the center of the pivot of Container 1 and Supporting Rods No. 1 and 2, while A_2 is the center of the pivot of Container 2 and Supporting

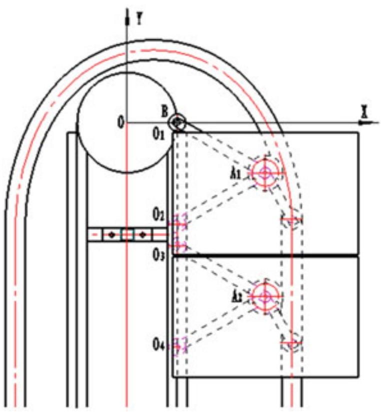

Fig. 152.2 The motion initial positions of the two neighbouring drug containers

Rods No. 3 and 4. The coordinates of A_1, A_2 are $(X_1, Y)_1$, (X_2, Y_2), respectively. The wheels do counterclockwise rotation.

Suppose located in the pitch circle is Point B, which is on the same horizontal line with Center O of the chain wheel, coinciding with O_1, O_2, O_3, O_4 are on the same vertical line. At the beginning of the container motion, O_1 moves unclockwise along the circle with r as the radius, while O_2, O_3, O_4 move upward vertically. When O_2 reaches the same height as that of Point O, O_1 and O_2 move along the same circle. θ_0 is the included angle between OO_1 and OO_2 when O_1, O_2 move along the same circle simultaneously; θ_1 is the angle between OB and X axis; θ_2 is the included angle between OO_2 and OO_3 when O_2, O_2 move along the same circle simultaneously.

Suppose, at the motion of Containers 1 and 2, ΔX and ΔY are the horizontal space and the vertical space of the Centers of Pivots A_1 and A_2, the condition of nonintervention motion is (Zheng 1992):

if $0 \leq \Delta X \leq w$,

$$|\Delta Y| > h, \tag{152.1}$$

When $\Delta X > w$, there must be no intervention between the two drug containers.

152.4 The Optimum Design of Chain Transmission Based on Non-Intervention Motion

152.4.1 The Mathematical Model of the Optimum Design of Chain Transmission

152.4.1.1 The Idea of the Optimum Design of Chain Transmission

The floor area of the erected circular medicine-chest refers to the projected area of the outline of the steelwork, whose length is affected by such factors as the length of the drug containers, while whose width by such factors as the turning radius and the width of the drug containers. After the design of the drug containers, the following references may be given, including the width w and height h of the container, as well as the pitch of the chain. In the design of the chain transmission, available are the best overhang of the support rods c and the pitch radius of the chain wheel r based on the optimum design, thus also available is the minimum turning radius of the container, whose outline of the steelwork is smallest in width. If the length remains the same, the floor area will be reduced, also reduced will be the mechanical deformation of the steelwork.

152.4.1.2 The Design Variables and Objective Functions

Based on the analysis of the condition of nonintervention motion, θ_1 is a independent variable, if the coefficient λ is introduced, and $c = \lambda r$, then λ and r will be variables, so:

$$X = [x_1 \quad x_2 \quad x_3]^T = [\lambda \quad r \quad \theta_1]^T$$

To make available the smallest width of the outline of the steelwork, the Turning Radius L is taken as the objective function, then:

$$L = c + r = r(1 + \lambda) \tag{152.2}$$

Based on the above, the expression of the objective function of the optimum design is:

$$f(x) = x_2(1 + x_1)$$

152.4.1.3 Constraints

① The vertical nonintervention motion of the containers on the left and those on the right:

$$2L \geq w + A + 2s$$

In the practical design, selected are the following data:
$W = 420$ mm, A = 30 mm, $s = 87$ mm

$$\because L = c + r = r(1 + \lambda),$$

$$\therefore r(1 + \lambda) \geq 0.312\,\text{m}$$

② Since the container forces on the support rods, the overhang of the support rod should not be too long in order to ensure the enough strength of the chain. In the design:

$$0.15\,\text{m} \leq c \leq 0.25\,\text{m}$$

$$l{\cdot}\varepsilon \quad 0.15\,\text{m} \leq r\,\lambda \leq 0.25\,\text{m} \tag{152.3}$$

③ The diameter of the chain pitch circle:

$$d = \frac{p}{\sin\frac{180}{z}} \tag{152.4}$$

: the pitch of the chain, here $p = 12.7\,\text{mm}$, $z : 40 \sim 60, 60,$

$$0.081\,\text{m} \le r \le 0.121\,\text{m} \tag{152.5}$$

④ The space between the centers of the pivots of the two neighbouring drug containers:

$\because p = 12.7\,\text{mm}$,

$\therefore H$ (the space between the centers of the pivots of the two neighbouring drug containers moving vertically) must meet the following condition:

$$H \ge h + h_0$$

h_0: the gap between the two neighbouring drug containers moving vertically, generally $h_0 \ge 3\,\text{mm}$.

Then, according to the structure of the chain, $H = np$.

n: the number of the pitches whose total length amounts to h, i.e. the height of the container.

Here $h = 275\,\text{mm}$, and it may be calculated: $n \ge 22$. If $n = 22$,the total number of the pitches will be 264.

$$\therefore H = 279.4\,\text{mm}$$

⑤ $\theta_{0,}\ \theta_2$:

$$\theta_0 = \frac{n_1 360^\circ}{z} = 36 \text{ arc sin}\left(\frac{6.35}{r}\right) \tag{152.6}$$

$$\theta_2 = \frac{n_2 360^\circ}{z} = 8 \text{ arc sin}\left(\frac{6.35}{r}\right) \tag{152.7}$$

n_1: the number of the pitches whose total length amounts to the distance between O_1 and O_2; n_1: the number of the pitches whose total length amounts to the distance between O_2, O_3.

⑥ Based on Formulae (152.3) and (152.4), it may be deduced:

$$1.24 \le \lambda \le 3.08$$

⑦ The scope of: $0 \le \theta_1 \le \pi + 2\theta_0 + \theta_2$

152.4.1.4 The Mathematical Model

Omitted here are the track equations of the centers of Pivots and that of the guide rail of the balance bars

From the above, Variables x_1, x_2 and x_3 may be substituted in the formula, then the optimum mathematical model of the chain transmission based on the conditions of the Non-intervention Motion of the containers may be expressed as follows (Liu 2005; Peng 2007; Wang 2005):

$$\min f(x) = x_2(1 + x_1)$$

$$g_1(x) = 0.312 - x_2(1 + x_1)$$

$$g_2(x) = 0.15 - x_2 x_1$$

$$g_3(x) = x_1 x_2 - 0.25$$

When $0 \le \theta_1 \le \theta_0$,

$$g_4(x) = -\Delta X_1$$

$$g_5(x) = \Delta X_1 - 420$$

$$g_6(x) = 275 - Y_1 + x_2 x_3 - 393.7$$

When $\theta_0 < \theta_1 \le \theta_0 + \theta_2$,

$$g_4(x) = -x_2 + R\cos(x_3 - \theta_0/2)$$

$$g_5(x) = x_2 - R\cos(x_3 - \theta_0/2) - 420$$

$$g_6(x) = 275 - R\sin(x_2 - \theta_0/2) + x_2 x_3 - 393.7$$

When $\theta_0 + \theta_2 < \theta_1 \le \pi$,

$$g_4(x) = -\Delta X_3$$

$$g_5(x) = \Delta X_3 - 420$$

$$g_6(x) = 275 - \Delta Y_3$$

When $\pi < \theta_1 \le \theta_0 + (\theta_2 + \pi)/2$,

$$g_4(x) = -\Delta X_4$$

$$g_5(x) = \Delta X_4 - 420$$

$$g_6(x) = 275 - \Delta Y_4$$

When $\pi < \theta_1 \le 2\theta_0 + \theta_2$,

$$g_4(x) = -\Delta X_5$$

$$g_5(x) = \Delta X_5 - 420$$

$$g_6(x) = 275 - \Delta Y_5$$

$$g_7(x) = 1.24 - x_1$$

$$g_8(x) = x_1 - 3.08$$

$$g_9(x) = 0.081 - x_2$$

$$g_{10}(x) = x_2 - 0.121$$

$$g_{11}(x) = -x_3$$

$$g_{12}(x) = x_3 - \pi - 2\theta_0 - \theta_2$$

152.4.2 The Optimization Based on Matlab

It may be seen from the mathematical model, the optimum design belongs to that of the constrained nonlinear optimization (Su et al. 2004). The Matlab functions to solve the above problem of the constrained nonlinear optimization are FMINCON.

The calculation results based on Matlab are:

$$\lambda = 1.7609,\ r = 113\,\text{mm},\ L_{\min} = 312\,\text{mm}$$

According to formula (152.8), z = 55.88, rounded for z = 56, then

$$d = \frac{p}{\sin\frac{180}{z}} = 226.5\,\text{mm}$$

i.e. $r = 113.25\,\text{mm}$

According to Formula (152.2), if $c = 199.5$ mm, the turning radius of the container $L = 312.75$ mm.

The results of the optimum design include the pitch of the chain: 12.7 mm, the overhang of the support rod: 199.5 mm, the number of the pitches whose total length amounts to the height of the container: 22, the total number of the pitches: 264, the diameter of the pitch: 226.5 mm, the teeth number of the chain wheel: 56, the length of the chain: 3352.8 mm, the theoretical center distance: 1320.8 mm

152.5 The Simulation Analysis Based on UG and ADAMS

According to the results of the optimum design, by applying UG/Model, built up are the models of the chain wheels, chain, containers and support rods etc. The solid model for the analysis of the container motion is built up as shown in Fig. 152.3 (Lijun and Qin 2002).

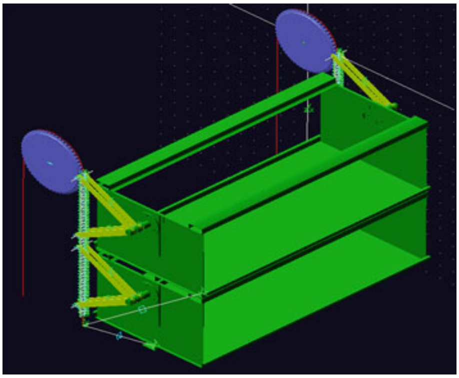

Fig. 152.3 The solid model for the analysis of the container motion

According to the test results of the motion simulation intervention, based on the conditions of the Non-intervention Motion of the containers, feasible are the results that the turning radius of the container $L = 312.75$ mm and the horizontal overhang of the support rods $c = 199.5$ mm.

152.6 Conclusion

The analysis is made on the working principle of the erected circular medicine-chest, built up are the conditions in regard to non-intervention motion of neighbouring drug containers, structure optimization is implemented by the application of Matlab, feasibility of the above mentioned structural optimum design is established by the analysis based on modeling and simulation.

Acknowledgments This work was completed with the support of the project of national natural science foundation of china (No. 51105041)

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Chapter 153
Application of Noise Estimator with Limited Memory Index on Flexure Compensation of Rapid Transfer Alignment

Wei-dong Zhou and Yu-ren Ji

Abstract In order to solve the flexure compensation problem in rapid transfer alignment, the error equations are simplified by noise compensation method firstly. Due to the time variant characteristics of flexure process in time domain, which leads to the fixed noise statistical characteristics cannot follow the variation of actual environment, the noise estimator with limited memory index is proposed. By limiting the memory length of obtained data, too old historical data is giving up and the accuracy of online noise estimator is improved. The final simulation verifies that the method proposed have higher accuracy and faster convergence speed than conventional methods.

Keywords Flexural deformation · Limited memory · Noise compensation · Transfer alignment

153.1 Introduction

Transfer alignment is an important technology of moving base alignment. In the process of transfer alignment, the maneuver of carrier is required and the running environment is getting complicated. As a result, the flexural deformation is one of the most important error sources (Kain and Cloutier 1989; Spalding 1992; Wendel et al. 2004; Xiao and Zhang 2001).

There are mainly two methods for the compensation of flexural deformation, the model construction method and noise compensation method. Because of the high complexity of physical modeling, most researches are turned to the experimental modeling, which uses the markov process to describe the random flexural

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E. Qi et al. (eds.), *The 19th International Conference on Industrial Engineering and Engineering Management*, DOI: 10.1007/978-3-642-38391-5_153,

deformation. The flexure motion is modeled as the third-order markov model driven by the white noise through analysis of experimental data in literature (Kain and Cloutier 1989). On the base of above job, the markov process is further divided into high frequency mode and low frequency mode by literature (Spalding 1992). In literature (Xiao and Zhang 2001), the elastic deformation of aircraft wing is modeled as two-order markov process. The model construction method is realized by computing the Markov parameters based on the similarity principle of power spectral density (Jones et al. 1993; Lim and Lyou 2001; Ross and Elbert 1994; Robert 1996). However, modeling of Markov process will lead to rapid increase of state dimension and computation burden, so a suboptimal filter without the third-order markov model is proposed in literature (Kain and Cloutier 1989), where the strength of system noise is enhanced to compensate the uncertainty of flexural deformation, which is just the noise compensation method. Comparing to model construction method, the complexity of noise compensation method is reduced and the robustness is improved, but the accuracy also declines. It is mainly attributed to the variation of actual noise because of the environmental change while the noise statistics is set to a fixed value in the filter. Adaptive filter can be used to solve this problem (Sage and Husa 1969; Qi and Han 2008; Xiong et al. 2006, 2007). A noise estimation algorithm based on maximum likelihood is proposed for linear system in literature (Mohamed 1999). Noise variance estimator is designed based on EM principle in literature (Bavdekar et al. 2011). An nonlinear noise estimation algorithm is proposed based on maximum-posterior likelihood in literature (Zhao and Wang 2009). Aiming at the rapid time-variant characteristics of flexural deformation, the limited memory index is combined with the noise estimator. By limitation of memory length, the old history data is abandoned to improve the precision of online noise estimator.

In this paper, the system error equation is simplified by noise compensation method firstly. Then the adaptive filter with limited memory index is designed. Finally the effectiveness of the algorithm is verified by simulation.

153.2 System Error Model

153.2.1 Velocity Error Model

The velocity differential equation of master inertial navigation system (MINS) is given by

$$\dot{V}_m^n = C_m^n f_m^m - \left(2\omega_{ie}^n + \omega_{en}^n\right) \times V_m^n + g_m^n \tag{153.1}$$

The velocity differential equation of slave inertial navigation system (SINS) is given by

$$\dot{V}_{s^*}^n = C_{s^*}^n f_s^s - \left(2\tilde{\omega}_{ie}^n + \tilde{\omega}_{en}^n\right) \times V_{s^*}^n + g_{s^*}^n \tag{153.2}$$

where the relations between the variables can be defined by

$$\begin{aligned} f_s^s &= f_m^s + f_l^s + a_f^s + \nabla^s \qquad \delta V = V_{s^*}^n - V_m^n - V_r^n \\ \delta \dot{V} &= \dot{V}_{s^*}^n - \dot{V}_m^n - \dot{V}_r^n \quad \tilde{\omega}_{ie}^n \approx \omega_{ie}^n \quad \tilde{\omega}_{en}^n \approx \omega_{en}^n \quad g_{s^*}^n \approx g_m^n \end{aligned} \tag{153.3}$$

By inserting (153.3) to the difference between (153.1) and (153.2), leading to

$$\dot{V}_{s^*}^n - \dot{V}_m^n = C_{s^*}^n f_s^s - C_{s^*}^n C_m^{s^*} C_s^m \left(f_s^s - f_l^s - a_f^s - \nabla^s\right) - \left(2\omega_{ie}^n + \omega_{en}^n\right) \times \left(V_{s^*}^n - V_m^n\right) \tag{153.4}$$

The lever-arm velocity and its differential equation are given by

$$\begin{aligned} V_r^n &= C_i^n C_s^i \omega_{is}^s \times r^s \\ \dot{V}_r^n &= C_i^n \omega_{ni}^i \times V_r^i + C_s^n \left(\omega_{is}^s \times \omega_{is}^s \times r^s + \dot{\omega}_{is}^s \times r^s\right) \end{aligned} \tag{153.5}$$

where the term of $\omega_{is}^s \times \omega_{is}^s \times r^s + \dot{\omega}_{is}^s \times r^s$ is lever-arm acceleration, which can be written as

$$f_l^s = \omega_{is}^s \times \omega_{is}^s \times r^s + \dot{\omega}_{is}^s \times r^s \tag{153.6}$$

So (153.5) is given by

$$\dot{V}_r^n = C_s^n f_l^s - \omega_{in}^n \times V_r^n \tag{153.7}$$

The Coriolis term is given as

$$\left(2\omega_{ie}^n + \omega_{en}^n\right) \times \left(V_{s^*}^n - V_m^n\right) \approx \omega_{in}^n \times \left(V_r^n + \delta V\right) \tag{153.8}$$

When physical misalignment ψ_a and measurable misalignment ψ_m are small, their direction cosine matrix can be written as

$$\begin{aligned} C_m^{s^*} &= I - \psi_m \times \\ C_s^m &= I + \psi_a \times \end{aligned} \tag{153.9}$$

Using (153.7) (153.8) and (153.9), reducing two-order small terms, (153.4) can be given by

$$\delta \dot{V} = C_{s^*}^n (\psi_m - \psi_a) \times f_s^s - \left(2\tilde{\omega}_{ie}^n + \tilde{\omega}_{en}^n\right) \times \delta V + C_{s^*}^n \left(a_f^s + \nabla^s\right) \tag{153.10}$$

153.2.2 Attitude Error Model

Differential equation of direction cosine matrix of ψ_m can be written as

$$\dot{C}_{s^*}^m = C_{s^*}^m \omega_{ms^*}^{s^*} \times \tag{153.11}$$

where

$$\omega_{ms^*}^{s^*}\times = \dot{\psi}_m\times \tag{153.12}$$

Expansion and differentiation of (153.11) results in

$$\dot{C}_{s^*}^m = C_n^m\omega_{mn}^n \times C_{s^*}^n + C_n^m C_{s^*}^n \tilde{\omega}_{ns}^s\times \tag{153.13}$$

By inserting (153.11), (153.12) and (153.13) leading to

$$\dot{\psi}_m\times = C_n^{s^*}\omega_{mn}^n \times C_{s^*}^n + \tilde{\omega}_{ns}^s\times \tag{153.14}$$

thus

$$\dot{\psi}_m = -C_m^{s^*}C_s^m\omega_{nm}^s + \tilde{\omega}_{ns}^s \tag{153.15}$$

where

$$\tilde{\omega}_{ns}^s = \omega_{is}^s - \tilde{\omega}_{in}^s \tag{153.16}$$

$\tilde{\omega}_{in}^s$ is instruction angular velocity computed by SINS, ω_{is}^s is measured angular rate which can be written as

$$\omega_{is}^s = \omega_{im}^s + \omega_f^s + \varepsilon^s \tag{153.17}$$

Using (153.16), (153.17), (153.15) becomes

$$\dot{\psi}_m = -C_m^{s^*}C_s^m\omega_{nm}^s + \omega_f^s + \varepsilon^s + \omega_{im}^s - \hat{\omega}_{in}^s \tag{153.18}$$

where

$$\omega_{im}^s - \hat{\omega}_{in}^s \approx \omega_{nm}^s \approx \tilde{\omega}_{ns}^s \tag{153.19}$$

According to (153.9), by inserting (153.19) to (153.18) leading to the attitude error model

$$\dot{\psi}_m = (\psi_m - \psi_a)\tilde{\omega}_{ns}^s + \omega_f^s + \varepsilon^s \tag{153.20}$$

153.2.3 Inertial Instrument Error Model

The error model of accelerometer and gyro are composed by constant drift and white noise, which can be written as

$$\nabla = \nabla_c + \omega_a,\ \dot{\nabla}_c = 0 \tag{153.21}$$

$$\varepsilon = \varepsilon_c + \omega_g,\ \dot{\varepsilon}_a = 0 \tag{153.22}$$

153.2.4 Analysis of System Error Model

According to the error model of small misalignments, the state equation and measurement equation are linear equation with additive noise, whose discrete general formula can be given by

$$\begin{cases} x_k = \Phi_{k-1} x_{k-1} + w_{k-1} \\ z_k = H_k x_k + v_k \end{cases} \tag{153.23}$$

where x_k is the state of $n \times 1$ vector and z_k is the observable variable of $m \times 1$ vector. Process noise w_k and measurement v_k are zero mean white noise and uncorrelated, whose prior statistical characteristics can be expressed as

$$\begin{cases} E[w_k, w_j^T] = Q_k \delta_{kj}, \\ E[v_k, w_j^T] = R_k \delta_{kj} \end{cases} \tag{153.24}$$

where δ_{kj} is the function of Kronecker-δ. The flexure process a_f and ω_f are chosen as the state variables

$$X = [\,\delta V \quad \psi_m \quad \psi_a \quad \nabla \quad \varepsilon \quad a_f \quad \omega_f\,] \tag{153.25}$$

When Markov model is used to describe the flexure process, the dimension of state will increase rapidly. If the east channel and west channel are considered and the two-ordered Markov model is adopted, the required state variables will be 8. If all the three channels are described by three-ordered Markov model, the required state variables will be 18. So the system model needs to be simplified and the state equation can be written by

$$x_k = \Phi_{k-1} x_{k-1} + \Delta\Phi_{k-1} + w_{k-1} \tag{153.26}$$

where $\Delta\Phi_{k-1}$ can be written by

$$\Delta\Phi_{k-1} = \begin{bmatrix} C_{s^*}^n a_f^s \\ \omega_f^s \end{bmatrix} \tag{153.27}$$

So the process noise is adjusted as

$$w_{k-1}^* = \Delta\Phi_{k-1} + w_{k-1} \tag{153.28}$$

In time domain, the uncertainty caused by flexure process is presented as zero mean oscillation curve, which means the process noise obeys the statistical characteristics of zero mean and unknown variance. So the compensated noise needs to be estimated online.

153.3 Design of Adaptive Filter Based on Noise Estimator with Limited Memory Index

153.3.1 Classic Kalman Filer

When error model is built accurately and the system noise can be obtained correctly, the classic Kalman filter can be written by

(1) Set of initial value

$$\begin{aligned} \hat{x}_0 &= E(x_0) \\ P_0 &= E\left[(x_0 - \hat{x}_0)(x_0 - \hat{x}_0)^T\right] \end{aligned} \tag{153.29}$$

(2) Time and measurement update

$$\hat{x}_{k,k-1} = \Phi_{k-1}\hat{x}_{k-1} \tag{153.30}$$

$$P_{k,k-1} = \Phi_{k-1}P_{k-1}\Phi_{k-1}^T + Q_{k-1} \tag{153.31}$$

$$\hat{z}_{k,k-1} = H_k\hat{x}_{k,k-1} \tag{153.32}$$

(3) State update

$$K_k = P_{k,k-1}H_k^T\left[H_kP_{k,k-1}H_k^T + R_k\right]^{-1} \tag{153.33}$$

$$P_k = [I - K_kH_k]P_{k,k-1} \tag{153.34}$$

$$\hat{x}_k = \hat{x}_{k,k-1} + K_k\left[z_k - z_{k,k-1}\right] \tag{153.35}$$

153.3.2 Noise Estimator Based On Limited Memory Length

According to the analysis of Sect. 153.2, the variance of compensated noise is unknown, so the noise estimator will be designed in this section. The process noise estimator based on maximum likelihood principle can be given by

$$\hat{Q}_k = \frac{1}{k}\sum_{i=1}^{k}\left\{K_i\left[\left(z_i - h_i\hat{x}_{i,i-1}\right)\left(z_i - h_i\hat{x}_{i,i-1}\right)^T\right]K_i^T - \Phi_{i-1}P_{i-1}\Phi_{i-1}^T + P_i\right\} \tag{153.36}$$

Because the observability needs to be increased by adopting required maneuvers, the running environment will become complicated and the statistical characteristics of compensated noise vary rapidly, as a result the effectiveness of too old history data will become weak and even negative. So the length of history data is limited to improve the accuracy of process noise estimator, which will be expressed as follows. Firstly the weighted coefficient $\{\beta_i\}$ is given by

$$\sum_{i=1}^{m} \beta_i = 1, \quad \beta_i = \beta_{i-1} b \tag{153.37}$$

where m is the memory length, b is forgetting factor. According to (153.37), β_i can be further deduced as

$$\beta_i = \frac{b^{i-1} - b^i}{1 - b^m} \tag{153.38}$$

By inserting (153.38) to (153.36), leading to

$$\hat{Q}_k = \frac{1}{k} \sum_{i=1}^{k} \beta_{k+1-i} \left\{ K_i \left[\left(z_i - h_i \hat{x}_{i,i-1} \right) \left(z_i - h_i \hat{x}_{i,i-1} \right)^T \right] K_i^T - \Phi_{i-1} P_{i-1} \Phi_{i-1}^T + P_i \right\} \tag{153.39}$$

So the process noise estimator based on limited memory length is given by

$$\begin{aligned}\hat{Q}_k =& b\hat{Q}_{k-1} + \frac{1-b}{1-b^m} \left\{ K_k \left[\left(z_k - H_k \hat{x}_{k,k-1} \right) \left(z_k - H_k \hat{x}_{k,k-1} \right)^T \right] K_k^T - \Phi_{k-1} P_{k-1} \Phi_{k-1}^T + P_k \right\} \\ & - \frac{b^m - b^{m+1}}{1-b^m} \left\{ K_{k-m} \left[\left(z_{k-m} - H_{k-m} \hat{x}_{k-m,k-m-1} \right) \left(z_{k-m} - h_{k-m} \hat{x}_{k-m,k-m-1} \right)^T \right] K_{k-m}^T \right. \\ & \left. - \Phi_{k-m-1} P_{k-m-1} \Phi_{k-m-1}^T + P_{k-m} \right\}\end{aligned} \tag{153.40}$$

where the memory length m can be adjusted according to actual environment.

153.4 Simulation and Analysis

The rapid transfer alignment of shipboard aircraft is simulated, where the swing maneuver of ship is driven by sea wave. To obtain better observability, velocity/attitude matching is selected whose measurement equation is given by

$$z = Hx + v \tag{153.41}$$

According to Sect. 153.2, after compensation of process noise, the state can be given by

$$X = [\delta V \quad \psi_m \quad \psi_a \quad \nabla \quad \varepsilon] \tag{153.42}$$

So the observing matrix can be written as

$$H = \begin{bmatrix} I_{2\times2} & 0_{2\times3} & 0_{2\times8} \\ 0_{3\times2} & I_{3\times3} & 0_{3\times8} \end{bmatrix} \quad (153.43)$$

The initial position of ship is 45.6° north latitude and the velocity is $V_n = 10$ m/s. The ship move northward and the swinging model driven by the sea wave can be expressed as

$$\begin{aligned} \theta_x &= \theta_{xm}\sin(\omega_x t + \theta_{x0}) \\ \theta_y &= \theta_{ym}\sin(\omega_y t + \theta_{y0}) \\ \theta_z &= \theta_{zm}\sin(\omega_z t) + \theta_{z0} \end{aligned} \quad (153.44)$$

The swinging amplitude θ_{xm}, θ_{ym}, θ_{zm} are 5°, 4°, 2°, the frequency ω_x, ω_y, ω_z are 0.18, 0.13, 0.06 Hz and initial angle θ_{x0}, θ_{y0}, θ_{z0} are all set 0°. The gyro constant drift of SINS is set 0.05°/h and accelerometer offset is set 10^{-3} g. The variance (variances) of white noise of gyro and accelerometer are set respectively $(0.001°/\text{h})^2$ and $(10^{-4}\ \text{g})^2$. Misalignments ψ_x, ψ_y, ψ_z are 15′, 30′, 1°. Simulation time is 100 s.

The two-ordered Markov model is adopted for the true flexural deformation and the model coefficients of three channels are set $\beta_x = 0.1$, $\beta_y = 0.2$, $\beta_z = 0.4$, simultaneously the variance of white noise are $(0.05/\text{h})^2$ and $(10^{-3}\ \text{g})^2$. Scheme 1 takes the same model but with different coefficients, which are set $\beta_x = 0.2$, $\beta_y = 0.3$, $\beta_z = 0.5$. Noise compensation method is used in Scheme 2, but the statistical characteristics of noise is set a fixed value, in which the compensation coefficient is set 1.5. The process noise estimator with limited memory index is used in Scheme 3, the memory length m is set 10 and forgetting factor b is set 0.3. The filter frequency is set 5 Hz. Estimation results of three schemes are shown from Figs. 153.1, 153.2, and 153.3.

There are slight deviations in model coefficients between true model and Scheme 1. However, it can be seen from the simulation results that in Scheme 1

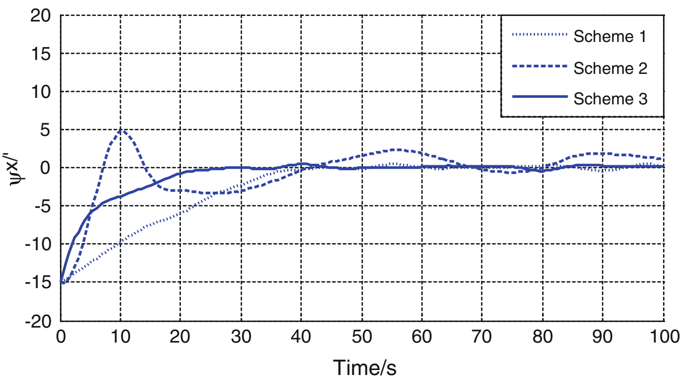

Fig. 153.1 Estimation error of misalignment ψ_x

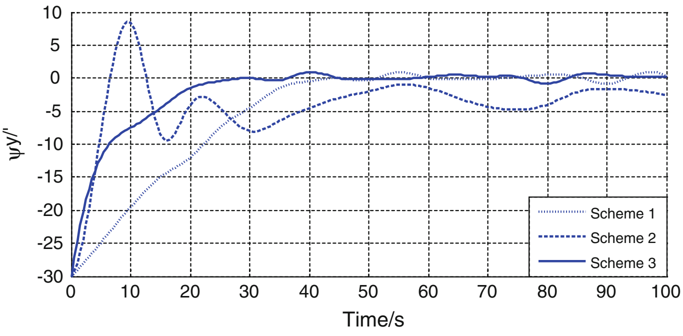

Fig. 153.2 Estimation error of misalignment ψ_y

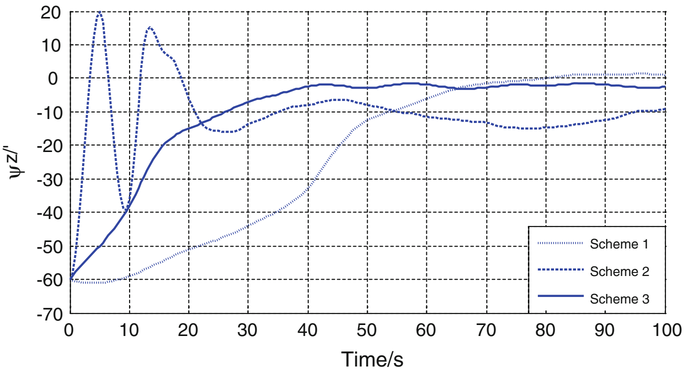

Fig. 153.3 Estimation error of misalignment ψ_z

the standard deviations of three misalignments are 0.32′, 0.67′, 2.19′. But limited to the high computation burden, the convergence speed declines. In Scheme 2, because of the reduction of state, the convergence speed is improved. However, the cost is the declining of filter accuracy since the fixed noise statistical characteristics cannot follow the variation of actual environment. The standard deviations of three misalignments are 1.43′, 3.56′, 12.53′. On the basis of Scheme 2, Scheme 3 uses noise estimator with limited memory index to real-time track the system noise. The standard deviations of three misalignments are 0.28′, 0.76′, 2.55′, which are better than Scheme 2 and faster than Scheme 1.

153.5 Conclusion

After model building of rapid transfer alignment, the error equations are simplified by noise compensation method. Aiming at the time variant characteristics of flexure process in time domain, the noise compensation problem of flexural deformation is transformed to the problem of online estimation of system noise, which is dealt with the noise estimator based on limited memory length. The final simulation shows that, when external interference cannot be obtained accurately, the method proposed by this paper can provide a new idea for the compensation of flexural deformation.

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Chapter 154
A Cumulative SaaS Service Evolution Model Based on Expanded Pi Calculus

Jun He, Tong Li and De-hai Zhang

Abstract SaaS emphasizes the concept of "customization" and it can provide a higher level of service customizability, dynamic adaptability and customer transparency. By abstracting software functions into "services", expanding the grammar of the typical Pi calculus, and identifying the mapping between the progress theory and service evolution, this paper proposes a cumulative evolution model of SaaS service based on an expanded Pi calculus. It first analyses four atom cumulative evolution models and then presents the integration among them. The four atom cumulative evolution models are respectively the sequential, the reverse, the simultaneous and the consecutive and for each of the models, the formula is accordingly demonstrated. The model this paper proposes is supposed to contribute to the customizability and dynamic adaptability of SaaS services so that the evolutionary process of the services should be more transparent for customers and thus the customers should have better on-line experiences.

Keywords SaaS · Expanded Pi calculus · Cumulative evolution · Model

154.1 Introduction

Software as a Service (SaaS) is an internet-based software service supply and delivery model (Wei 2011). It can provide services exactly as customers appoint, namely "services provided as appointed". Different from the customer groups the traditional software services are faced with, customer groups nowadays are more

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E. Qi et al. (eds.), *The 19th International Conference on Industrial Engineering and Engineering Management*, DOI: 10.1007/978-3-642-38391-5_154,

mixed and harder to approach as their requirements are open to more rapid changes and variations. To meet their needs, a new revolutionary software service that permits an enhanced customizability and dynamic adaptability is called for.

SaaS software is just the right thing that comes in. Compared to traditional software, it can orchestrate much more complex evolution processes and it can deal with the frequent corrections and replacements caused by both universal and particular needs of the customers simultaneously. However, whether the post-evolution services are customer-friendly or not poses challenges. Therefore, SaaS has to be evolved on a coarsest-grained layer so that the evolution process is unknown and transparent to customers to guarantee a better on-line experience on their part. For the moment, the biggest challenges posed by the evolution of SaaS services range from the problem of the coarsest-grain, transparency to progressiveness.

A number of researches on the evolution of SaaS software have been conducted. However, they are mainly focused on the issue of "multi-tenant versus one instance" for the customization of work procedures and measures for data safety (Luo and Wu 2011; Liang et al. 2010; Bezemer and Zaidman 2009). One research (Liang et al. 2011) brings forward, from the perspective of work flow, an evolution model and its method that supports a supreme work flow; one research is on evolution model and data dependence (Liu et al. 2010); another research, though yet to be expressed in formulas, proposes the concept of services in evolution to describe the incessant changes of services and a possible solution to the cooperation across services (Ramil and Lehman 2002).

With the expanded Pi calculus (EPI) as its descriptive formula, this paper proposes a cumulative model to support the evolution of SaaS services so as to bring forward a theoretical formula that will be applicable to an automatic evolution of services in prospect.

154.2 SaaS Services Formularized in Expanded Pi Calculus

154.2.1 Expanded Pi Calculus

The Pi Calculus (Milner 1999) is the calculus model brought forward by Milner and others on the basis of Calculus of Communication System (CCS) to depict and analyze the top structure in change. It is often used to describe inter-process interactions and concurrent communicative operations. The formula can be put in several ways (Sangiorgi and Walker 2003). The one my paper adopts is in its ordinary form. It can be defined as following (Liao et al. 2005):

Definition 154.1 Suppose N is a set of an infinite number of names, and i, j, k, l, m, n,... are the names of the N; capital letters A, B, C,... denote different processes; and capital letters P, Q, R,… stand for the expressions of the processes, then the basic grammar is as in (154.1).

$$P ::= 0|\bar{i}j.P|j(i).P|\tau.P|P+Q|P|Q| \\ (i)P|[i=j]P|A(i,j,\ldots,k) \tag{154.1}$$

Besides:

1. 0 indicates 0 process, which means no operation ever occurs.
2. $P+Q$ indicates a selective execution of process P or Q
3. Prefixed expression differentiates no positive prefix or negative prefix. $\bar{i}j$ is seen as a negative prefix, $\bar{i}j.\ P$ denotes: to output the name j at the interface i, and then execute P; $j(i)$is a positive prefix, $j(k/i).P$ indicates: to input a random name k at the interface j, then execute $P\{k/i\}$ (k/i means replacing i with k). The symbol i in the prefixed expression is a pass, a link that connects two reciprocal interfaces i and $\bar{i}$; $\tau.P$ is seen as a dumb prefix used to indicate the invisible operations out of process.
4. $P|Q$ is the expression for parallel processes, it means process P and process Q are executed concurrently.
5. $(i)P$ is the expression for restrictive processes, it means the new pass i permits no ulterior operation; whereas P as interior communication is allowed to go through the pass i.
6. $[i=j]P$ is the expression for identical processes, it means when i and j are identical passes, their operations are the same as P, or the process is a 0 process.
7. $A(i,j,\ldots,k)$ is the symbol of process, $i,j,\ldots,k$ refers to any of the random processes.

These are just a brief review of the definitions of the Pi calculus; further explorations into it are provided in other papers (Milner 1999; Sangiorgi and Walker 2003). The Pi calculus has proven to be a very useful formula when it comes to applications like the description of procedural activities, structuring of models etc. However, it can scarcely be used to depict services as it cannot denote the proprietary relationship between a sub-service and the service sequence the sub-service belongs to, nor can it properly describe the restrictive conditions that determine transfers from service to service. Due to some original understandings of the characteristics of SaaS service, and inspirations coming from the perceptive literature (Zhou and Zeng 2009), I first propose in this paper an expansion of the typical Pi calculus so as to present the cumulative model in the end (Zhou and Ceng 2007).

Definition 154.2 The expansion of the typical Pi calculus is mainly in two aspects:

1. Use the symbol "→", an indicator of two-tuple relationship, to describe the proprietary relationship in which the collection N includes an infinite number of names. $A \rightarrow B$ signifies that the name A belongs to B. The employment of the proprietary relationship can properly describe the belonging of a sub-process to

the process of an upper level, for example: $i \rightarrow S_i$ means the process i belongs to the process sequence S_i, and thus the analysis of the relationship of processes can be limited to a certain layer.

2. Use the symbol "[θ]" to describe the restrictive conditions of process transfers, while θ is the symbol of the conditions responsible for transfers, and it can be taken as $[i = j]P$, an expression expanded but identical, i.e. $[\theta]P \supset [i = j]P$. Symbols ! and ? respectively indicate the output and input of data; $i!x$ indicates the output of data x through data channel$i$; and $j?y$ indicates the input of data y through data channel j. Expressions $[\theta_i]!x$ and $[\varphi_j]?x$ are used to indicate the conditions that invoke the transfer of processes as well as the emission and reception of data. And $[\theta_i]!x$ indicates the process i sends the data x under the condition of θ_i; $[\varphi_j]?x$ indicates the process j receives the data x under the condition of φ_j.

154.2.2 Description of SaaS Services

When SaaS software functions are abstractedly taken as services, the evolution of services can be applied to realize the dynamic change and maintenance of software. As the evolution is basically the changes in structure, property and operation of SaaS services (Papazoglou 2008), so to build an organizational structure that encompasses all these factors can not only illustrate the relationship between an upper and a lower service layer, define the property of services and the type of operations, demonstrate the mapping relationships among them, but also illuminate the organic integration of the service structures and the mechanism of service solicitations SaaS software involves. Based on the analysis of the evolution of services and the mapping relationship embodied by the expanded Pi calculus, the following definition is made:

Definition 154.3 Suppose there are SaaS services whose sequences are as many as n, it can be put as S_i, and $i = \{1, 2, \ldots, n\}$. S_i is a set of atom services, then it follows $S_i = \{r | r \rightarrow S_i\}$. The atom service r in the expression is equal to the process in the expanded Pi calculus.

Definition 154.4 A service schema of the SaaS services can be defined as a quintuple, as in (154.2).

$$\sum s = (S, A, E, C, f) \tag{154.2}$$

In it:

1. S indicates the set of atom services of the SaaS services,$S = \{S_1, S_2, \ldots, S_n\}$.

2. $A = \bigcup_{i=1}^{n} A_i$ is the set of the service operations that each of the atom services provides, $A_i = \{a_{i1}, a_{i2}, \ldots, a_{in}\}$ indicates the set of the service operations that the atom service S_i provides.
3. E indicates the set of the sequential execution processes provided by the atom service S, an execution process refers to a partly sequence that consists of nuclear services, for example: $S_1 \prec S_2 \prec S_3 \prec S_4 \prec S_5 \prec \cdots$ is a partial sequence.
4. C is a partial sequence of a service operation, for example: $(S_1, a_{11}) \prec (S_2, a_{21}) \prec (S_3, a_{31}) \prec (S_4, a_{41}) \prec (S_5, a_{51}) \prec \cdots$ is a partial sequence of a service operation.
5. The expression $f : A \to A^*$ is to define the operational mapping function of the services from an upper layer to a lower one, and f justifies the expression $f(S, E) = C$, and f can be defined as a recursive function, it indicates a SaaS service can be multiplied into a number of layers and grains according to actual customer needs. Such a rendering of the definition can greatly improve the applicability of the formula.

154.3 The Cumulative Evolution Model of SaaS Services

In the running process of a SaaS software, customer needs and commercial logic keep changing. Though the changes are only relevant to some of the customers, the evolution process is supposed to be transparent and cumulative to all users undistinguished. To improve the service customizability and dynamic adaptability of a SaaS software, this paper proposes an cumulative evolution model of the SaaS, and the model is discussed in terms of four atom evolutions and the integration of them. The four nuclear evolutions are: the cumulative evolution in sequential order, the cumulative evolution in reverse order, the cumulative evolution in parallel order, and the cumulative evolution in corrective order.

Definition 154.5 The Service Schema proposed in Definition 154.4 can be used to express a SaaS service: $\sum s = (S, A, E, C, f)$. The capitalized A, B, C,… each indicates one of the service serials represented by services i, j, r,… The symbol f, as a nuclear service, can be evolved into a mapping function in operation, standing for the mapping relationship of the service sequences prior to and post an evolution.

154.3.1 The Sequential Cumulative Evolution

The sequential cumulative evolution means to add the service r to the sequence S, and the sequence can be transformed into a new service sequence as a result. The sequential cumulative evolution is an atom form for other evolutions.

The service sequence S before evolution can be expressed as: $i \to S_i \bullet [\theta_i]!x \bullet [\varphi_j]?x \bullet j \to S_j$, in which: $A = i \to S_i \bullet [\theta_i]!x \bullet 0$, $B = [\varphi_j]?x \bullet j \to S_j$.

The added service can be expressed as $\mathrm{r} \to \mathrm{S}_r$, thus, the sequential cumulative evolution of the service sequence S is:

$$f_{SIE} : i \to S_i \bullet [\theta_i]!x \bullet [\varphi_r]?x \bullet r \to S_r \bullet [\theta_k]!y \bullet [\varphi_j]?y \bullet j \to S_j \tag{154.3}$$

in which:

$$A = i \to S_i \bullet [\theta_i]!x \bullet 0, C = [\varphi_r]?x \bullet r \to S_r \bullet [\theta_k]!y, B = [\varphi_j]?x \bullet j \to S_j$$

With the running of the evolution of service sequence, changing are the data receiving and sending conditions responsible for the happening of evolution. This again suggests that the evolution process of a service sequence is always dynamic and incessant.

154.3.2 The Reverse Cumulative Evolution

The reverse cumulative evolution is the opposite of the sequential cumulative evolution.

The service sequence S before evolution can be expressed as in (154.4).

$$i \to S_i \bullet [\theta_i]!x \bullet [\varphi_j]?x \bullet j \to S_j \bullet [\theta_j]!y \bullet [\varphi_k]?y \bullet k \to S_k \tag{154.4}$$

in which:

$$A = i \to S_i \bullet [\theta_i]!x \bullet 0,\ B = [\varphi_j]?x \bullet j \to S_j \bullet [\theta_j]!y \bullet 0, C = [\varphi_k]?y \bullet k \to S_k$$

The cumulative service in reverse can be expressed as $j \to \mathrm{S}_j$.

The cumulative evolution of service sequence S in reverse can be expressed as in (154.5).

$$f_{SIE}^{-1} : i \to S_i \bullet [\theta_i]!z \bullet [\varphi_k]?z \bullet k \to S_k \tag{154.5}$$

in which:

$$A = i \to S_i \bullet [\theta_i]!z \bullet 0, B = [\varphi_k]?z \bullet k \to S_k$$

154.3.3 The Parallel Cumulative Evolution

The parallel cumulative evolution supports the concurrent running of two services, of which one is an inset and both services can be executed as parallels. Once one service is added as an inset, then the number of messages sent or received by the prepositive and postpositive service of either of them will increase from 1 to 2.

The service sequence S prior to the evolution can be expressed as in (154.6).

$$\begin{gathered} i \rightarrow S_i \bullet [\theta_i]!x \bullet \left[\varphi_j\right]?x \bullet j \rightarrow S_j \bullet [\theta_k]!y \bullet \\ [\varphi_k]?y \bullet k \rightarrow S_k \bullet [\theta_k]!y \end{gathered} \tag{154.6}$$

In which:

$$\begin{aligned} &A = i \rightarrow S_i \bullet [\theta_i]!x \bullet 0,\ B = \left[\varphi_j\right]?x \bullet j \rightarrow S_j \bullet [\theta_k]!y \bullet 0, \\ &C = [\varphi_k]?y \bullet k \rightarrow S_k \bullet [\theta_k]!y \end{aligned}$$

The cumulative service can be expressed as $r \rightarrow S_r$, and u, v indicate the inlet and outlet of message the service r is responsible for.

The parallel cumulative evolution of the service serial S thus can be expressed as in (154.7).

$$\begin{aligned} &f_{PIE} : i \rightarrow S_i \bullet ([\theta_i]!x|\left[\theta_i'\right]!u) \bullet \\ &((\left[\varphi_j\right]?x \bullet j \rightarrow S_j \bullet \left[\theta_j\right]!y)|([\varphi_r]?u \bullet \\ &r \rightarrow S_r \bullet \left[\theta_r\right]!v)) \bullet ([\varphi_k]?y|\left[\varphi_k'\right]?v) \bullet k \rightarrow S_k \end{aligned} \tag{154.7}$$

In which:

$$\begin{aligned} &A = i \rightarrow S_i \bullet ([\theta_i]!x|\left[\theta_i'\right]!u) \bullet 0, B = \left[\varphi_j\right]?x \bullet j \rightarrow S_j \bullet \left[\theta_j\right]!y \bullet 0, \\ &C = ([\varphi_k]?y|\left[\varphi_k'\right]?v) \bullet k \rightarrow S_k \end{aligned}$$

154.3.4 The Adaptive Cumulative Evolution Model

When a service can no longer appeal to customers, it entails the replacement of the old service with either one that is adapted or one that is brand new.

The service sequence S before evolution can be expressed as in (154.8).

$$i \rightarrow S_i \bullet [\theta_i]!x \bullet \left[\varphi_j\right]?x \bullet j \rightarrow S_j \bullet \left[\theta_j\right]!y \bullet [\varphi_k]?y \bullet k \rightarrow S_k \tag{154.8}$$

In which:

$$A = i \rightarrow S_i \bullet [\theta_i]!x \bullet 0, B = [\varphi_j]?x \bullet j \rightarrow S_j \bullet [\theta_j]!y \bullet 0, C = [\varphi_k]?y \bullet k \rightarrow S_k,$$

The service that needs to be adapted is $j \rightarrow S_j$, the service through adaptation is $j' \rightarrow S_{j'}$, the messages received and sent are transformed into u and v.

The service sequence S in its adaptable cumulative evolution model thus can be expressed as in (9).

$$f_{CIE} : i \rightarrow S_i \bullet [\theta_i]!u \bullet [\varphi_{j'}]?u \bullet j' \rightarrow S_{j'} \bullet [\theta_k]!v \bullet [\varphi_k]?v \bullet k \rightarrow S_k \qquad (154.9)$$

In which:

$$A = i \rightarrow S_i \bullet [\theta_i]!u \bullet 0,\ B = [\varphi_{j'}]?u \bullet j' \rightarrow S_{j'} \bullet [\theta_{j'}]!u \bullet 0,\ C = [\varphi_k]?v \bullet k \rightarrow S_k$$

154.3.5 The Integration of the Cumulative Evolution Models

The sequential cumulative evolution, the reverse cumulative evolution, the parallel cumulative evolution and the adaptive cumulative evolution are the four atom evolution models that underlie the ultimate cumulative evolution of SaaS service in question. Every evolution process of it can be realized by variedly configuring the four atom evolutions. Among them, as the sequential cumulative evolution and the parallel cumulative evolution involve the question of branching, it is necessary to analyze the interrelationship of the evolution sequences and its evolution outcomes. The integrated evolution process can be expressed as (Figs. 154.1, 154.2):

The service sequence S before integration can be expressed as in (154.10).

$$i \rightarrow S_i \bullet [\theta_i]!x \bullet [\varphi_j]?x \bullet j \rightarrow S_j \bullet [\theta_j]!z \bullet [\varphi_k]?z \bullet k \rightarrow S_k \qquad (154.10)$$

Fig. 154.1 Integration 1

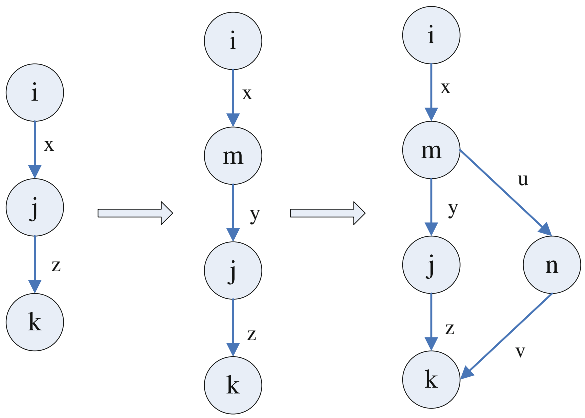
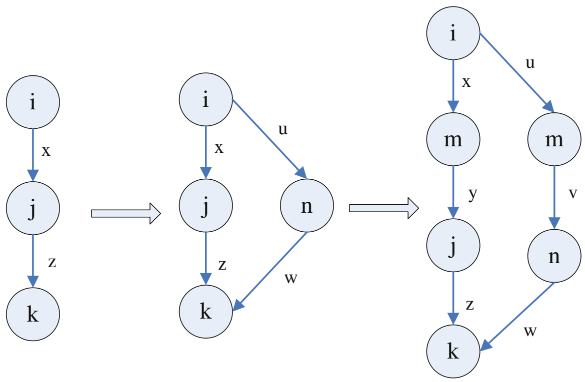


Fig. 154.2 Integration 2



In which:

$A = i \to S_i \bullet [\theta_i]!x \bullet 0, B = [\varphi_j]?x \bullet j \to S_j \bullet [\theta_k]!z \bullet 0, C = [\varphi_k]?z \bullet k \to S_k$

When the sequential integration runs before the parallel integration:

$$\begin{aligned} & i \to S_i \bullet [\theta_i]!x \bullet [\varphi_m]?x \bullet m \to S_m \bullet [\theta_m]!y \bullet [\varphi_j]?y \bullet \\ & j \to S_j \bullet [\theta_j]!z \bullet [\varphi_k]?z \bullet k \to S_k \end{aligned} \tag{154.11}$$

$$\begin{aligned} & i \to S_i \bullet [\theta_i]!x \bullet [\varphi_m]?x \bullet m \to S_m \bullet ([\theta_m]!x| \\ & [\theta_m^{'}]!u) \bullet (([\varphi_j]?y \bullet j \to S_j \bullet [\theta_j]!z)|([\varphi_n] \\ & ?v \bullet n \to S_n \bullet [\theta_n]!v)) \bullet ([\varphi_k]?z|[\varphi_k^{'}]?v) \bullet k \to S_k \end{aligned} \tag{154.12}$$

When the sequential integration runs after the parallel integration:

$$\begin{aligned} & i \to S_i \bullet ([\theta_i]!x|[\theta_i^{'}]!u) \bullet (([\varphi_j]?x \bullet j \to S_j \bullet \\ & [\theta_j]!z)|([\varphi_n]?u \bullet n \to S_n \bullet [\theta_n]!w)) \bullet \\ & ([\varphi_k]?z|[\varphi_k^{'}]?w) \bullet k \to S_k \end{aligned} \tag{154.13}$$

$$i \to S_i \bullet ([\theta_i]!x|\left[\theta_i^{'}\right]!u) \bullet (([\varphi_m]?x \bullet m \to S_m \bullet \left[\theta_m\right]!y \bullet \left[\varphi_j\right]?y \bullet j \to S_j \bullet \left[\theta_j\right]!z)| ([\varphi_m]?u \bullet m \to S_m \bullet \left[\theta_m\right]!v \bullet [\varphi_n]?v \bullet n \to S_n \bullet \left[\theta_n\right]!w)) \bullet ([\varphi_k]?z|\left[\varphi_k^{'}\right]?w) \bullet k \to S_k \tag{154.14}$$

When the parallel integration runs before the sequential integration, the evolution process would be more complex as it may induce redundant services. Therefore, the elimination of the redundant services has to be considered.

Whether formula (154.13) and (154.14) are equal in value has to be verified.

Theorem 154.1 *When the sequential cumulative evolution and the parallel cumulative evolution are simultaneously executed in the service sequence* S*, then the outcomes of the two evolution sequences are the same.*

Proof The interactive simulation theory (Milner 1999). To differentiate the outcomes of the two evolutions, the services of integration sequencing 2 are to be represented by i', j', k', m', m'', n', and m' and m'' are equal in value.

Suppose (*S*, *T*) is a system that indicates the transfer of symbols, *T* represents the transfer of services from the service *S*

$$T = \{(i, m), (i', m'), (m, n), (m, i), (m', n), (m'', n')\}$$

And suppose *F* is a two-tuple of *S*, then

$$F = \{(i, i'), (j, j'), (m, m'), (m, m''), (n, n')\}$$

The transfer of the service *i* within *T* is identical with the transfer of the service i' within *T*, and the transfer of the service *j* within *T* is identical with the transfer of the service *j* within *T*, similarly, all of the services in pair within F can match and simulate mutually.

The reflexivity, symmetry, and transmissibility of *S* can be verified. According to the definition of compulsory equaling of values as stipulated in the theory of mutual simulation, it can be concluded that the results of the two evolution sequences are the same.

Deduction To inset services as numerous as n between every two random services (as well as two services in immediate sequence) of the service sequence S either in parallel order or in sequential order, the results of their evolutions do not reflect the difference in their operation orders.

154.4 Conclusion

SaaS is an internet-based software service supply and delivery model. With the development of the cloud computing technology, researches on SaaS are getting momentum (Wu et al. 2011; Ardagna et al. 2007). But the literature that is focused on the evolution of SaaS service remains inadequate. As the evolution of SaaS software involves a higher level of service customizability and dynamic adaptability than that the traditional software requires, the evolution has to be executed in a coarsest-grained, transparent and gradual way (Weber et al. 2008). The paper proposes a cumulative evolution model of SaaS service on the basis of an expanded Pi calculus. By expanding the typical Pi calculus, it is possible to multiply the proprietary relationships in the collection of names and the restrictive conditions that determine the transfers of processes, and thus probable is the overall orchestrating of the evolution of SaaS services. Following the analysis of the cumulative evolution, four atom cumulative evolutions are discussed. After that, the possible integrations of them and the conditions under which they are equal in value are also demonstrated. A relevant research to be furthered should be on the layering of the services and the testing of the functions of the model.

Acknowledgments Foundation item: National Natural Science Fund Project (No. 60963007); Software College of Yunnan University Construction Fund Project (No. 2010KS01).

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Chapter 155
Permanence and Extinction of Periodic Delay Predator–Prey System with Two Predators and Stage Structure for Prey

Wei-wei Zheng and Er-dong Han

Abstract In this paper, a periodic predator–prey delay system with Beddington–DeAngelis and Holling IV functional response is proposed and analyzed, where prey has stage structure and all three species are density dependent. Using the comparison theorem and analytical method, sufficient conditions of the permanence and extinction of the predators and prey species are obtained. In addition, sufficient conditions are derived for the existence of positive periodic solutions of the system. According to the conclusions of the theorems, two examples are given to check the correctness of the main results.

Keywords Beddington–DeAngelis functional response · Delay · Extinction · Permanence · Stage Structure

155.1 Introduction

The aim of this paper is to investigate the permanence and extinction of the following periodic delay three species predator–prey system with Holling IV and Beddington–DeAngelis functional response and stage-structure for prey

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E. Qi et al. (eds.), *The 19th International Conference on Industrial Engineering and Engineering Management*, DOI: 10.1007/978-3-642-38391-5_155,

$$\begin{cases} x_1'(t) = a(t)x_2(t) - b(t)x_1(t) - a(t-\tau_1)e^{-\int_{t-\tau_1}^{t} b(s)\mathrm{d}s} x_2(t-\tau_1) - \dfrac{h_1(t)x_1(t)}{\alpha_1(t) + x_1^2(t)} y_1(t), \\ x_2'(t) = a(t-\tau_1)e^{-\int_{t-\tau_1}^{t} b(s)\mathrm{d}s} x_2(t-\tau_1) - c(t)x_2^2(t) - \dfrac{h_2(t)x_2(t)}{\alpha_2(t) + \beta(t)x_2(t) + \gamma(t)y_2(t)} y_2(t), \\ y_1'(t) = y_1(t)\left[-q_1(t) + \dfrac{p_1(t)x_1(t-\tau_2)}{\alpha_1(t) + x_1^2(t-\tau_2)} - g_1(t)y_1(t)\right], \\ y_2'(t) = y_2(t)\left[-q_2(t) + \dfrac{p_2(t)x_2(t-\tau_3)}{\alpha_2(t) + \beta(t)x_2(t-\tau_3) + \gamma(t)y_2(t-\tau_3)} - g_2(t)y_2(t)\right], \end{cases} \tag{155.1}$$

where $x_1(t)$ and $x_2(t)$ denote the densities of immature and mature prey species at time t, respectively; $y_1(t)$ and $y_2(t)$ denote the densities of the predators that prey on immature and mature prey at time t , respectively; $a(t)$, $b(t)$, $c(t)$, $g_i(t)$, $h_i(t)$, $p_i(t)$, $q_i(t)$, $\alpha_i(t)$, $i = 1,\ 2$, $\beta(t)$, $\gamma(t)$ are all continuous positive ω- periodic functions; τ_i, $i = 1, 2, 3$ are positive constants.

We can refer to (Liu and Yan 2011; Zhu et al. 2011) to get biological significance of all parameters and assumptions explanation of (155.1).

The initial conditions for system (155.1) is as follow

$$\begin{gathered} x_i(s) = \phi_i(s), y_i(s) = \psi_i(s) > 0, \phi_i(0) > 0, \psi_i(0) > 0, \\ i = 1, 2,\ s \in [-\tau, 0]. \end{gathered} \tag{155.2}$$

where $\tau = \max\{\tau_1, \tau_2, \tau_3\}, \phi = (\phi_1, \phi_2, \phi_3, \phi_4) \in C\big([-\tau, 0], R_{+0}^4\big)$, here we let $R_{+0}^4 = \{(x_1, x_2, x_3, x_4) | x_i \geq 0, i = 1, 2, 3, 4\}$.

For the convenient of the following discussion, to a continuous $\omega-$ periodic function $f(t)$, we set

$$m(f) = \frac{1}{\omega}\int_0^{\omega} f(t)\mathrm{d}t$$

Meanwhile, we add definition

$$B(t) \overset{\text{def}}{=} a(t-\tau_1)\exp\left\{-\int_{t-\tau_1}^{t} b(s)\mathrm{d}s\right\}$$

According to the analysis of the above, we get the following system (155.3).

$$\begin{cases} \dot{x}_1(t) = a(t)x_2(t) - b(t)x_1(t) - B(t)x_2(t-\tau_1) - \dfrac{h_1(t)x_1(t)}{\alpha_1(t) + x_1^2(t)}y_1(t), \\ \dot{x}_2(t) = B(t)x_2(t-\tau_1) - c(t)x_2^2(t) - \dfrac{h_2(t)x_2(t)}{\alpha_2(t) + \beta(t)x_2(t) + \gamma(t)y_2(t)}y_2(t), \\ \dot{y}_1(t) = y_1(t)\left[-q_1(t) + \dfrac{p_1(t)x_1(t-\tau_2)}{\alpha_1(t) + x_1^2(t-\tau_2)} - g_1(t)y_1(t)\right], \\ \dot{y}_2(t) = y_2(t)\left[-q_2(t) + \dfrac{p_2(t)x_2(t-\tau_3)}{\alpha_2(t) + \beta(t)x_2(t-\tau_3) + \gamma(t)y_2(t-\tau_3)} - g_2(t)y_2(t)\right]. \end{cases} \tag{155.3}$$

The dynamic behavior of the predator–prey system with delay and stage structure for prey has been long discussed [see (Liu and Yan 2011; Zhu et al. 2011; Li and Qian 2011; Li et al. 2011)]. Recently, Wang (Xiong and Li 2008) study the model of this type, by using software Maple, the authors got the corresponding numeric results of the conclusions. We can refer to (Hao and Jia 2008; Wang and Chen 2010; Liu and Yan 2011; Naji and Balasim 2007; Cai et al. 2009; Zhao and Lv 2009; Feng et al. 2010; Zhang et al. 2011; Liu and Yan 2011) to have in-depth understanding of more research achievement of those models. Furthermore, the research concerning the stage structure while being time delays predator–prey periodic systems are quite rare. Indeed, recently, Kar (Ta and Nguyen 2011), Huang (Chen and You 2008) and Chen (Huang et al. 2010) project those systems on permanence and extinction. To keep the biological variety of ecosystem, the dynamic behavior of biotic population is a significant and comprehensive problem in biomathematics. So it is meaningful to investigate the system (155.3).

In the next section, we state the main results of this paper. Sufficient conditions of the permanence and extinction of the system (155.3) are proved in Section III. The conclusions we obtain further promote the analysis technique of Huang (Chen and You 2008) and Chen (Huang et al. 2010).

155.2 Statement of the Main Results

Theorem 155.2.1 Suppose that

$$\begin{aligned} m\left(-q_1(t) + \frac{p_1(t)x_1^*(t-\tau_2)}{\alpha_1(t) + x_1^{*2}(t-\tau_2)}\right) > 0, \\ m\left(-q_2(t) + \frac{p_2(t)x_2^*(t-\tau_3)}{\alpha_2(t) + \beta(t)x_2^*(t-\tau_3)}\right) > 0, \end{aligned} \tag{155.4}$$

hold, where $x_1^*(t), x_2^*(t)$ is the unique positive periodic solution of system (155.4) given by Lemma 155.2.2 [see (Chen and You 2008)]. Then system (155.3) is permanent.

Theorem 155.2.2 Assume the condition (155.4) hold, there is at least a positive ω- periodic solution of system (155.3).

Theorem 155.2.3 Suppose that

$$m\left(-q_1(t)+\frac{p_1(t)x_1^*(t-\tau_2)}{\alpha_1(t)+x_1^{*2}(t-\tau_2)}\right)\le 0,$$
$$m\left(-q_2(t)+\frac{p_2(t)x_2^*(t-\tau_3)}{\alpha_2(t)+\beta(t)x_2^*(t-\tau_3)}\right)\le 0, \tag{155.5}$$

hold, then any solutions of system (155.3) with initial condition (155.2) satisfies

$$\lim_{t\to+\infty} y_i(t)=0,\ i=1,2.$$

155.3 Proof of the Main Results

We need the Lemma155.3.1–155.3.4 to proof Theorem 155.2.1.

Lemma 155.3.1 There exist positive constants M_x and M_y, such that

$$\lim_{t\to+\infty}\sup x_i(t)\le M_x,\ \lim_{t\to+\infty}\sup y(t)\le M_y, i=1,2.$$

for all solutions of system (155.3) with initial condition (155.2).

Proof Let (x_1,x_2,y_1,y_2) be a solution of system (155.3) with initial conditions (155.2), so we have

$$\begin{cases} x_1'(t)\le a(t)x_2(t)-b(t)x_1(t)-B(t)x_2(t-\tau_1), \\ x_2'(t)\le B(t)x_2(t-\tau_1)-c(t)x_2^2(t) \end{cases}.$$

By using Lemma 155.2.2, the following auxiliary equation:

$$\begin{cases} u_1'(t)=a(t)u_2(t)-b(t)u_1(t)-B(t)u_2(t-\tau_1), \\ u_2'(t)=B(t)u_2(t-\tau_1)-c(t)u_2^2(t). \end{cases} \tag{155.6}$$

has a globally asymptotically stable positive $\omega-$ periodic solution $\left(x_1^*(t),x_2^*(t)\right)$. Let $(u_1(t),u_2(t))$ be the solution of (155.6) with initial condition $(u_1(0),u_2(0))=(x_1(0),x_2(0))$. According to the comparison theorem [see (Hao and Jia 2008)], we have

$$x_i(t)\le u_i(t)(i=1,2),\ t\ge 0 \tag{155.7}$$

By (155.4), there exists a $\varepsilon>0$ which is sufficiently small, such that

$$m\left(-q_i(t)+\frac{p_i(t)\left(x_1^*(t)+\varepsilon\right)}{\alpha_i(t)}\right)>0. \tag{155.8}$$

Thus, from the global attractive of $\left(x_1^*(t),x_2^*(t)\right)$, for every given $\varepsilon(0<\varepsilon<1)$, there exists a $T_1>0$, such that

$$\left|u_i(t)-x_i^*(t)\right|<\varepsilon,\ t\geq T_1. \tag{155.9}$$

On the basis of (155.7) and (155.9), we have

$$x_i(t)<x_i^*(t)+\varepsilon,\ t>T_1. \tag{155.10}$$

Let $M_x=\max\limits_{t\in[0,\omega]}\left\{x_i^*(t)+\varepsilon,i=1,2\right\}$, we have

$$\lim_{t\to+\infty}\sup x_i(t)\leq M_x,\ i=1,2.$$

For, $t\geq T_1$, from system (155.3) and (155.10), we can obtain

$$\begin{aligned}y_i'(t)&\leq y_i(t)\left[-q_i(t)+\frac{p_i(t)x_i(t-\tau_2)}{\alpha_i(t)}-g_i(t)y_i(t)\right]\\&\leq y_i(t)\left[-q_i(t)+\frac{p_i(t)}{\alpha_i(t)}\left(u_i^*(t-\tau_2)+\varepsilon\right)-g_i(t)y_i(t)\right].\end{aligned}$$

Consider the following equation:

$$v_i'(t)=v_i(t)\left[-q_i(t)+\frac{p_i(t)}{\alpha_i(t)}\left(u_i^*(t-\tau_2)+\varepsilon\right)-g_i(t)y_i(t)\right]. \tag{155.11}$$

From the Lemma 155.2.2 of (Chen and You 2008), (155.11) has a unique ω-periodic solution $y_i^*(t)>0,i=1,2$.. Similarly to the above analysis, there exists a $T_2>T_1$, such that for the above ε, we have

$$y_i(t)<y_i^*(t)+\varepsilon,\ t>T_2.$$

Let $M_x=\max\limits_{t\in[0,\omega]}\{y_i*(t)+\varepsilon,i=1,2\}$, then

$$\lim_{t\to+\infty}\sup y_i(t)\leq M_y,\ i=1,2.$$

To the same argument of Lemma 155.3.1, we can easily get Lemma 155.3.2.

Lemma 155.3.2 There exists positive constant $\eta_{ix}<M_x$, $i=1,2$, such that

$$\lim_{t\to+\infty}\inf x_i(t)>\eta_{ix},\ i=1,2.$$

Lemma 155.3.3 Assumed that (155.4) holds, then there exists two positives constants $\eta_{iy},i=1,2$, such that any solutions $(x_1(t),x_2(t),y_1(t),y_2(t))$ of system (155.3) with initial condition (155.2) satisfies

$$\lim_{t\to+\infty}\sup y_i(t) > \eta_{iy},\ i = 1,2. \tag{155.12}$$

Proof Assume that condition (155.4) is establish, there exists a constant $\varepsilon_0 > 0$, and $\varepsilon_0 > \frac{1}{2}\min_{t\in[0,\omega]}\{x_i * (t)\}$, such that

$$m\big(\varphi_{\varepsilon_0}(t)\big) > 0, m\big(\psi_{\varepsilon_0}(t)\big) > 0, \tag{155.13}$$

where

$$\varphi_{\varepsilon_0}(t) = -q_1(t) + \frac{p_1(t)\big(x_1^*(t-\tau_2)-\varepsilon_0\big)}{\alpha_1(t)+\big(x_1^*(t-\tau_2)-\varepsilon_0\big)} - q_1(t)\varepsilon_0,$$

$$\psi_{\varepsilon_0}(t) = -q_2(t) + \frac{p_2(t)\big(x_2^*(t-\tau_3)-\varepsilon_0\big)}{\alpha_2(t)+\beta(t)\big(x_2^*(t-\tau_3)-\varepsilon_0\big)+\gamma(t)\varepsilon_0} - q_2(t)\varepsilon_0.$$

Take the equation below with a parameter $e > 0$ into account:

$$\begin{cases} x_1'(t) = a(t)x_2(t) - \left(b(t) + 2e\dfrac{h_1(t)}{\alpha_1(t)}\right)x_1(t) - B(t)x_2(t-\tau_1), \\ x_2'(t) = B(t)x_2(t-\tau_1) - \left(c(t) + 2e\dfrac{h_2(t)}{\alpha_2(t)}\right)x_2^2(t). \end{cases} \tag{155.14}$$

By Lemma 155.2.2, system (155.14) has a unique positive ω- periodic solution $\left(\widetilde{x}_{1e}^*(t), \widetilde{x}_{2e}^*(t)\right)$, which is global attractive. Let $(\bar{x}_{1e}(t), \bar{x}_{2e}(t))$, be the solution of (155.14) with initial condition $\bar{x}_{ie}(0) = x_i^*(0), i = 1,2$. Then, for the above ε_0, there exists a sufficiently large $T_4 > T_3$, such that

$$\left|\bar{x}_{ie}(t) - x_{ie}^*(t)\right| < \frac{\varepsilon_0}{4},\ t \geq T_4.$$

We have $\bar{x}_{ie}(t) \to x_i^*(t)$ in $[T_4, T_4+\omega]$, as $e \to 0$. Then, for $\varepsilon_0 > 0$, such that

$$\left|\bar{x}_{ie}(t) - x_i^*(t)\right| < \frac{\varepsilon_0}{4},\ t \in [T_4, T_4+\omega],\ 0 < e < e_0.$$

So, we can get

$$\left|x_{ie}^*(t) - x_i^*(t)\right| \leq \left|\bar{x}_{ie}(t) - x_{ie}^*(t)\right| + \left|x_{ie}^*(t) - x_i^*(t)\right| < \frac{\varepsilon_0}{2}.$$

Since $x_{ie}^*(t), x_i^*(t)$ are all ω-periodic, hence

$$\left|x_{ie}^*(t) - x_i^*(t)\right| < \frac{\varepsilon_0}{2},\ i = 1,2,\ t \geq 0,\ 0 < e < e_0.$$

Choosing a constant $e_1(0 < e_1 < e_0, 2e_1 < \varepsilon_0)$, we have

$$x_{ie}^*(t) \geq x_i^*(t) - \frac{\varepsilon_0}{2},\ i = 1, 2,\ t \geq 0. \tag{155.15}$$

Assuming (155.12) is false, then there exists $\phi \in R_+^4$, such that, under the initial condition $(x_1(\theta), x_2(\theta), y_1(\theta), y_2(\theta)) = \phi, \theta \in [-\tau, 0]$. We have $\lim_{t\to+\infty} \sup y_i(t, \phi) < e_1,\ i = 1, 2$.

So, there exists $T_5 > T_4$, such that

$$y_i(t, \phi) < 2e_1 < \varepsilon_0,\ t \geq T_5. \tag{155.16}$$

By using (155.16), from system (155.3), for all $t \geq T_6 \geq T_5 + \tau_1$, we can obtain

$$x_1'(t) \geq a(t)x_2(t, \phi) - \left(b(t) + 2e_1 \frac{h_1(t)}{\alpha_1(t)}\right)x_1(t, \phi) - B(t)x_2(t - \tau_1, \phi),$$

$$x_2'(t) \geq B(t)x_2(t - \tau_1, \phi) - \left(c(t) + 2e_1 \frac{h_2(t)}{\alpha_2(t)}\right)x_2^2(t, \phi).$$

Let $(u_1(t), u_2(t))$ be the solution of (155.14), with $e = e_1$ and $(x_1(T_6, \phi), x_2(T_6, \phi))$, then

$$x_i(t, \phi) \geq u_i(t),\ i = 1, 2, t \geq T_6.$$

From the global attractive of $\left(\overline{x}_{1e_1}(t), \overline{x}_{2e_1}(t)\right)$, here we let $\varepsilon = \frac{\varepsilon_0}{2}$, there exists $T_7 \geq T_6$, such that

$$\left|u_i(t) - x_{ie_1}^*(t)\right| < \frac{\varepsilon_0}{2},\ i = 1, 2,\ t \geq T_7.$$

So, we have

$$x_i(t, \phi) \geq u_i(t) > x_{ie_1}^*(t) - \frac{\varepsilon_0}{2},\ i = 1, 2,\ t \geq T_7.$$

Hence, by (155.15), we can obtain

$$x_i(t, \phi) \geq x_i^*(t) - \varepsilon_0,\ i = 1, 2,\ t \geq T_7. \tag{155.17}$$

Therefore, by (155.16) and (155.17), for, $t \geq T_7 + \tau_2$, such that

$$\begin{aligned} & y_1'(t, \phi) \\ & \geq y_1(t, \phi)\left[-q_1(t) + \frac{p_1(t)\left(x_1^*(t - \tau_2) - \varepsilon_0\right)}{\alpha_1(t) + \left(x_1^*(t - \tau_2) - \varepsilon_0\right)} - g_1(t)\varepsilon_0\right] \\ & = \varphi_{\varepsilon_0}(t)y_1(t, \phi); \end{aligned}$$

$$
\begin{aligned}
&y_2'(t,\phi)\\
&\geq y_2(t,\phi)\left[-q_2(t)+\frac{p_2(t)\big(x_2^*(t-\tau_3)-\varepsilon_0\big)}{\alpha_2(t)+\beta(t)\big(x_2^*(t-\tau_3)-\varepsilon_0\big)+\gamma(t)\varepsilon_0}-g_2(t)\varepsilon_0\right]\\
&=\psi_{\varepsilon_0}(t)y_2(t,\phi).
\end{aligned}
\tag{155.18}
$$

Integrating both sides of (155.18) from $T_7+\tau_2$ to t and from $T_7+\tau_3$ to t, respectively, so we can get

$$
y_1(t,\phi)\geq y_1(T_7+\tau_2,\phi)\exp\int_{T_7+\tau_2}^{t}\varphi_{\varepsilon_0}(t)\mathrm{d}t,
$$

$$
y_2(t,\phi)\geq y_2(T_7+\tau_3,\phi)\exp\int_{T_7+\tau_3}^{t}\psi_{\varepsilon_0}(t)\mathrm{d}t.
$$

Thus, from (155.16), we obtain $y_i(t,\phi)\to+\infty, i=1,2, t\to+\infty$. It is a contradiction of the Lemma 155.3.1. So the proof of the theorem 155.3.3 is complete.

Lemma 155.3.4 Under the condition (155.4), there exist positive constants τ_{iy}, $i=1,2$, such that any solutions of system (155.3) with initial condition (155.2) satisfies

$$
\lim_{t\to+\infty}\inf y_i(t)>\tau_{iy},\ i=1,2. \tag{155.19}
$$

Proof of Theorem 155.2.1 By Lemma 155.3.2 and 155.3.3, system (155.3) is uniform weak persistent. Further, from the Lemma 155.3.1 and 155.3.4, system (155.3) is persistent.

Proof of Theorem 155.2.2 From the proof of Lemma 155.3.1–155.3.4 in Theorem 155.2.1, using the same method, we can proof the Theorem 155.2.2. Here we omit the detail of certificate process.

Proof of Theorem 155.2.3 Actually, by (155.5), for any given positive constant $\varepsilon(\varepsilon<1)$, there exist $\varepsilon_1>0\,(0<\varepsilon_1<\varepsilon)$ and $\varepsilon_0>0$, we get the following (155.20).

$$
\begin{aligned}
&m\left(-q_1(t)+\frac{p_1(t)\big(x_1^*(t-\tau_2)+\varepsilon_1\big)}{\alpha_1(t)+\big(x_1^*(t-\tau_2)+\varepsilon_1\big)^2}-g_1(t)\varepsilon\right)\leq-\frac{\varepsilon}{2}m(q_1(t))<-\varepsilon_0,\\
&m\left(-q_2(t)+\frac{p_2(t)\big(x_1^*(t-\tau_3)+\varepsilon_1\big)}{\alpha_2(t)+\beta(t)\big(x_1^*(t-\tau_2)+\varepsilon_1\big)}-g_2(t)\varepsilon\right)\leq-\frac{\varepsilon}{2}m(q_2(t))<-\varepsilon_0.
\end{aligned}
\tag{155.20}
$$

Since

$$x_1^{'}(t) \le a(t)x_2(t) - b(t)x_1(t) - B(t)x_2(t-\tau_1),$$
$$x_2^{'}(t) \le B(t)x_2(t-\tau_1) - c(t)x_2^2(t).$$

For the above ε_1, there exists a $T^{(1)} > 0$, such that

$$x_i(t) < x_i^*(t) + \varepsilon_1,\ t \ge T^{(1)}. \tag{155.21}$$

It follows from (155.20) and (155.21) that for $t \ge \max\{T^{(1)} + \tau_2, T^{(2)} + \tau_3\}$,

$$\begin{aligned} m\left(-q_1(t) + \frac{p_1(t)x_1(t-\tau_2)}{\alpha_1(t) + x_1^2(t-\tau_2)} - g_1(t)\varepsilon\right) &< -\varepsilon_0, \\ m\left(-q_2(t) + \frac{p_2(t)x_2(t-\tau_3)}{\alpha_2(t) + \beta(t)x_2(t-\tau_3)} - g_2(t)\varepsilon\right) &< -\varepsilon_0. \end{aligned} \tag{155.22}$$

First, there exists a $T^{(2)} > \max\{T^{(1)} + \tau_2, T^{(2)} + \tau_3\}$, such that $y_i(T^{(2)}) < \varepsilon (i = 1, 2)$. Otherwise, by (155.22), we have

$$\begin{aligned} &\varepsilon \le y_1(t) \\ &\le y_1(T^{(1)} + \tau_2) \exp\left\{\int_{T^{(1)}+\tau_2}^{t} \left(-q_1(s) + \frac{h_1(t)x_1(s-\tau_2)}{\alpha_1(s) + x_1(t-\tau_2)} - q_1(s)\varepsilon\right) \mathrm{d}s\right\} \\ &\le y_1(T^{(1)} + \tau_2) \exp\left\{-\varepsilon_0\left(t - T^{(1)} - \tau_2\right)\right\} \to 0. \end{aligned}$$

As $t \to +\infty$. Similarly, we can get

$$\varepsilon \le y_2(t) \le y_2(T^{(1)} + \tau_3) \exp\left\{-\varepsilon_0\left(t - T^{(1)} - \tau_3\right)\right\} \to 0, t \to +\infty.$$

So we have $\varepsilon < 0$, which is contradictions.
Second, we will prove that

$$y_i(t) \le \varepsilon \exp\{M(\varepsilon)\omega\},\ i = 1, 2,\ t \ge T^{(2)}, \tag{155.23}$$

where

$$M(\varepsilon) = \max_{t \in [0,\omega]}\left(q_i(t) + \frac{p_i(t)x_1(t-\tau_j)}{\alpha_i(t) + x_1(t-\tau_j)} + g_i(t)\varepsilon, i,j = 2,3, i \ne j\right),$$

is a bounded constant for $\varepsilon \in [1, 0]$. Otherwise, then there exists a $T^{(3)} \ge T^{(2)}$, we can obtain

$$y_i(T^{(3)}) > \varepsilon \exp\{M(\varepsilon)\omega\},\ i = 1, 2.$$

By the continuity of $y_i(t)$, then there must exists $T^{(4)} \in \left(T^{(2)}, T^{(3)}\right)$, such that $y_i(T^{(4)}) = \varepsilon$ and $y_i(t) > \varepsilon$, for $t \in \left(T^{(4)}, T^{(3)}\right]$. Let P_1 be the nonnegative integer such that $T^{(3)} \in \left(T^{(4)} + P_1\omega, T^{(3)} + (P_1 + 1)\omega\right]$. From (155.22), we have

$$\begin{aligned}
&\varepsilon \exp\{M(\varepsilon)\omega\} \\
&< y_1(T^{(3)}) < y_1(T^{(4)}) \exp\left\{\int_{T^{(4)}}^{T^{(3)}} \left(-q_1(t) + \frac{h_1(t)x_1(t-\tau_2)}{\alpha_1(t) + x_1^2(t-\tau_2)} - g_1(t)\varepsilon\right) \mathrm{d}t\right\} \\
&= \varepsilon \exp\left\{\int_{T^{(4)}}^{T^{(4)}+P_1\omega} + \int_{T^{(4)}+P_1\omega}^{T^{(3)}}\right\} \left(-q_1(t) + \frac{h_1(t)x_1(t-\tau_2)}{\alpha_1(t) + x_1^2(t-\tau_2)} - g_1(t)\varepsilon\right) \mathrm{d}t \\
&< \varepsilon \exp\left\{\int_{T^{(4)}+P_1\omega}^{T^{(3)}} \left(-d_2(t) + \frac{h_1(t)x_1(t-\tau_2)}{\alpha_1(t) + x_1^2(t-\tau_2)} - q(t)\varepsilon\right) \mathrm{d}t\right\} \\
&\leq \varepsilon \exp\{M(\varepsilon)\omega\}.
\end{aligned}$$

We can see that this is a contradiction. Similarly, from the second equation of (155.22), we have

$$\varepsilon \exp\{M(\varepsilon)\omega\} < y_2(T^{(3)}) \leq \varepsilon \exp\{M(\varepsilon)\omega\}.$$

Which is also contradiction, so (155.23) holds. By the random of the parameter ε, we know $y_i(t) \to 0, i = 1, 2,\ t \to +\infty$. So we complete the proof of Theorem 155.2.3.

155.4 Examples and conclusion

Example 1 From system (155.3), cause $a(t) = 4, b(t) = 2/3,\quad c(t) = 9 \exp\{-0.3\}(1 - \exp\{-0.3\}), q_1(t) = 1/4 - \cos t, q_2(t) = 1/5 - \cos t, h_1(t) = 5, h_2(t) = 6, p_1(t) = 2 + \cos t, p_2(t) = 3 + \cos t, \alpha_1(t) = 1, \alpha_2(t) = 1/4(1 - \exp\{-0.3\})$, $\beta(t) = 7 + 2\cos t, \gamma(t) = 1, \tau_1 = \tau_2 = \tau_3 = 0.6, g_i(t), i = 1, 2$ are any arbitrary nonnegative continuous 2π-periodic functions.

The above parameters conditions satisfy Theorem 155.2.1, so system (155.3) is permanent and admits at least a positive 2π-periodic solution. From Fig. 155.1, we can see that the density restriction of the predators have a major impact on the stability of the predator–prey system. When predator species have no crowding effect, the predator species is at high density; and with crowding effect, the predator species is at low density.

Example 2 Assuming that the conditions of example 1 are established. Causing $q_1(t) = 5/4 - \cos t, q_2(t) = 1/2 - \cos t$, those parameters satisfy the Theorem 155.2.3. So any positive solution of system (155.3) satisfies

$$\lim_{t \to +\infty} y_i(t) = 0,\ i = 1, 2.$$

Figure 155.2 shows that two predators are extinction and the immature and mature preys are permanent.

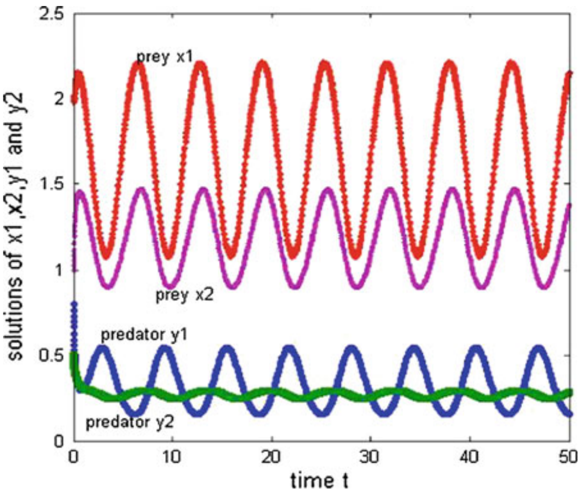

Fig. 155.1 The growth curve of system (1.3) with initial condition $(x_1(\theta), x_2(\theta), y_1(\theta), y_2(\theta)) = (1 - \exp\{-0.5\}, 0.5, 1, 2), g_1(t) = 2 + \sin t, g_2(t) = 2 + \sin t, 0 \le t \le 50, -0.6 \le \theta \le 0$

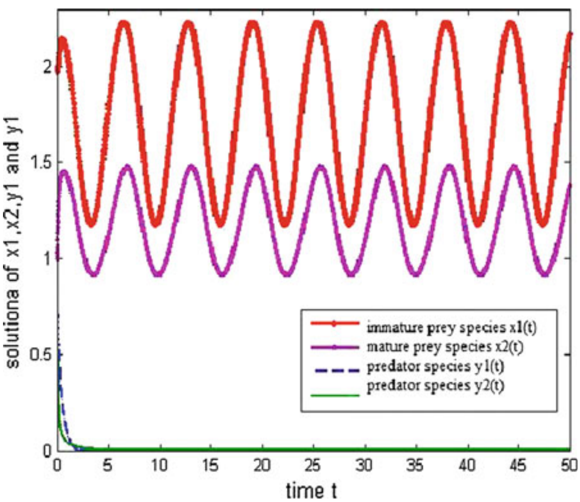

Fig. 155.2 The growth curve of system (1.3) with initial condition $(x_1(\theta), x_2(\theta), y_1(\theta), y_2(\theta)) = (1 - \exp\{-0.5\}, 0.5, 1, 2), 0 \le t \le 50, -0.6 \le \theta \le 0$

From the Theorem 155.2.1–155.2.3, we can get a conclusion: the death rate and the density restriction of the two predator population have a great extent influence on the dynamic behavior of the system.

Acknowledgment This paper is supported by the Natural Science Fund of Shaanxi Provincial Education Administration Bureau (Grant No. 11JK0502) and the Doctor's Research Fund of Xi'an Polytechnic University.

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Chapter 156
Design of Military Logistics Management System Based on Internet of Things Technology

Xue-jiang Wei, Jian-fei Feng, Shao-juan Feng and Yu-zhu Zhai

Abstract Since the capability of information collection, information processing and information using is the bottleneck of the development of military logistics, this paper puts forward "three-layer architecture" of military logistics management system based on Internet of Things technology after analyzing the operation process of military logistics, and introduces its functions which include demand management, decision-making assistant, procurement management, warehouse management, transportation & distribution management.

Keywords Internet of things · Military logistics · Military logistics management system · RFID

156.1 Introduction

The ultimate objective of military logistics operation is distributing military supplies to all combat troops actively at the right time and places (O'hanlon 2009). The achievement of this objective is greatly influenced by the capability of information collection, information transmission, information analyzing, information processing and information using, which has been the bottleneck of the development of military logistics (Jiang 2009). This situation may be changed by developing and applying Internet of Things technology in military logistics. Based on the Internet of Things technology, some appropriate objectives of military logistics can be easily achieved by optimizing military logistics operation process and constructing military logistics management system (Yang and Pan 2011; Li 2011a).

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E. Qi et al. (eds.), *The 19th International Conference on Industrial Engineering and Engineering Management*, DOI: 10.1007/978-3-642-38391-5_156,

156.2 Analysis of Military Logistics Operation Process

The military logistics operation process can be divided into three phases: demand applying, material acquisition, transportation & distribution (Zhang et al. 2007), as shown in Fig. 156.1.

(1) *Demand applying*. When combat troops need some materials, they apply the demand including material names, amounts, quality standards, deadlines and destinations to military logistics command.
(2) *Material acquisition*. When military logistics command receives combat troops' material demands, it makes material acquisition decision promptly after contracting demand with inventory. If the inventory is enough, it will give an outing order to military depot; otherwise it will give a material procurement mission to military procurement agency which will purchase those needed materials from suppliers.
(3) *Transportation & distribution*. During the period of carrying out material acquisition mission, military logistics command decides how to distribute the supplies. If it is dangerous for civil logistics enterprise, military logistics command will select military transportation agency to transport the supplies; otherwise it will select civil logistics enterprise. If the supplies are only distributed to one place, they will be transported to the destination directly; otherwise they will be transported to distribution center firstly and be distributed to combat troops by distribution center later.

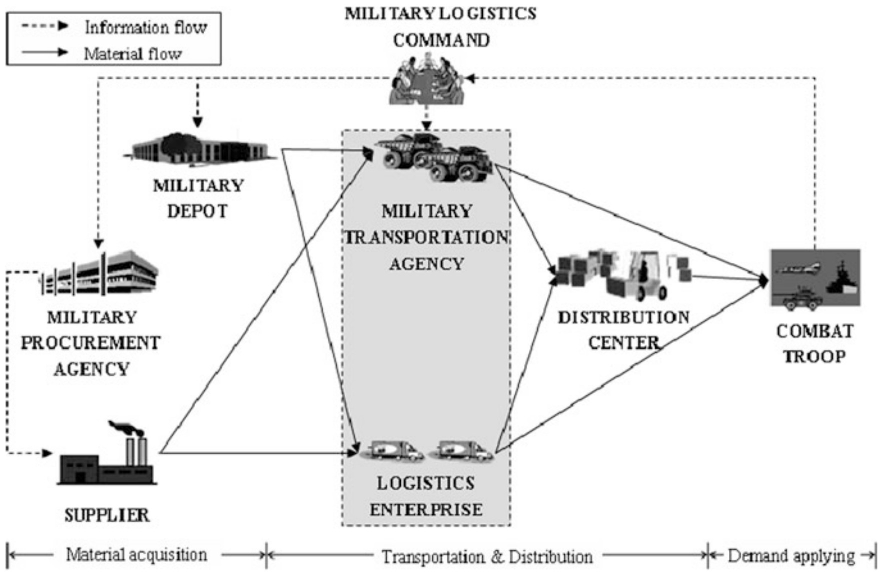

Fig. 156.1 Military logistics operation process

156.3 Design of Military Logistics Management System

156.3.1 Objective of Military Logistics Management System

Military logistics management system aims at providing an information management platform to military logistics command, military procurement agency, military depot and military transportation agency, and combining them with suppliers and logistics enterprises by information flow. It also aims at achieving automatic information collection, intelligent information processing, scientific resource configuration and maximum support efficiency by applying Internet of Things technology and Geographic Information System (GIS).

156.3.2 Architecture of Military Logistics Management System

Architecture of military logistics management system includes three layers: sensing layer, network layer and application layer (Li 2011b; Qu 2010; Su 2011; Lin 2011; Chen and Jiang 2011; Zhu 2010), as shown in Fig. 156.2.

156.3.3 Functions of Military Logistics Management System

156.3.3.1 Military Logistics Decision-Making Assistant

Military logistics decision-making assistant is provided to military logistics command, which includes demand management, potential support capability evaluation and decision-making assistant of material support plan (Ruan and Lu 2011).

(1) *Demand management*. After combat troops apply material demands through internet or by Personal Digital Assistant (PDA), military logistics management system integrates these demands with same material and destination automatically accorded with the common rule and request of demand management by the assistance of computers.
(2) *Potential support capability evaluation*. When receiving a supply mission, military logistics management system analyzes the information provided by supplier database, inventory database and transportation database intelligently, and evaluates the potential support capability provided by suppliers, military depots, military transportation agencies and logistics enterprises automatically by the assistance of GIS application support service, cloud computing service and intelligent analysis service.

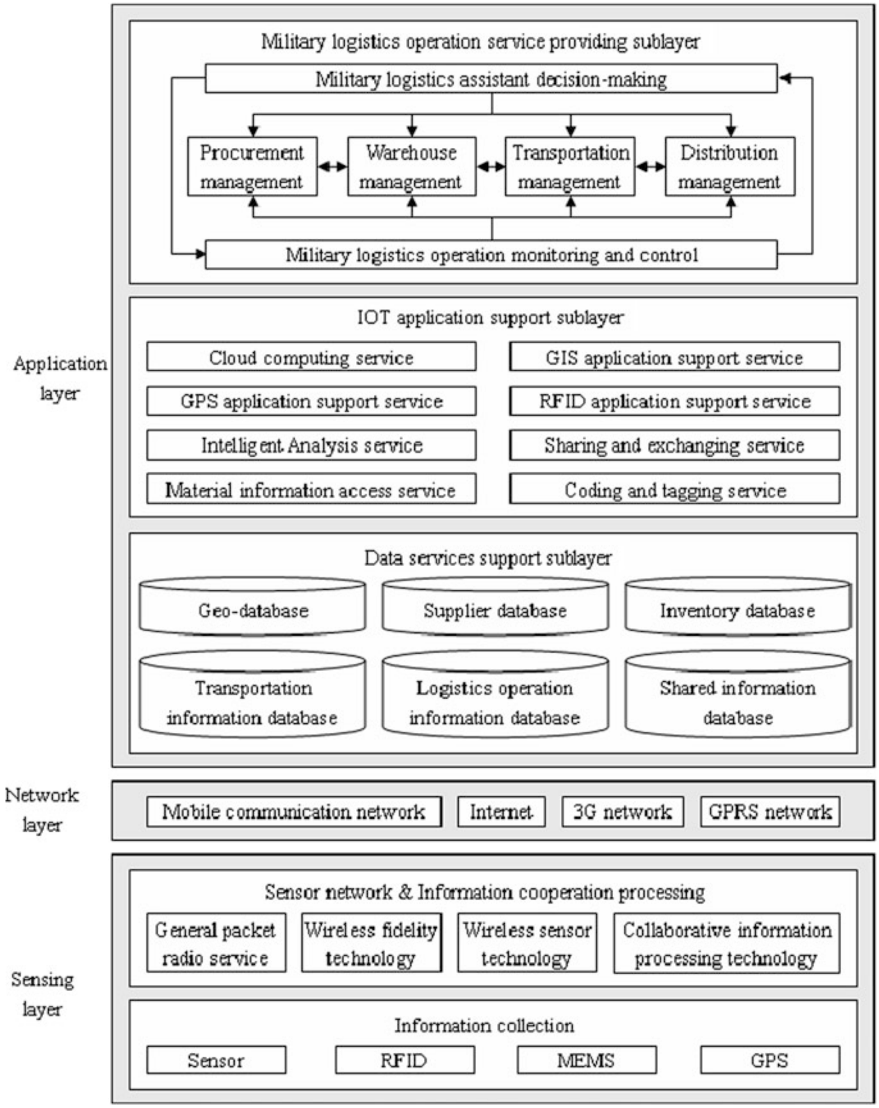

Fig. 156.2 Architecture of military logistics management system

(3) *Decision-making assistant of material support plan*. Based on the evaluation of potential support capability, military logistics management system can assist the commander to make decision after analyzing the situation of military logistics, the distribution of resources and the condition of transportation.

156.3.3.2 Procurement Management

Procurement management is provided to military procurement agency, which includes supplier selection and E-Procurement management (Huang 2006).

(1) *Supplier selection*. With the assistance of Geo-database and GIS application support service, military logistics management system searches those suppliers which accord with demands intelligently following the rules set by commander, and transforms the result into report automatically.
(2) *E-procurement management*. Through military logistics management system, all material procurement activities such as promulgating procurement information, bidding, evaluating bids, contracting and payment can be carried out online.

156.3.3.3 Warehouse Management

Warehouse management is provided to military depot, which includes storage location assignment, out-warehouse and in-warehouse management, inventory management, monitoring and control to warehouse's surroundings (Wu 2011).

(1) *Storage location assignment*. Military logistics management system provides graphical interfaces to users, and assigns storage location intelligently according to the information of materials including deposit periods, bulk & weight, destination and so on, in order to improve the utilization ratio of storage location and speed of inbound & outbound operation.
(2) *Out-warehouse & in-warehouse management*. Military logistics management system transmits out-warehouse & in-warehouse information through local area network (LAN) of military rear depot, and collects materials information automatically by using Radio Frequency Identification technology (RFID).
(3) *Inventory management*. Military logistics management system provides graphical interface to users, collects information and refreshes data automatically and periodically, calculates the threshold value of inventory with the assistance of intelligent analysis service, and advises manager to apply for material while inventory is under threshold value.
(4) *Monitoring and control of warehouse's surroundings*. Military logistics management system will give an alarm while incident happens such as in-break, fire and leak of dangerous materials, sense the temperature and humidity of warehouses and activate adjustments automatically while temperature or humidity is out of normal scope.

156.3.3.4 Transportation Management

Transportation management is provided to military transportation agency, which includes vehicle monitoring, transportation planning and routing planning.

(1) *Vehicle monitoring*. Military logistics management system provides a graphical interface to users to monitor vehicle on electronic map with the application of GPS and the assistance of GPS support service.
(2) *Transportation planning*. Military logistics management system provides assistance to users to select transportation mode and vehicles according to destination, material type, material amount and material bulk & weight.
(3) *Routing planning*. Military logistics management system gives advice about routing planning to commander, and provides guidance to vehicles while some selected routes are interrupted.

156.3.3.5 Distribution Management

Distribution management is provided to distribution center, which includes distribution planning and loading planning (Li 2011c).

(1) *Distribution planning*. Distribution center may distribute one batch materials to several combat troops and demand included several types of materials which are applied by one combat troop may be grouped in different batches, so distribution planning is one of the most important tasks of distribution center. Military logistics management system provides assistance to distribution center by making distribution plans automatically based on contrasting received materials with combat troops' demands.
(2) *Loading planning*. Military logistics management system makes loading decisions that include loading orders and loading modes based on intelligent analysis service.

156.3.3.6 Military Logistics Operations Monitoring and Control

This function is provided to military logistics command. Military logistics management system records and reviews the operation process to the commander, so the commander can adjust the plan while emergency happens.

156.4 Conclusion

Military logistics management system which is based on Internet of Things aims at improving the capability of information collection, information processing and information using. Sensing layer provides functions of information collection and collaborative information processing; Network layer provides the function of information transmitting just-in-time; Application layer provides functions which include decision-making assistant, procurement management, warehouse management, transportation management and distribution management to each department of military logistics. To achieve the objective, it needs not only to solve the technical problems, but also to solve those problems such as standardization of material code, network security and maximization of economic benefit.

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Chapter 157
Simulation and Optimization of the Steel Enterprise Raw Material System

Lin-wei Xu, Pei-qing Wang, Shang-lun Chen and Xing-li Zhong

Abstract This paper uses discrete system simulation method to simulate the production scheduling material factory, verify the feasibility of the material factory system design, find out the system weakness, optimize the design and scheduling schemes, save investment, reduce the cost of operation. With the understanding of production and operation in detailed, we use system simulation to build material factory simulation model, the system simulation not only provides a powerful data analysis, and supports virtual reality 3D animation. On the optimization problem of belt conveyor route, we compare the A * algorithm and depth-first recursion algorithm, the best algorithm was obtained. About the yard optimization problem, we use unfixed type and variable tonnage stock pile, and use search mechanism to dispatch belt conveyor route and reclaimer, combining Optimization module to optimize the yard. At the same time we can get the input of coal field to formulate purchase plan.

Keywords Materials factory · Simulation · Optimization

157.1 Introduction

With the further adjustment of China's steel industry structure, steel enterprises gradually develop to be large-scale; the delivery and storage capacity of the material factory has become one of the bottlenecks which restrict the production scale. The major domestic steel enterprises have risen a new turn of energy saving and emission

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E. Qi et al. (eds.), *The 19th International Conference on Industrial Engineering and Engineering Management*, DOI: 10.1007/978-3-642-38391-5_157,

reduction and eliminate backward production capacity. Further optimizing design which aims to improve the production capacity of material factory is in research and practice. With the social economic development, the land resources are becoming more and more expensive, steel enterprises can not expand its area of material factory indefinitely. With limited resources how to optimize design, explore the potential, and improve the production capacity of material factory is a common problem for all designers of raw material plant. Simply increasing the investment to expand raw material scale can increase its production capacity, but apparently it isn't the economic way; Compression investment, streamline processes, improve the efficiency of equipment and explore production capacity is also exposed to the risk of insufficient capacity. We need an accurate evaluation method that can give quantitative data to balance the two sides and provide the useful data for the decision-making (Sun and Xu 2009a, b; Hopp and Spearman 2002).

Material factory has much equipment, scattered layout, complex process and its subsystem intersect with each other, and it is a typical of random discrete event system, Mathematical analytical method cannot give a comprehensive analysis and optimization. Thus the current design often uses empirical coefficient method. In order to avoid wasting a lot manpower, material and time, system simulation is the inevitable choice to support and optimize design. The system simulation allows us to observe the dynamic change of the system model, identify bottlenecks, modified parameters repeatedly and find the best parameters, and then optimize the performance of the entire system. The system simulation of material factory makes us to accurately evaluate the quality of the design in its planning stage, improve the reliability of the actual production, and achieve better social and economic benefits, at the same time, we can simulate various scheduling schemes to optimize the inventory of the material factory and guide the production.

157.2 Material Factory System Design

This paper simulate a typical coal yard where store eight kinds of coking coal, two kinds of thermal coal, two kinds of blind coal and three kinds of injecting Mixed Coal. There are A, B, C, D four material strip feeder. Each material strip feeder has a track bed with two bucket-wheel stacker reclaimer above it.

157.2.1 Input System

The input system mainly including the pier and the rail car dumper input system. The main raw material is transported from the sea to the pier and then transported into the material factory through belt conveyor, the other material unload by the train car dumper and then transported by the belt conveyor too. The pier input system designed to one conveyor line. The rail input system consists of car dumper and relevant delivery system that designed to two lines.

157.2.2 Output System

The coking coal output system is designed to two lines that mainly transported coking coal from coal yard to coking coal blending bunker, transported blind coal from coal yard to sintering blending bunker and transported injecting mixed coal from coal yard to the blast furnace injection blending bunkers. The thermal coal output system is designed to one line that mainly transported thermal coal from coal yard to power plant. The blast furnace output system and the coking coal output system use the same transport lines.

157.3 Equipment of the Material Factory and Simulation Module

Establish each simulation module and the simulation model shown in Fig. 157.1. In the following section this paper will introduce various equipment and simulation module.

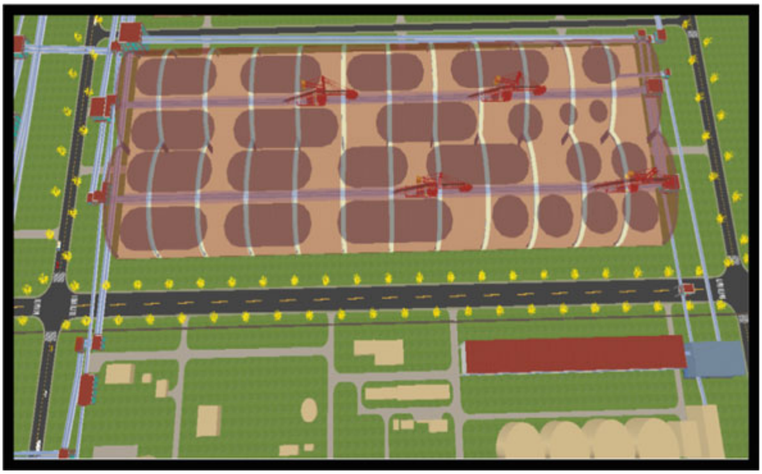


Fig. 157.1 The simulation model diagram

157.3.1 The Belt Conveyor Module

The belt conveyor is a material handing machine that continuous transfer material in a certain line, also known as a tape machine. Belt conveyor can be horizontal, tilt and vertical transport, the space can also be composed of transport lines, transport lines are generally fixed. Belt conveyor transport capacity, long distance, but also in the transportation process of a number of processes operating at the same time, so a wide range of applications. The simulation software has a standard fixed belt conveyor module, so set the parameters then can use it.

157.3.2 The Stacker-Reclaimer Module

The stacker-reclaimer is are widely used in building materials, mining, coal, power, metallurgical, chemical, cement and other industries. Because of there is no corresponding standard module in the software, so this module need to completely customize. The stacker-reclaimer movement is very complex, it not only walk, rotate arm, but also the bucket wheel need to be rotated, so the stacker-reclaimer need to customize a variety of kinematics, Import 3D models, the module shown in Fig. 157.2.

157.3.3 The Bunker Module

There are a variety of bunkers to provide raw material for the production system in the raw material system, it is the end for the transport system, but for the production it is the beginning. Each bunker consumption rates and demand are not the

Fig. 157.2 Stacker and reclaimer

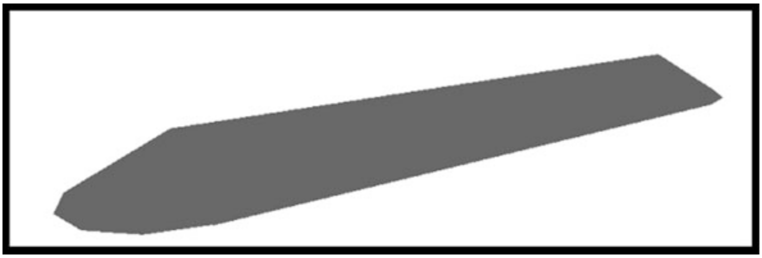


Fig. 157.3 The coal pile simulation module

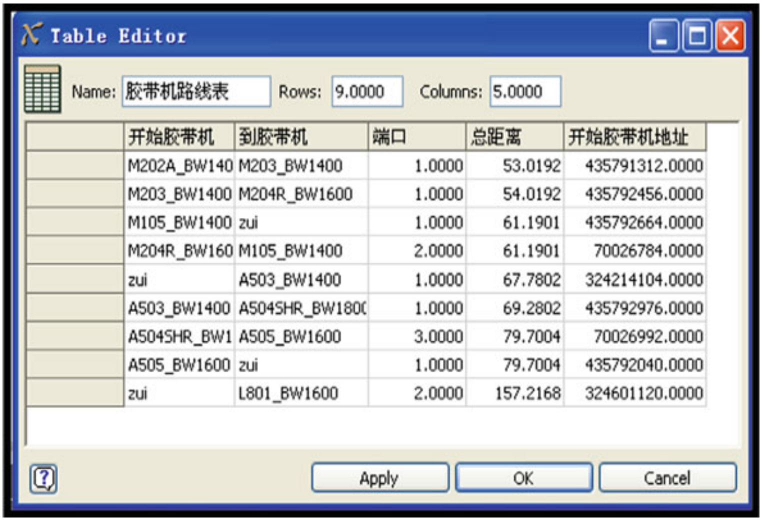
same. The bunker that contains a lot of codes is a Satellite control centre in simulation system. The bunker will call the belt conveyor line and scheduling module of stacker-reclaimer according to the level of the material. Central control module will determine the task priority. Finally, the bunker module appoints belt conveyor line and stacker-reclaimer. Then the belt conveyor line and stacker-reclaimer finish the task.

157.3.4 The Coal Pile Module

Coal pile is the most important module in the simulation model and the amount of code it contains is also the largest, because it is not only required the coal but also the supplier, so it is not only an active judgment entity but also a passive entity. When it is in the active state, it sends a message to the port module or railway station module. Then it will call the belt conveyor and stacker-reclaime, and then the module will call the central control module to determine the task priority, finally finishes the transport task. When it is in a passive state, it only receives the message sent by the central control module to tell which bunker does the coal send to. Its three-dimensional entity shows in Fig. 157.3.

157.3.5 The Central Control Module

The role of this module is to determine which task execute first based on task priority parameters, it can be a no-display graphical entity; the other is the interrupt module, its role is mainly to interrupt the non-critical tasks to free the resource, the freed resource will meet the emergence situation based on the number of interrupt within a certain time.



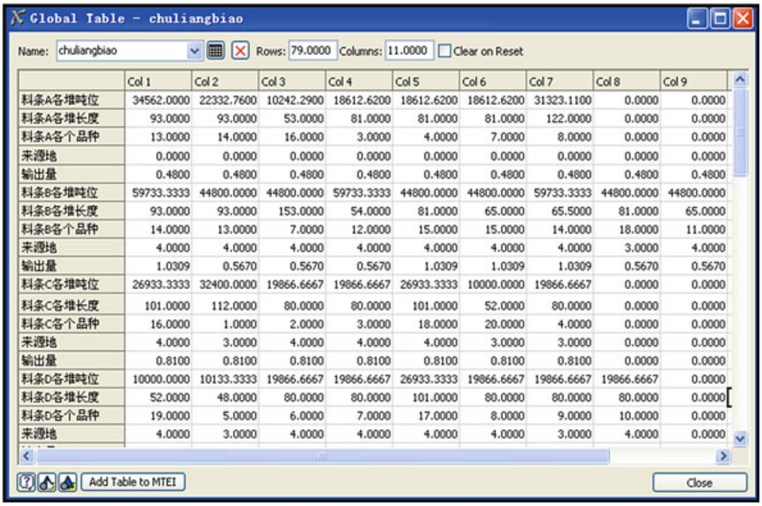
开始胶带机	到胶带机	端口	总距离	开始胶带机地址
M202A_BW140	M203_BW1400	1.0000	53.0192	435791312.0000
M203_BW1400	M204R_BW1600	1.0000	54.0192	435792456.0000
M105_BW1400	zui	1.0000	61.1901	435792664.0000
M204R_BW160	M105_BW1400	2.0000	61.1901	70026784.0000
zui	A503_BW1400	1.0000	67.7802	324214104.0000
A503_BW1400	A504SHR_BW180(	1.0000	69.2802	435792976.0000
A504SHR_BW1	A505_BW1600	3.0000	79.7004	70026992.0000
A505_BW1600	zui	1.0000	79.7004	435792040.0000
zui	L801_BW1600	2.0000	157.2168	324601120.0000

Fig. 157.4 Tape machine route table

157.4 Optimization of the Material Factory

157.4.1 Belt Conveyor Route Optimization

The belt conveyor route is very complex; there are a lot of transfer stations. Some of the transfer station between the belt conveyors is for several belt conveyor routes, so there is not only one belt conveyor route from one operating point to another, therefore it is necessary to determine which is the shortest route. Although there are some routes in the simulation process, but if one or a few belt conveyor of some routes has been occupied, so we must call the shortest route based on the available route situation. The shortest path algorithm is Dijkstra algorithm, A*(A start) algorithm, depth-first algorithm. Dijkstra algorithm is A* algorithm of the special case, also is the lowest efficiency case. If we just need to find a path, depth-first algorithm can quickly find out the route and jump out of the circulation; however, if we search for all the routes, and then compare all the paths, so the efficiency is very low. In the simulation model, each task need to call the search path algorithm, so if the shortest path algorithm efficiency is low, which will affect the simulation speed. A* algorithm is actually a heuristic search (Manuel and Johan 2004; Dong et al. 2003; Chow 1990; Scholl 1999; Zhao et al. 2000); A* algorithm uses a best-first search and finds a least-cost path from a given initial node to one goal node. It uses a distance-plus-cost heuristic function to determine the order in which the search visits nodes in the tree. The A* can be implemented more efficiently—roughly speaking, no node needs to be processed more than once (Clymer and Cheng 2001; Solow 2005). If we use general function to package the


Global Table - chuliangbiao

Name: chuliangbiao Rows: 79.0000 Columns: 11.0000 Clear on Reset

	Col 1	Col 2	Col 3	Col 4	Col 5	Col 6	Col 7	Col 8	Col 9
料条A各堆吨位	34562.0000	22332.7600	10242.2900	18612.6200	18612.6200	18612.6200	31323.1100	0.0000	0.0000
料条A各堆长度	93.0000	93.0000	53.0000	81.0000	81.0000	81.0000	122.0000	0.0000	0.0000
料条A各个品种	13.0000	14.0000	16.0000	3.0000	4.0000	7.0000	8.0000	0.0000	0.0000
来源地	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
输出量	0.4800	0.4800	0.4800	0.4800	0.4800	0.4800	0.4800	0.4800	0.4800
料条B各堆吨位	59733.3333	44800.0000	44800.0000	59733.3333	44800.0000	44800.0000	59733.3333	44800.0000	44800.0000
料条B各堆长度	93.0000	93.0000	153.0000	54.0000	81.0000	65.0000	65.5000	81.0000	65.0000
料条B各个品种	14.0000	13.0000	7.0000	12.0000	15.0000	15.0000	14.0000	18.0000	11.0000
来源地	4.0000	4.0000	4.0000	4.0000	4.0000	4.0000	4.0000	3.0000	4.0000
输出量	1.0309	0.5670	0.5670	0.5670	1.0309	1.0309	1.0309	0.5670	0.5670
料条C各堆吨位	26933.3333	32400.0000	19866.6667	19866.6667	26933.3333	10000.0000	19866.6667	0.0000	0.0000
料条C各堆长度	101.0000	112.0000	80.0000	80.0000	101.0000	52.0000	80.0000	0.0000	0.0000
料条C各个品种	16.0000	1.0000	2.0000	3.0000	18.0000	20.0000	4.0000	0.0000	0.0000
来源地	4.0000	3.0000	4.0000	4.0000	4.0000	3.0000	3.0000	0.0000	0.0000
输出量	0.8100	0.8100	0.8100	0.8100	0.8100	0.8100	0.8100	0.0000	0.0000
料条D各堆吨位	10000.0000	10133.3333	19866.6667	19866.6667	26933.3333	19866.6667	19866.6667	19866.6667	0.0000
料条D各堆长度	52.0000	48.0000	80.0000	80.0000	101.0000	80.0000	80.0000	80.0000	0.0000
料条D各个品种	19.0000	5.0000	6.0000	7.0000	17.0000	8.0000	9.0000	10.0000	0.0000
来源地	4.0000	3.0000	4.0000	4.0000	4.0000	4.0000	3.0000	4.0000	0.0000

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Fig. 157.5 Stock pile layout optimization table

A*, we call this function then we can get a belt convey or route. As shown in Fig. 157.4, through this route table, the coal entities can reach its destination.

157.4.2 Storage Yard Optimization

Each strip feeder has a certain amount of stock pile, in order to optimize, each stock pile set a unique number and tonnage, if the consumer want to find the right stock pile by the unique number, so it must search the storage yard module. In other words, we can change the unique number and tonnage of each stock pile in storage yard module, that mean the stock pile martial changed. By set the unique number constraints and tonnage constraint and the objective function in the optimize module, run the simulation we can get the best storage layout. As shown in Fig. 157.5.

157.5 Simulation Results and Conclusions

By way of simulation we can get the utilization of all kinds of equipment, as shown in Table 157.1, by analyzing utilization of the equipment, we can find out the bottlenecks and redundancy of the system, and then we can find out system defects and reduce redundant equipment to reduce costs.

Table 157.1 A part of utilization of tape machine

Convey	Idle (%)	Blocked (%)	Conveying (%)
G303_BW1400	35.54	0.00	64.46
G304SHR_BW1400	35.84	0.00	64.16
B304_BW1600	37.60	0.00	62.40
B302_BW1600	39.19	0.00	60.81
G104_BW1600	40.43	0.00	59.57
G102_BW1600	40.61	0.00	59.39
G103SHR_BW1800	40.61	0.00	59.39
G101_BW1600	40.62	0.00	59.38
B305SHR_BW1800	38.23	0.00	58.40
P131_BW1200	41.84	0.00	58.16
P207_BW1200	41.86	0.00	58.14
P205_BW1200	42.60	0.00	57.40
P107_BW1200	42.63	0.00	57.37
P108SHR_BW1400	42.68	0.00	57.32
P206SHR_BW1400	42.68	0.00	57.32
P203_BW1200	42.72	0.00	57.28
P105_BW1200	42.74	0.00	57.26
P204R_BW1200	43.16	0.00	56.84

Table 157.2 Inventory of coal pile

Object	Minimum inventory	Maximum inventory	Average inventory
Stock pile b1	33162	33600	33212.87
Stock pile b2	24741	25200	25016.22
Stock pile b3	23934	25200	24613.88
Stock pile b4	32731	33600	33315.41
Stock pile b5	24365	25200	24759.07
Stock pile b6	24141	25200	24653.88
Stock pile b7	33037	33600	33362.62
Stock pile b8	22921	25200	24187.45
Stock pile b9	24611	25200	24858
Stock pile c1	14235	15150	14667.43
Stock pile c2	17346	18225	17796.27
Stock pile c3	10314	11175	10849.64
Stock pile c4	10727	11175	11011.88
Stock pile c5	15150	15150	15150
Stock pile c6	5438	5625	5607.377
Stock pile c7	10713	11175	10934.45
Stock pile d1	5439	5625	5566.625
Stock pile d2	5225	5700	5505.055
Stock pile d3	10307	11175	10774.34
Stock pile d4	11175	11175	11175
Stock pile d5	13827	15150	14468.55
Stock pile d6	10345	11175	10790.21
Stock pile d7	10724	11175	10918.79
Stock pile d8	9843	11175	10619.38

Table 157.3 Input of storage yard

Begin time	End time	Type	Quantity delivered	Source
204493.9498	213501.039	5	3000	Railway
229834.1575	238175.9075	8	5000	Ship
239054.1902	247395.9402	2	5000	Ship
310582.79	319589.8792	1	3000	Railway
364302.9018	380978.0684	7	10000	Ship
396078.4561	404420.2061	3	5000	Ship
485135.0921	494142.1813	1	3000	Railway

We can also get the maximum, minimum and average inventory of each bunker and stock pile. At the same time, so we can get minimum safe stock to reduce the costs (Table 157.2).

Get the input information of the storage yard by ways of simulation is earlier to make procurement plan. Management staff can make out the corresponding purchasing transport plan. Table 157.3 is input information of the storage yard.

Finally by means of using simulation technology we can make quantitative evaluation and analysis of the material factory and optimize the design and scheduling. This paper also showed that we can use simulation technology to establish the random complex large production scheduling system model. If we change the Parameters and strategy, we can get the simulation results quickly, and by using optimization function of simulation software, we can get the optimal configuration of the system resources.

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Chapter 158
Comprehensive Evaluation and Optimizing for Boarding Strategies

Da-wei Sun, Xia-yang Zheng, Zi-jun Chen and Hong-min Wang

Abstract In this paper, we focus on the need for reducing boarding time for airlines. Therefore existing researches devoted to designing boarding routines and studying boarding strategies in existence. A model based on cellular automata is developed for calculating the integrated boarding time and testifies that the Reverse-Pyramid way is one of the most effective strategies. Aiming at giving an optimal boarding strategy, this paper combines a new evaluating criterion with some further analysis of Reverse-Pyramid and finally concludes that Reverse-Pyramid strategy which is divided into 5 groups and has more groups with a particular proportion is the best. Somehow the present paper solves the neglect of passengers' satisfaction and time spent on organizing before boarding in existing researches and gives some recommendations to airlines at last.

Keywords Aircraft boarding · Aisle interference · Cellular automata · Evaluating criterion

158.1 Introduction

How much time is usually demanded for different necessary tasks when the airplane is landed, which are departure, fuel, baggage loading and unloading, catering, and passengers' boarding? According to reports from Boeing, the passengers' boarding is the most time-consuming task, around 60 % of the total (Capelo et al. 2008).

Because the plane makes money for airline only when it is in motion, reducing the boarding time is helpful to not only arrange more scheduled flight but also be

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E. Qi et al. (eds.), *The 19th International Conference on Industrial Engineering and Engineering Management*, DOI: 10.1007/978-3-642-38391-5_158,

beneficial to finance and customer's satisfaction. So in order to reduce the boarding time, many researches and the present paper build the boarding strategy, which is a group of rules that aim at boarding all passengers as quickly as possible.

For the former researches, in 2002, Van Landeghem and Beuselinck compared the random strategy and back-to-front strategy. And results showed that the random strategy performed better (Van Landeghem and Beuselinck 2002). Then in 2005, Pieric and Kai modeled the aisle interference by grid simulation (Ferrari and Nagel 2005). The same year, Menkes and Briel firstly came out the reverse pyramid strategy (Menkes et al. 2005).

For the present paper, a model based cellular automata is presented to study the different strategies. An integrated standard is given to estimate the strategies including the total boarding time, interference waiting time per passenger and time spent on organizing before boarding. Finally the paper optimizes the reverse pyramid strategy and gives some recommendations.

158.2 Comparing Boarding Strategies

158.2.1 Model

158.2.1.1 Assumptions

(1) Interferences are the major reasons lead to wait. There are two main kinds of interferences which are aisle interference and seat interference. The aisle interference shows that the process of placing baggage will delay the passengers who followed by them. And for the second kind, when a passenger wants to settle in the window seat, he may block other passengers of the same line. We call this 'seat interference'. But in the model, we ignore the seat interference, because many researches made clear that Outside-In strategy is better than Back-To-Front and random strategy mainly because Outside-In strategy avoiding the seat interference. The paper mainly studies the strategies which avoid seat interference themselves on the basis of predecessors, so the seat interference doesn't influence the results.

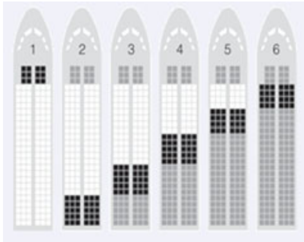
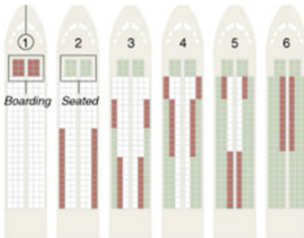
(2) Assumptions for the passengers: they will not happen to have other's seat or miss his seat. And they will obey our arrangement of boarding. Also the paper doesn't consider the passengers' coming late.

(3) Assumptions for the planes: the boarding gate is in the top of the cabin. And the business class seats and the first class seats are far less than economy class seats. That allows us to only consider the boarding of passenger in economy class.

158.2.1.2 Introduction of Three Strategies

See Table 158.1 for introduction of three strategies.

Table 158.1 Introduction of three strategies

	Picture
Name: Back-to-Front Advantages Somehow avoid the conflict of gangway because the back passenger will not be obstructed by the front passenger	
Name: Outside-In Advantages Totally avoid the conflict of seat and fully make use of the space of gangway to place the luggage	
Name: Reverse-Pyramid Advantages Have the advantages of the former two strategies	

158.2.1.3 Describe the Cabin

Because we want to describe the individual behavior, we decompose the cabin into many units. Just like Fig. 158.1. The figure follows these assumptions: (1) All the seats are treated as the same size and each seat is considered as one unit which is arranged very closely. (2) The gangway has the same width of a seat and it only

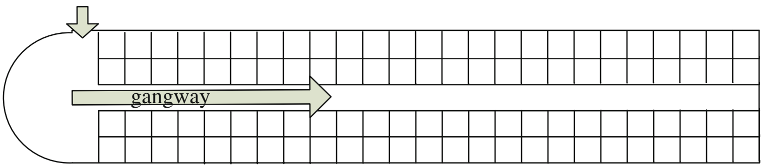


Fig. 158.1 Cabin

allows passengers to stand as single line. (3) The only entrance is at the top of the economy class.

This figure is the small size of plane that can have a capacity of 100 passengers.

158.2.1.4 Describe the Behavior of Passengers

All the passengers fit the following three rules.

(1) There are 100 passengers and everyone's target seat is his own seat and will not have a wrong seat. (2) If no one arranges the passengers, they will board randomly. (3) Passengers board continuously.

The individual behavior fits the following five rules. (1) If no one stops a passenger, he will walk directly to the 'gangway unit' that is the nearest one to his target seat. (2) Once the passenger arrive the nearest gangway unit, he will spend some time placing the luggage. (3) After placing the luggage, he will move to the target seat. (4) It is a discrete model, so when the timer adds a unit of time, every passenger can move to the empty unit near his present unit. (5) If timer adds a unit of time and the next unit that the passenger wants to move in is busy, the passenger will stay at his present unit until the next unit is empty.

158.2.1.5 Describe Time Spending on Placing Luggage for Every Passenger

Most researches consider the aisle interference as a probability event, without considering the influence of increasing and decreasing of the luggage. Although some considered it that the time grew linear with the quantity of luggage existed in the trunk. But these researches didn't account for the luggage capacity of the plane.

For these reasons, we draw support from literature (Shang et al. 2010).

$$\begin{aligned} &\mathrm{T_{bag}} = \frac{\lambda}{(c+1) - (n_{bin} + n_{lug})} n_{lug} \\ &\mathrm{s.t.}{:}0 \le (\mathrm{n_{bin}} + \mathrm{n_{lug}}) \le \mathrm{c} \end{aligned} \tag{158.1}$$

In the formula, T_{bag} means the time using for placing the luggage. n_{bin} means the present amount of baggage that already be placed in the luggage trunk. N_{lug} means the number of bags that will be put in the luggage trunk. c means the number of capacity of luggage rack for one row of seat. λ is correction coefficient. According to (Shang et al. 2010), $c = 4$, $\lambda = 20$ (Trivedi 2002; Kiwi 2006).

In this hyperbolic model, set ΔT to stand for the unit time of placing luggage. n_{total} stands for the total number of capacity of luggage rack for one row of seat.

So $\Delta T = f(n_{total})$ is a hyperbola (see Fig. 158.2). We can find that when the spare of suitcases become smaller, the time of placing luggage is longer. When $n_{total} > 4$, the time of placing luggage approaches infinite (Bohannon 1997).

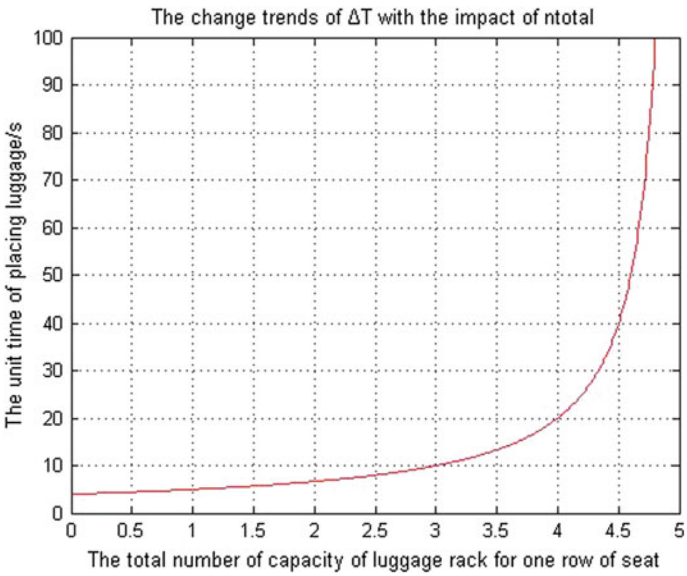


Fig. 158.2 Hyperbola

Table 158.2 Probability

Number of bags	Zero	One	Two
A passenger	20 %	70 %	10 %

But not everyone will bring luggage and they have different number of bags. The paper refers to the report from 'Data 100 Market Research' and gets the probability for every passenger as in Table 158.2 (Merry 1998).

158.2.2 Results

For each result, we simulate 200 times and average the results to become the finally result. And we calculate the root-mean-square deviation of every result and find that all the root-mean-square deviations are smaller than the 5 % of the corresponding results. So we can say the results are credible (Fig. 158.3).

Compare the results of strategy 1, 2, 3. We can see the strategy 3 is best because its boarding steps and waiting steps are the least. Strategy 1 is similar to the strategy of Back-To-Front. Strategy 2 is similar to the strategy of Outside-in. And strategy 3 is similar to the strategy of Reverse-Pyramid. Therefore, we can see the advantage of Reverse-Pyramid. For the same reason, when we compare the strategy 4, 5, 6, 7, we can get the same laws. So we can conclude that Reverse-Pyramid is the best one on the hand of total steps and waiting steps. So we concentrate on the strategy of Reverse-Pyramid.

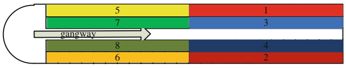
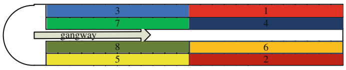
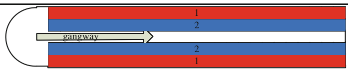
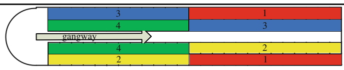
No.	How to dividethe group	Steps of boarding	Waiting steps
1		196.5	42.5
2		190	39
3		185	36
4		19 9	38.5
5		201	45
6		194	42
7		189	37

Fig. 158.3 Results

158.3 Optimal Number of Groups

The higher the number of groups of seats in the airship, the longer it takes to organize a line before boarding. Most researches didn't explain how they chose the number of groups. The present paper calculates the financial lose because of the time spent on organizing a line and waiting time. So using the economic indicator, we find the optimal number.

First we assume that all the 100 passengers sit in waiting hall by a line. Finally, different strategies require different orders of queues. For example, if one strategy requires every one boarding in a certain order, that's to say, the number of groups is 100, the queue must be formed in order one by one. But, if one strategy makes the passengers' boarding randomly, all passengers will stand the position closest to his seat in waiting hall. Finally, we get the total average steps using for organizing a line for different number groups. Some results are showed in Table. 158.3.

We treat the steps using for organizing a line the same as the average waiting steps, because the two kinds of steps reflects the satisfaction of passengers. And according to the literature (Li 2010) and The Civil Aviation Act, Air China's flying

Table 158.3 Average number of steps

Number of groups	0	5	100
Organizing steps	0	105	2514

Table 158.4 Optimal number of groups

Number of groups	0	5	100
Total steps	226	211	217

hours is 736770 in 2007 and retained profits are 3773 million RMB. Also airline pays every passenger 200 RMB for 4 h aircraft delay. So according to the ratio of money, we get the ratio of waiting step and boarding step which is 1/25.605. With all the data, we can calculate the optimal number of groups. The result is that 5 is the most optimal number and there are some results in Table. 158.4.

All the results in Sect. 158.3 are for Reverse-Pyramid strategy.

158.4 Optimal Reverse-Pyramid Strategy

Compare with the four strategies in Fig. 158.4, we find the strategy 13 is the best. These four strategies are all Reverse-Pyramid. The difference between the four strategies is shape of the second, the third and the fourth group. The second group has some window seats and some aisle seats. If we change the proportion of the two kinds of seats, the results will change. For the same reason, changing the third and the fourth groups' proportion of two kinds of seats will change the final results. Comparing these four strategies, we infer that it is better to arrange more groups that have the proportion of 7/3 approximately (7 is window seat and 3 is aisle seat).

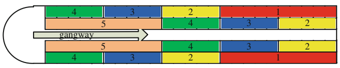
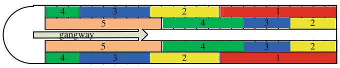
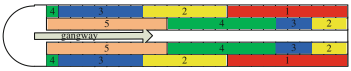
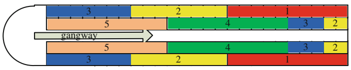
No.	How to dividethe group	Steps of boarding	Waiting steps
11		209	44.9
12		207.5	44.7
13		205.5	44.2
14		209.5	45.4

Fig. 158.4 Comparison of strategies

158.5 Conclusion

The present paper simulates a model to calculate the total boarding steps, waiting steps and organizing steps. First the model compares the three boarding strategies. Finding that the best one is Reverse-Pyramid, the model's results are the same as the other researches and that somehow proves the reliability of the model. Then a new way of evaluating boarding strategies comes out and shows that dividing into 5 groups is the best choice. Finally an optimal Reverse-Pyramid is given. And the paper recommends airline that for the similar structure as Fig. 158.1, it's better to use Reverse-Pyramid strategy which is divided into 5 groups and arranges more groups that have the proportion of 7/3 approximately. For the other type of planes, one method is to divide the bigger plane into the structures as Fig. 158.1 shows. Another way is to change the parameter in Fig. 158.1 to fit the special type plane. Both methods are easy to achieve.

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Chapter 159
Modeling for Crime Busting

Da-wei Sun, Xia-yang Zheng, Zi-jun Chen and Hong-min Wang

Abstract The paper models for identifying people in a 83-workers-company who are the most likely conspirators. The train of thought is that: (1) get a priority list for valuing the suspicious degree of the workers, (2) get a line separating conspirators from nonconspirators, (3) get the leader of the conspiracy. The paper first sets different values of suspicious degree for messages with various features in order to value the suspicious degree of everybody. Secondly, we optimizes the primary figure by using a formula based on weighted average method. Thirdly, we worked through each individual on the better priority list from both ends. Then, the paper used some methods of semantic analysis to better distinguish possible conspirators from the others and finally got the priority list. Next, the discriminate line is determined by using probability theory and clustering analysis theory. At last, get the leaders by the priority list and discriminate line.

Keywords Mathematic model · Crime busting · Social network · Text analysis

159.1 Restatement of the Problem

The present paper is for investigating a conspiracy to commit a criminal act. Now, we realize that the conspiracy is taking place to embezzle funds from the company and use internet fraud to steal funds from credit cards of people who do business with the company. All we know is that there are 83 people, 400 messages (sent by the 83 people), 15 topics (3 have been deemed to be suspicious), 7 known conspirators, 8 known non-conspirators and there are three managers in the company.

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E. Qi et al. (eds.), *The 19th International Conference on Industrial Engineering and Engineering Management*, DOI: 10.1007/978-3-642-38391-5_159,

159.2 Model and Results

159.2.1 Step1

Our goal is to get a table to explain the suspicious degree of different messages, and then we can get a preliminary priority list on the basis of the table.

We consider that every message connects two workers. According to the suspicious degree of the message's topic, we add a reasonable weight to each worker. The weight is related not only to the suspicious degree of the message's topic, but also to the suspicious degree of the speaker and listener.

In Table 159.1, 'c.' means conspirator. This table gives the value to Q_m that we use in the formula (159.1). The corner mark 'm' means the number of a message. Mentioned in the section of sensitivity analysis, '(A#)' stands for the number of the cell in the table. This table is one of our foundations of the model. We can see the Q_m is decided by three factors: the speaker, the listener and the topic of No. m message.

$$Y_i = \sum_{m=0}^{N} R_{im} \times Q_m \qquad (159.1)$$

'Y_i' is an intermediate variable for worker i and we will use 'Y_i' in formula (159.2). 'N' means total amount of the messages and in our case $N = 400$. 'm' means the No. of a message. 'Q_m' means the weight that No. m message gives. The value of 'Q_m' is given by Table 159.1. R_{im} means the relation between No. m message and worker i. If the No. m message is sent from or sent to worker i, $R_{im} = 1$. If not $R_{im} = 0$. At first we use 'Y_i' to present the suspicious degree for every workers.

The primary priority list is the result and it is made by traversal all messages with Matlab.

It is obvious that there are two special points (20, 12) and (56, 58). Our goal is to distinguish conspirators and non-conspirators, so there should be one special point to divide the figure into two parts in theory. So we don't satisfy with this figure, and there must be some other factors that we didn't take into consideration.

Table 159.1 Values for Q_m

	Suspicious topics			Normal topics		
Spoken to Weight Spoken from	Known c.	Unknown worker	Known non-c.	Known c.	Unknown worker	Known non-c.
Known c.	15(A11)	10(A1)	2(A12)	4(A15)	2(A16)	1(A16)
Unknown worker	10(A2)	6(A3)	4(A4)	2(A17)	1(A8)	0(A9)
Known non-c.	2(A13)	4(A15)	0(A14)	1(A17)	0(A10)	0(A18)

159.2.2 Step2

Our goal is to optimize the priority figure we have got in step1 using method of weighted average.

We think 'Y_i' (mentioned in formula (159.1)) to stand for the suspicious degree is not reliable. Through a formula we create, we can evaluate the suspicious degree of each worker by using the method of weighted average.

$$W_i = \frac{\sum_{k=1}^{M} Sd(k) \times A_i(k)}{A_i \times Sd_{max}} \times Y_i \tag{159.2}$$

'W_i' means the crime suspicious degree of worker i. 'k' means the No. of the topic. M means the total amount of topics and in our case, M = 15. 'Y_i' is given by formula (159.1). Sd(k) stands for the influence of linguistics for No. k topic. Before step4, Sd(k) = 1 when topic k is not suspicious and Sd(k) = 2 when topic is the suspicious. And we will optimize the value of Sd(k) at step4 and finally give many different values for Sd(k) according to different topic number. Sd_{max} is defined by

$$Sd_{max} = \max\{Sd_1 Sd_2 \ldots Sd_M\} \tag{159.3}$$

A_i is the total amount of text topics worker i gets. For example, if David receives only one message and sent no message. And the only message includes three text topics, $A_{David} = 3$. $A_i(k)$ is the total amount of text topics of number k. That is to say

$$A_i = \sum_{k=1}^{M} A_i(k) \tag{159.4}$$

We can get W_i, which is the crime suspicious degree of worker i, by searching all messages. Then we get the priority list by ranking W_i.

Figure 159.2 is better than Fig. 159.1, because there is only one inflection point. But the slope of both sides of the inflection point is not different largely. We want to optimize the priority figure further more in the step3.

159.2.3 Step3

Our goal is to optimize the better priority figure we have got in step2 using method of iteration.

We find a disadvantage of step1 and step2: We didn't consider the difference between the unknown workers. In fact, some of the unknown workers are criminals and the others are not. So they should be considered differently. In another word, different unknown worker have different influence for other's 'W_i'. We consider these different influences in step3 to optimize our priority list.

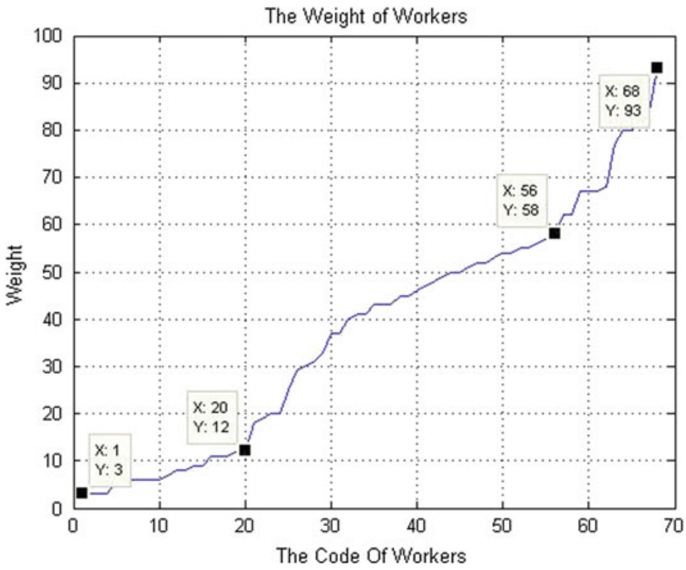

Fig. 159.1 Primary priority figure

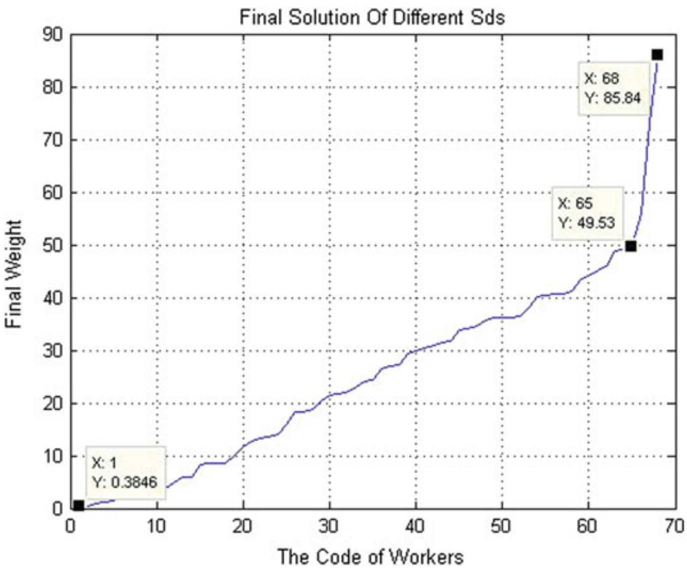

Fig. 159.2 Better priority figure

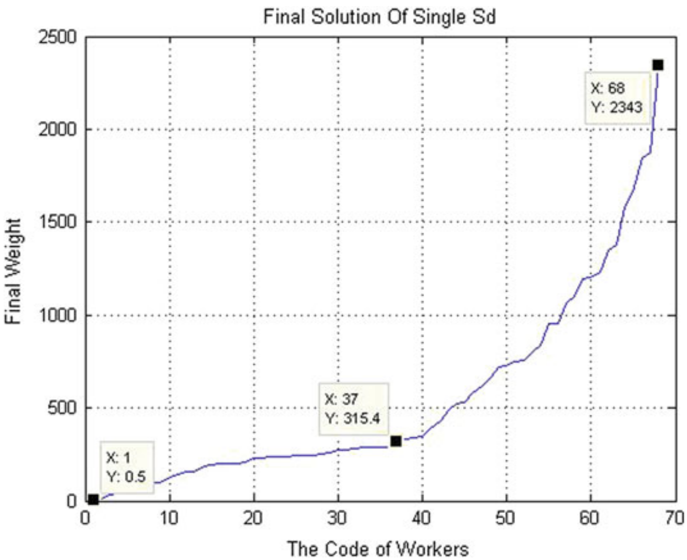

Fig. 159.3 Final priority figure

In Fig. 159.1, point (1, 3) worker and point (68, 93) worker are considered differently in this step. We treat point (68, 93) worker as a known criminal and treat point (1, 3) worker as an innocent. And use the way of step1 again. So we get another priority list.

But we think it's unconvincing that let two unknown worker to be a criminal and an innocent apart in each time. Because if you see the Fig. 159.1, you will find the point (68, 93) worker has obvious difference from the near one in crime suspicious degree. But point (1, 3) worker has tiny difference from the near one. So we match the 67 points a curve and use slopes of the two vertex tangents to describe how many unknown workers should be treated as criminals and innocents. So we do these continually and finally we will places all unknown workers in two categories: criminals and innocents. We will get a priority list at last (Fig. 159.3).

159.2.4 Step4

Our goal is that: consulting the literatures about the text analysis methods, we try to optimize our priority figure by this method.

We set 'Sd(k)' which means the suspicious degree for the No. k topic. We think that the topics talked more frequently in the group of conspirators should be added a larger value for 'Sd(k)'. We use the following formula (159.5) and (159.6) to describe 'Sd(k)'

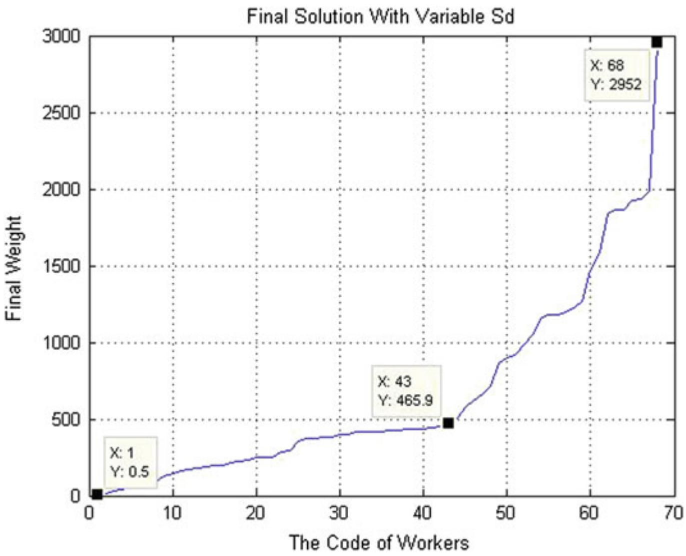

Fig. 159.4 Final priority figure with linguistics

$$Sd(k)_{i+1} = \frac{Sd_{maxi}}{\varphi_{maxi}} \times \left[\varphi(k)_i - \varphi_{avei}\right] \div 10 + Sd(k)_i \tag{159.5}$$

$$\varphi(k) = \frac{p(k)_h}{h} \Big/ \frac{p(k)_j}{j} \tag{159.6}$$

'$P(k)_h$' means the times that topic k is talked by criminals. 'h' means the amount of criminals. 'j' means the total amount of people, which means $j = 83$. $\varphi(k)$ describes the frequency degree of topic k in conversation of criminals. $\varphi_{maxi} = \max\{\varphi(k)_i\}$; $\varphi_{avei} = \text{average}\{\varphi(k)_i\}$; $Sd_{maxi} = \max\{Sd(k)_i\}$. In step2, we elect unknown workers to be criminals and innocents continually. So we set circulating in Matlab and the corner mark 'i' means the times we circulate.

We use the text analysis idea to value Sd(k), and finally change the 'W_i' (degree of crime suspicious for worker i).

With the considering of influence from text analysis method to 'Sd(k)', we get the final priority figure with linguistics. We get our final priority list by the priority figure (Fig. 159.4).

159.2.5 Step5

In step5, our goal is to locate a discriminate line to help distinctly categorize the unknown workers using the ideas of cluster analysis and method of hypothesis testing.

We find a variable ‘AW1’ to describe the degree of conspiring for the group of conspirator. ‘AW’ is defined by the following formula (159.7)

$$AW1_x = \left(\sum_{i=x}^{67} W_i + W_{83-K} \times K \right) \div (83 - x) \quad (159.7)$$

‘AW1’ means the average weight for the group of conspirators, and it stands for the degree of conspiring. The ‘x’ is the abscissa of the point where the discriminate line located at. ‘W_i’ is defined in formula (159.2). ‘K’ is the amount of the known conspirators. We consider the suspicious degrees (‘W_i’) of all known conspirators are all same and the value of these suspicious degrees is same as the most right point in Fig. 159.4.

(a) Draw the Fig. 159.5 that shows the changing of ‘$AW1_x$’ by growing of the ‘x’.

(b) For the same reason, we can define ‘AW2’ to describe the degree of conspiring for the group of non-conspirator, using formula (159.8).

$$AW2_x = \left(\sum_{1}^{i=x} W_i + W_L \times L \right) \div (L + X) \quad (159.8)$$

‘L’ is the amount of the known non-conspirators. We consider the suspicious degrees (‘W_i’) of all known non-conspirators are all same and the value of these suspicious degrees is same as the most left point in Fig. 159.4. And we can draw Fig. 159.6 shows the changing of ‘$AW2_x$’ by growing of the ‘x’.

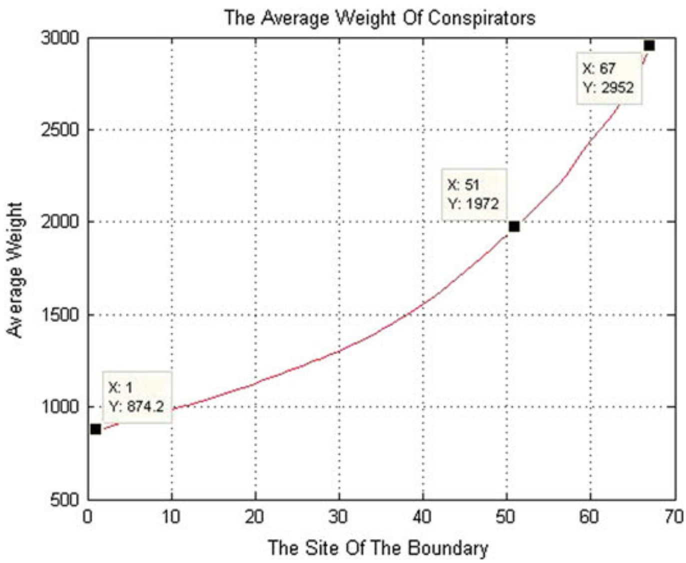

Fig. 159.5 Changing of ‘$AW1_x$’ by growing of the ‘x’

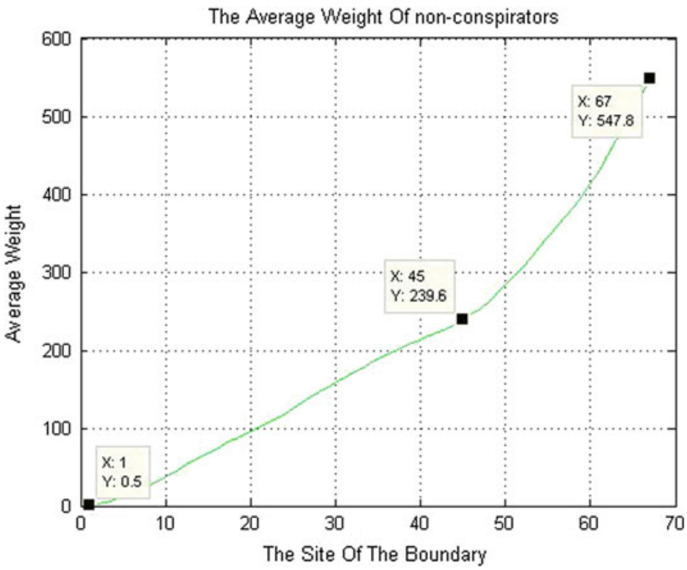

Fig. 159.6 Changing of '$AW2_x$' by growing of the 'x'

We finally give different discriminate lines and evaluate the solution according to different probability of first type error and second type error to fit different requires of the police.

The first type error in our model is let the conspirators get away with crime. We describe the probability of first type error by 'P1%' using formula (159.9)

$$P1\% = 1 - \left(\frac{\int_{x}^{x_2} f(x)dx}{\int_{x_1}^{x_2} f(x)dx} \right) \times 100\% \quad (x_1 \leq x \leq x_2) \tag{159.9}$$

The f(x) is the function of the curve we match in Fig. 159.5. X1 and X2 is left and right point's abscissa.

The second type error in our model is let the non-conspirators be treated as conspirators. We describe the probability of first type error by 'P2%' using formula (159.10)

$$P1\% = 1 - \left(\frac{\int_{x_1}^{x} g(x)dx}{\int_{x_1}^{x_2} g(x)dx} \right) \times 100\% \quad (x_1 \leq x \leq x_2) \tag{159.10}$$

The g(x) is the function of the curve we match in Fig. 159.6. And we finally find that P2%, the probability of second type error, is decreasing with the increasing of ‘x’.

If we change the value of ‘x’, the probability of the first and second type error will change too. At last we find when ‘x’ = 55, the value of P1% + P2% is the smallest. So we recommend police to locate discriminate line at the point whose abscissa is 55 in Fig. 159.4 (Li and Zhu 2008; Guo and Zhu 2005).

159.2.6 Step6

We try to find the boss of the crime group using the concept of point centrality in study of social network analysis (Ma and Guo 2007).

Now that we know Jerome, Dolores and Gretchen are the senior managers of the company. If one or two, or even all of these three people are in the list of conspirators, we can credibly make sure that the leader or leaders come from the group of the three managers (Estevez et al. 2007; Santos et al. 2006; Kiss et al. 2006).

If all of them are not in the primary priority list, it will become more complex. Assuming the crime group is isolated from the other group, that is to say, it has little connection to the outside, so we can focus only on them. From previous work, we can obtain the criminal topics and their Sd(k). So we can calculate everyone’s weight of point centrality by the same formula as formula (159.2). If someone’s weight is much higher than others, we can surely know that he is the leader (Klovdahl et al. 1994; Klovdahl 1985; Peiris et al. 2003; Svoboda et al. 2004).

159.3 Sensitivity Analysis and Model Evaluating

In our models, the value of weight in Table 159.1 and Sd(k) are defined by ourselves through perceptual knowledge and some experiments of the example of Investigation EZ. That is to say, the weight and Sd(k) have no certain standard, so it is necessary for us to make sure how it will affect our results.

There are 18 weights needed in our models, named A1, A2, A3, A4, A5……A18, which you can see them in Table 159.1. We choose A3 and A16 randomly. With previous value, we get the priority list as follows (be expressed by the code for unknown workers):

3, 32, 15, 37, 17, 40, 10, 81, 34, 22, 31, 13 ……

First, change A3 from 4 to 5, we got the result:

3, 32, 15, 37, 40, 17, 10, 81, 4, 34, 31 ……

Then, change the value of A16 from 1 to 2, we got result:

3, 32, 15, 37, 17, 40, 10, 81, 34, 22, 31, 13 ……

The basic value of Sd(k) is defined to be 1 when topic k has nothing about crime. Otherwise, the topic is suspicious. The problem is that we didn’t define the

Table 159.2 The results

No.	Known criminals	Known non-criminals	Criminals	Similar	Time to count
1	7, 18, 21, 43, 49, 54, 67	0, 2, 48, 64, 65, 68, 74, 78	7, 18, 21, 43, 49, 54, 67, 3, 32, …	–	28
2	–	0, 2, 48, 64, 65, 68, 74, 78	67, 21, 54, 7, 3, 43, 81, 49, 10, …	89.5 %	30
3	7, 18, 21, 43, 49, 54, 67	–	7, 18, 21, 43, 49, 54, 67, 3, 32, …	89.5 %	31
4	–	–	21, 67, 54, 7, 3, 43, 32, 2, 18, 1, …	84.2 %	33
5	7, 18, 21, 43	0, 2, 48, 64, 65, 68, 74, 78	7, 18, 21, 43, 67, 54, 3, 49, 17, …	94.7 %	29
6	7, 18, 21, 43, 49, 54, 67	0, 2, 48, 64	7, 18, 21, 43, 49, 54, 67, 3, 17, …	94.7 %	25

maximum value of its initial value. The value will influent the results of formula (159.2). In our models, we defined it as 2. Now, we analysis whether the small change of the value will affect our results.

3, 32, 17, 15, 10, 37, 81, 40, 22, 16, 34, 4, 44 ……

Observing these results carefully, we can conclude that when we change the weight or the maximum initial value of Sd(k), the results are not sensitive. We can say that our models behave well during the process of sensitivity analysis.

Now we evaluate this model, because we don't know whether it is stable or accurate. We guess that our model seems rely on the initial conditions. If it relies tightly on initial conditions, the model may not be trustful because no one can make sure the initial condition. So we will show that how our model's result may change when the initial conditions change. And we only take the conspirators who are at the top of the priority list into consideration. These are some extreme conditions.

Condition 1. Set initial conditions as normal, this result can be the basic standard.

Condition 2. Assume we cannot identify the conspirators;

Condition 3. Assume we cannot identify the non-conspirators;

Condition 4. Assume we cannot identify all of them;

Condition 5. Assume we can only identify some of the conspirators, such as 7, 18, 21, 43;

Condition 6. Assume we can only identify some of the non-conspirators, such as 0, 2, 48, 64 (Marsden 2002; Newman 2003).

Through the analysis of Table 159.2, we conclude some laws:

(1) The initial conditions about 'Known conspirators' and 'Unknown conspirators' will affect the results, but the effect is tolerable; (2) The more accurate initial conditions there are, the more fast and accuracy the results have; (3) More initial conditions means more accuracy and less time(especially for large data base), however it also means more energy it costs; (4) Our model has great stability so that it can be used widely, and it will show strong adaptability (Anderson and May 1992).

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Chapter 160
Personalized Emotion Model Based on Support Vector Machine

Jin-bin Wu and Wan-sen Wang

Abstract Emotion deficit is an intelligent in e-learning technology research. The main purpose of the paper is based on Support Vector Machine (SVM) through the samples data analysis of the face area, interpupillary distance, eye spacing and mouth curvature to build to the aversion degree, cheer degree and pleasure degree based emotion model of personality academic emotions. All of these lay the foundation for emotional teaching in E-Learning system.

Keywords Academic emotions · Emotion deficit · E-Learning · Support vector machine

160.1 Introduction

Analysis of the existing E-Learning system, we can easily find a common phenomenon: the current system is often web-based information technology "boilerplate" are text-based teaching can be seen, usually posted on the Internet, teaching practice, and related methods, this teaching method is indifferent learning lack of personalized teaching guidance, we generally call "emotional deficit" (Zhang 2009). The importance of emotions in the E-Learning, University of Adelaide Professor Kerry O'Regan, told that students conducted a survey of distance learning, she found that the emotion was the key to learning networks and was the essential factor in the teaching and learning process (O'Regan 2003). In addition, according to the psychological studies, emotional factors have an important impact on the learning behaviors (Su and Xu 2009).

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E. Qi et al. (eds.), *The 19th International Conference on Industrial Engineering and Engineering Management*, DOI: 10.1007/978-3-642-38391-5_160,

The main purpose of these researches is the introduction of emotional teaching function in the traditional E-Learning. With the rapid development of information technology in the field of education, e-learning has rapidly changed distance education. But after the initial practice boom retreated, people gradually return to rationality. E-Learning has many advantages, but due to the lack teachers to participate and can not completely replace the classroom educational activities of teachers and students learning is not as conceived so perfect. This emotional missing affected the teaching effectiveness and widely used of distance education. Meanwhile, Chinese educational psychologist Professor Qing-lin Wu pointed out that intelligent e-learning system is not only a truly personalized teaching system but also is emotional (Wu 2003).

160.2 Basic Conception

This research focuses on learners' emotions and emotional modeling. In general, the mood in psychology with a number of different classification methods, the each different method can be divided into several different types.

Emotions have physiological and explicit characteristics: the physiological characteristics mainly refer to the obvious physiological changes inside the body, such as breathing, heartbeat, etc. The explicit features refer to the physical external changes, such as smiling, frowning, etc. The explicit characteristics often refer to the expression. Different emotional characteristics access to information is different. Physiological characteristics of access to information usually require a physical means of galvanic skin contact. While expression information can be obtain by video, audio and other non-contact means. Visible, in network learning, expression method access to information is practical and significant.

The expression can be divided into three types, such as facial expressions, body expressions and language expressions. Because the expression is the external expression of emotions, so if a different expression has recognized, it can be judged by different expression from different emotions of the people, and also by the different expressions of the people to express different emotions. In the three expressions, the facial expression is the most identification of emotional signs, the most sophisticated to identify the specific mode of the different nature of emotions. Emotional modeling is the core of this paper and important aspects of emotional information in E-Learning. In this paper, the extraction of facial expression characteristics, its steps, the first analyses the sample data for stability and reliability, and then introduce aversion degree, cheer degree and pleasure degree to describe the emotional state of the learners. Select a few learners to information collection and analysis the image filter as a sample. Experiment in a variety of environments, the rapid classification of the characteristics of small samples by Support Vector Machine (SVM), build the aversion degree, cheer degree and pleasure degree of sample data for modeling and analysis.

OCC emotion model is proposed by a book named emotional cognitive structure, write by Ortony A, Clore G, Collins A, which is also the earliest and most complete one of the model study of human emotions. According to the emotional causes, OCC emotion model is divided into the following three categories: the results of the event, the action of the agent, the object perception. The model defines a total of 22 species basic emotions and the relationship between their levels. The OCC model is not a basic emotion set or a clear multi-dimensional space to express their feelings to express emotion, but with consistency cognitive export conditions. In particular, in the model assumes that the emotional satisfaction and dissatisfaction Agent, happy and unhappy event, and the likes and dislikes object, they constitute the reaction of the situation in a positive or negative tendency. The model summarizes the standards, which includes 22 kinds of emotional type used to generate the basic structure of the rules, and these emotional types are derived by different cognitive conditions.

In this paper, academic emotions, defined as three dimensions (Wang 2009), discuss the reverse of each other in the most common of the six academic emotions: interested, bored, excited, tired, happy and distress. In the basic emotional space, A represents the interest, B is boredom, C is excited mood, D is fatigue, E is a happy and F is distressed. The origin of coordinates is removed from the emotional space, because the origin of coordinates is emotional state, so it does not meet the normal human emotions.

160.3 Support Vector Machine Introduction

Support vector machine (Cores 1995) designed to solve nonlinear problems of the small sample study and classification. On the one hand, to overcome, the least squares method is too simple, can not distinguish between complex nonlinear classification designs; on the other hand, support vector machine has good classification ability, but neural network had the problem of overfitting and underfitting. SVM technology, the most critical is the selection of the kernel function: different kernel functions have a great impact on the classification results. There are several different ideas in the selected kernel function to solve practical problems: The first use of an expert transcendental knowledge for kernel function selected; the other is the Cross-Validation method, kernel function selection process, experimenting with different kernel functions and parameters; the third using mixed kernel function method (Smits et al. Proposed), which is using different kernel functions combined to obtain better performance, it is also the basic idea of the mixed kernel function. On the whole, the parameter selection problem, in essence, is an optimization problem.

In this paper, using the main advantage of the SVM algorithm is to classify training data characteristics of the facial expression modeling and has obtained good experimental results. In the research, using libsvm (http://www.csie.ntu.edu.tw/~cjlin/libsvm/index.html) toolbox in Matlab, it is developed by National Taiwan

University Professor LinChin-jen. The aim is to design a simple, easy to use support vector machine (SVM) to solve pattern recognition and linear regression package. The software not only provides a compiled version of Microsoft Windows, but also other operating systems. The executable file is open source code, facilitate others to improve and modify; the software can solve the C-support vector (C-SVC), nu-support vector classification (nu-the SVC), one-class SVM (distribution estimation), epsilon-support vector regression (epsilon-SVR), nu-support vector regression (nu-SVR) and other problems, including based on one-on-one algorithm to solve the related many types of algorithm's problems. Support vector machine is used to solve the problem of pattern recognition or regression, the international scientific community has not yet formed a unified view the parameters choice and the choice of kernel function. This also means that the parameter selection of the optimal SVM algorithm can only use the excellent previous experience, or comparative experiments, or large-scale search, or use the package cross-validation function. Also use other algorithms to achieve optimization, the algorithms such as genetic algorithm (Kang et al. 2011), particle swarm optimization (PSO) (Chen and Mei 2011) and cats swarm optimization (CSO) (Wang and Wu 2011). In this paper, due to the complexity of the experimental constraints, only to choose the experts and experience the results of selected parameters.

160.4 Comprehensive Experiment

Due to the complexity of the human face, related to the study about this experiment, I proposed the three main concepts are aversion degree, cheer degree and pleasure degree. Aversion is based on the face area and interpupillary distance to locate positioning method. Positioning and calculation of the face and the pupil of the eye is to determine the learners in the learning process, interested in learning the current content. Under normal circumstances, when the detected face area and interpupillary distance is larger, which means learners leaned forward in the learning process, learning content is relatively interested in, aversion for bigger; On the contrary, when the changes in the hours means that learners lean back, and not interested in learning content, and even boredom, aversion for smaller.

Similarly, cheer degree of detect eye spacing heterozygosity is to describe and judge the cheer extend. And pleasure degree, through the mouth upturned angle to detect degree of pleasure in the learning process.

Verify the stability of the data to prove its stability. A learner and B learner within two hours (every 60 s tested once) detected in the normal state of learning data. Because of space constraints, I only cite the face area and interpupillary distance of data analysis figure, similar to other situations.

Detected sample data (the face area and interpupillary distance) really focused within a certain range. Accordingly, we propose a hypothesis: the face area and ongoing testing to get a sufficient amount of data, we believe that it is possible to meet the normal distribution, if that were true, then we can change the scope of the

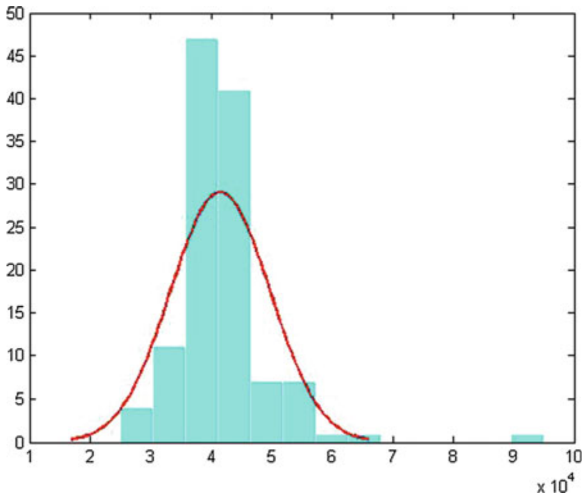

Fig. 160.1 Face area of a learner the normal reference curve

already mentioned, and then detect whether the current learners in the normal learning state. Figure 160.1 shows the results of tests of the data sample, to demonstrate that they meet the assumption.

160.4.1 Input Variable Selection

Aversion degree of face area and interpupillary distance, and the statistical analysis of previous data have been found that these two sets of data for normal distribution, indicating that learner's mood is relatively stable over a period of time.

We put this the face area and interpupillary distance of 120 sets of data in two different learners classification preprocessing, select 100 as the training set, the remaining 20 as test set. Consider a simplified classification of emotions into the four categories, which are very interested, interested, tired and very tired. So one On behalf of very tired, two is tired, three is interested and four is very interest, enter is test data of human face area and interpupillary distance. Figure 160.2 shows the relationship between category labels and face area, interpupillary distance, asterisk is the distribution of sample points.

160.4.2 Data Preprocessing

Training and test set were normalized preprocessing.

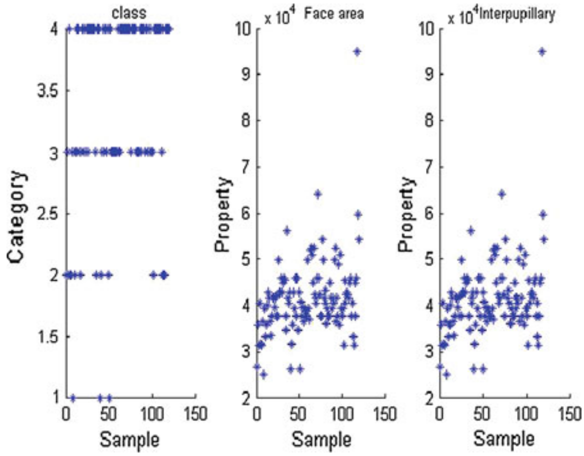

Fig. 160.2 Aversion degree labels and property distribution

160.4.3 Training and Prediction

Kernel function to select the radial basis kernel function, the function C is selected as 1000.

160.4.4 Analysis of Experimental Results

Operating results: Accuracy = 70 % (14/20) (classification).

The final classification results are as follows:

The experimental results can be seen from Fig. 160.3, the blue represents the classification of the actual test set, and red represents the prediction set

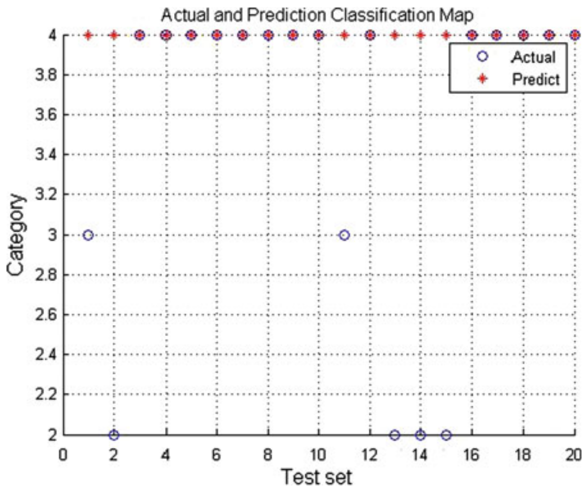

Fig. 160.3 Aversion degree of classification results

classification, the classification accuracy is 70 %, the basic realization of the successful implementation of the aversion degree modeling and analysis. Successful implement of the mapping from the face area and interpupillary distance to four different emotions.

Other, cheer degree and pleasure degree have the similar results. Accuracy can reach 95 %, to obtain good experimental results.

160.5 Conclusion

This paper is using fast learning classification adopting support vector machine network of small sample nonlinear characteristics based on the OCC emotion model, aversion degree, cheer degree and pleasure degree to establish academic emotions model in E-Learning. The model provides the necessary basis of academic emotions, is also a useful attempt of the SVM algorithm in the field of emotion recognition, achieved the good results.

Acknowledgments The research is supported by the National Natural Science Foundation of China (Grant No.60970052) and Beijing Natural Science Foundation (The Study of Personalized e-learning Community Education based on Emotional Psychology).

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Chapter 161
Research on Decision-Making Behavior Test System for Top Management Team Based on Simulation Environment

Xue-ying Hong, Zhu-chao Yu, Zhu Wang and Yang Jiang

Abstract The decision made by Top Management Team is fatally important for business operation. So, how to improve the quality and reliability of decision-making seems very necessary. Starting from the Prospect Theory of behavioral decision-making theory, this paper puts forward testing decision-making behaviors of Top Management Team, and analyzes the specific process and methods of decision-making. According to results of the decision-making behavior testing, the characteristics of Top Management Team can be obtained, and so as to provide reasonable foundation for evaluation and improvement of decision-making behaviors.

Keywords Behavior testing · Decision-making behavior · Decision simulation · Top management team

161.1 Introduction

The Nobel Prize Winner Herbert Simon used to say that "management is making decision", which reveals how important the decision-making is in business administration. With the global economic integration goes further in China, drastic market competition and rapid changes of information revolution, diversification oriented business and close coordination oriented department all present new challenges to executive leaders (Ancona and Nadler 1989). At the same time, team decision-making gradually takes place of personal decision-making and is

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E. Qi et al. (eds.), *The 19th International Conference on Industrial Engineering and Engineering Management*, DOI: 10.1007/978-3-642-38391-5_161,

becoming more and more important in business administration. By full understanding of Top Management Team (TMT) on decision-making behavior characteristics, we can make better use of the advantages of certain teams and achieve the effect that team decision is superior to individual decision, thus we can keep continual development of business in the long run.

Katzenbach defined TMT as "top leaders team in organizations and institutions", they usually have the power to solve problems, coordinate activities, mobilize organization members and make important decisions of the company. Because of the importance of the TMT, researchers in both domestic and overseas do a lot of researches on behaviors of TMT. Henning Bang and his partners got the conclusion that goal clarity and focused communication is positively related to team effectiveness by self-report and observer data from eight top management groups that processed 56 agenda items during meetings, thus provided instructions on how to make decisions efficiently. At the same time, they extended three dimensions related to team efficiency: Task performance, relationship quality, and member satisfaction (Bang et al. 2010). From two total different aspects: Functional-background and locus-of-control, Boone and Hendriks (2009) analyzed the compositional diversity and organizational performance by collecting and analyzing the data collected from scientific and technical corporations, and they finally provided instructions on the optimizing of team composition.

In this paper, we introduce decision simulation system into the research of decision-making test of TMT, so we can avoid the problems that are met in traditional surveys, such as information distortion and data ambiguous. This paper also takes advantage of management simulation programs to create management decision scenarios which are very similar with real market. By data collection and result analyzing, we can obtain decision-making characteristics of TMT, and finally help TMT to improve their decision performances.

161.2 Method

161.2.1 Behavioral Decision-Making Effect

Behavioral decision-making theory is a new theory developed to solve problems that are difficult to rational decision-making theory; classical decision theory also can be regarded as special case of behavioral decision-making theory when there are a lot of hypotheses. In 1979, Kahneman and Tversky (KT) put forward the Prospect Theory under uncertain conditions of personal decision behavior based on economic experiments (Kahneman and Tversky 1979), thus denied the Expected Utility Maximization Theory proposed by von Neumann and Morgenstern (1944). Expected Utility Maximization Theory holds the opinion that the preference of a decision maker is changeless, and his decisions can be predicted by statistical methods. On the contrary, Prospect Theory indicates that there exists Framing

Effect, Reference Point Effect, Deterministic Effect and other effects caused by irrational behaviors under uncertain conditions, what is more these irrational behaviors make individual decisions betray the Expected Utility Maximization. Framing Effect manifests that different formulations can lead to different preferences to the same problem. Deterministic Effect manifests that decision makers have obvious preference on certainty. In fact, these two effects are both caused by the changing of reference point which has a big influence on individual decisions. In different fields, different environments and among different individuals, decision makers' reference points may change, and we define this change as Reference Point Effect. For example, through experiments Zhan-lei Li validated that there exist Framing Effect, Reference Point Effect and Deterministic Effect in individual decisions under the environment of economy, society and culture (Li et al. 2007).

In view of different behavioral decision-making effects' different influences, in this paper we mainly use four effects (Reference Point Effect, Framing Effect, Fuzzy Avoid Effect and Deterministic Effect), which are extended from Prospect Theory, to test decision behaviors of TMT under different decision scenarios and analyze their behaviors' characteristics.

161.2.2 Management Simulation

Management Simulation is a kind of Computer simulation system using Computer Science, Management, Game Theory and Operational Research, and it is used to simulate management activities of business. The earliest Management Simulation came from some of American famous universities in 1850s, and the first university to use it was the University of Washington. In 1957, the University of Washington used a simulation system named High-level decision-making and management in the course of Business guidelines (Wang 1999). According to the data of 2001, more than half of the core members belonging to the Association to Advance Collegiate Schools of Business (AACSB) widely use Management Simulation in such courses as Strategic Management, Marketing, Accounting and Finance, and there are also Management Simulation Competitions in America and some other regions. At present, there are mainly 3 kinds of Management Simulation in the world, these are Management Game governed by Carnegie Melton University (CMU), MBABEST21 governed by CSIM College of Aoyama Gakuin University and Global Management Challenge (Xiao 2001).

When taking part in these Management Simulation systems, corporate executives will form several teams. These teams compete with each other and try to improve their own business's performance. As a result, they can experience management, use theory and cultivate innovative thinking (Iwai 2007).

Aiming at testing subjects' decision-making behaviors, this system takes advantage of parameter model used in traditional Management Simulation systems when design testing scenarios. Besides, we create various kinds of testing scenarios based on four basic effects. At last, we can analyze their decision-making characteristics by the data we collected.

161.2.3 Methods of Decision-Making Testing

From the middle of 1970s, behavioral decision-making had become an independent subject, and was widely used in areas of economy, finance and management. In this stage, research methods includes observational method, investigation method (mainly are questionnaire survey and interview survey) and experimental method (psychological experiment and economical experiment). Since then, these methods are also called general empirical research of decision-making behavior (Huang 2006). For example, by using "Asian disease problem", Tversky and Kahneman testified the existing of Framing Effect and successfully questioned traditional invariance (Kahneman and Tversky 1981).

At present, researches of behavioral decision-making theory mainly focus on summarizing behavioral characteristics and refining the behavioral variables, then apply it to analysis of rational decision-making. Representative studies of this kind of researches include such four investor psychology models as BSV model (Barberis et al. 1998), DHS model (Daniel et al. 1998), HS model (Hong and Stein 1999), BHS model (Barberis et al. 2001), and Behavioral Asset Pricing Model (Shefrin and Statman 1994), Behavioral Combination Model (Shefrin and Statman 2000).

Being different with general research methods, this paper's method uses logical processes to test TMT's decision-making behavior under management simulation scenarios. That is testing decision makers' behaviors and analyzing experiment results by controlling some variables under controlled experiment conditions, thus reinforce the reliability of the results. Besides, high emulation situation have directive functions in real life.

161.3 System Design

161.3.1 Overall Structure of the System

Aiming at testing decision-making behavioral characteristics of TMT, this system includes the function of managing multitask scenarios.

There are two main subsystems: Testing subsystem and analyzing subsystem. The overall structure of the system is shown in Fig. 161.1. As we can see, there are two modules in testing subsystem which are module of testing online and module of information services, and two modules in analyses system: Module of data statistics and module of management of testing scenarios. At first, subjects log in.

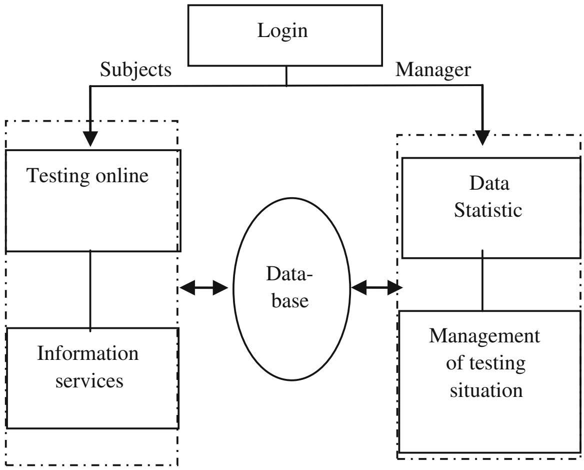

Fig. 161.1 Overall structure of decision-making behavior testing

Secondly, they should input their team information and then they can choose testing scenarios. After all of these, they will enter into testing subsystem to finish the whole processes under the guide of the system.

161.3.2 Design of Database

Database is used for depositing testing data of testing subsystem and system parameters of simulation programs. In testing phrases, subjects input decision variables and decision values as the simulation system asked. Then, the system will use relevant decision parameters that are set by managers in advance to calculate the results of simulation operation. Finally, the results will be seen in the interface as the form of reports; in decision-making behaviors analyzing phrase, managers take advantages of statistic analysis software to analyze all the decision data and give the results of the subjects' characteristics of decision-making behaviors.

161.3.3 Design of Function Module

This system obtains results of decision-making testing and of behavioral testing by calculating various of function modules, which includes module of parameter setting, module of operation calculating and modules of decision behavior analyzing. Among these modules, module of parameter setting is used for creating decision simulation environment and reducing errors to real situation; module of operation calculating, which includes demand function, constant cost function, variable function and so on, is used for calculating the operational results based on the values inputted by subjects; module of decision behavior analyzing is used for analyzing the decision data and the results of operation, and finally the testing results by classifying subjects' behaviors based on four effects mentioned before can be obtained.

161.4 System Implementation

Based on decision-making testing scenarios and researches of four effects, variable testing scenarios can be designed to cater for different demands of subjects. According to different testing scenarios and relevant parameters this system can provide special decision-making situation for subjects.

There are mainly four functional modules in this system: Situation management, testing online, data statistic analysis and information services.

161.4.1 Situation Management

This function includes adding testing scenarios that have been designed, modifying relevant marketing parameters in every progress according to different behavioral decision-making effects, editing or deleting certain situations that are not significance in testing phrase. Only managers have the right to modify parameters to cater for demands.

161.4.2 Testing Online

Testing online mainly provides functions that can be used to test subjects' decision-making behaviors. At first, subjects log in main interface, then under the guide of the system they can implement testing needed. This system provides individual settings, which are single-period testing and multiple rounds of simulations decision testing, in view of different testing aims. In single-period testing, system will guide subjects to another decision situation after they finished their first decision-making and provide simulation operation results. Subjects will be tested a lot of times under certain testing scenarios, where only some certain parameters will be changed in order to control certainty of simulation situation, until enough data has been collected. In multiple rounds of simulations decision testing, subjects will be required to manage a company for several periods and testing scenarios will be changed along with subjects' decisions. And different with single-period testing, subjects' decisions will always affect next period in multiple rounds of simulations decision testing.

161.4.3 Data Statistic Analysis

After all the tests are over, managers will use statistical analysis software to analyze data which subjects submitted, and final results will be obtained.

161.4.4 Information Services

There are mainly two aspects: In multiple rounds of simulations decision testing, operational results will be provided and can be searched; after tests over, decision-making behavioral characteristics and relevant suggestions will be provided. The process of searching is showed in Fig. 161.2.

161.5 Summary

The trend of economic globalization has brought great challenges to companies, so how to ensure the quality of executives in decision-making will become increasingly important. Decision simulation system, which integrates application of management science, decision science, computer technology and IT, can provide managers with a realistic management environment and good experimental environment for researches on decision-making behaviors. Based on the four behavioral decision-making effects of prospect theory, we develop a testing system to test executives' decision-making behaviors. Using this system, TMT can obtain their different decision-making preferences under the conditions of uncertainty and understand their own decision-making behavior characteristics. Thus, they can

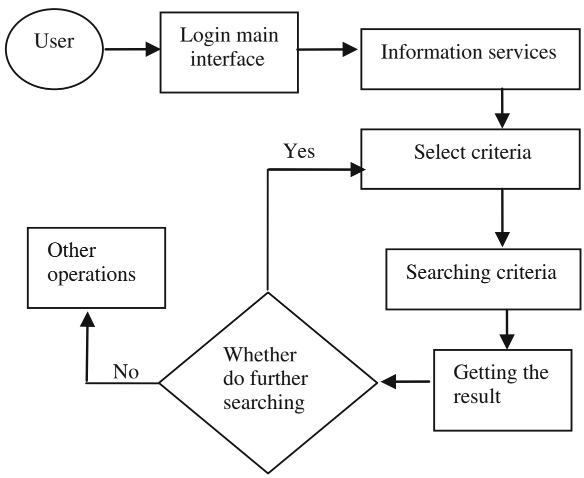

Fig. 162.2 Process of searching

avoid decision-making bias in a major decision and improve their decision-making as a whole quality. What's more, the testing system also provides practical directions on the composition of TMT according to their different decision-making behavioral characteristics.

Acknowledgments This work was partly supported by the National Science Foundation of China (Project No. 71171043), the National Basic Scientific Research Expenses—National Project Breeding Fund (Project No. N090406006) and the National Undergraduates Innovating Experimentation Project "Under Team Task Situations Decision-Making Behavior of Business Executives Test Platform" (Project No. 110105).

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Chapter 162
An Exploratory System Dynamics Model of Business Model Evolution

Xiao-lin Shao and Ju-wei Shi

Abstract The evolution of the business model is a complex dynamic process and shows abundant dynamic characteristics, which are the integrated effects of surroundings and inter structure of the system. By developing causal loop diagrams and stock and flow diagrams, we build a scientific dynamic system model to identify the relationships among key variables in the business model and probe its evolutionary dynamics. As a result, we are able to lay the foundation for further research of business model evolution.

Keywords Business model evolution · Causal loop diagram · Stock and flow diagram · System dynamic model

162.1 Introduction

The business model (BM hereafter) concept became prevalent in the mid 1990s with the advent of the Internet and its massive adoption for e-commerce (Amit and Zott 2001), rapid growth in emerging markets and interest in "bottom-of-the-pyramid" issues (Seelos and Mair 2007), as well as expanding organizations dependent on post-industrial technologies (Perkmann and Spicer 2010), and it has been gathering momentum since then.

In fact, each firm has its unique BM from its foundation. How to deal with the evolution of many elements and their interactions in each BM subsystem is one of

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E. Qi et al. (eds.), *The 19th International Conference on Industrial Engineering and Engineering Management*, DOI: 10.1007/978-3-642-38391-5_162,

the main problems bothering all firms which want to gain long-term survival and sustained competitive advantage in a changing market. However, the academic research on BM seems to lag behind practice and lacks the systematic and dynamic view, which leads to the confusion of management. Consequently, in practice, many managers don't know when and how to implement BM change; even if they take action, the results may be contrary to expectations due to the lack of system thinking or ignore delays in the system, triggering poor dynamic behaviors in the evolution of BM.

162.2 Literature Review

The initial research on the business model took a static approach and focused on the related concepts, structures and elements, etc. Recently, the dynamic approach emerges, but only emphasizes on the impetus, approach, and implementation of the BM innovation.

162.2.1 Review on the Static Perspective of Business Model

Despite the overall surge in the literature on BM, no generally accepted definition of the term "business model" has emerged. At a general level BM has been referred to as a statement (Stewart and Zhao 2000), a description (Applegate 2000), a representation (Morris et al. 2005), an architecture (Timmers 1998), a conceptual tool or model (Teece 2010). Morris et al. (2005) conducted a content analysis of key words in 30 definitions to identify three general categories of definitions which can be labeled economic, operational, and strategic, with each comprised of a unique set of decision variables (Stewart and Zhao 2000).

Though diversity in the available definitions poses substantive challenges for determining what constitutes a good BM, we can find "value" appears most frequently through a literature review, as shown in Table 162.1.

162.2.2 Review on the Dynamic Perspective of Business Model

The relationship between business model and time is little discussed, and the dynamic perspective has only recently been incorporated into research on this topic. Research at home and abroad explores the innovative impetus of BM from perspectives of technology, demand, competition, executives and systems (Wang and Wang 2010), which can be seen as the influencing factors of BM evolution.

Table 162.1 The components of business model

Source	Specific components	Number	E-commerce/general
Gordijn et al. (2001)	Actors, market segments, value offering, value activity, stakeholder network, value interfaces, value ports, and value exchanges	8	E
Applegate (2000)	Concept, capabilities, and value	3	G
Morris et al. (2005)	Factors related to offering, market factors, internal capability factors, competitive strategy factors, economic factors, growth/exit factors	6	G
Benoît and Xavier (2010)	Value proposition, resources and competences, organization	4	G
Zhang and Lei (2008)	Value proposition, value network, value maintenance, and value realization	4	G

Overall, the dynamic perspective tends to view the BM as a "black box" to examine environmental factors affecting its innovation, which ignores the interactions and changes among the elements within BM as well as its evolution in the long run.

162.2.3 Summary of the Literature Review

Through literature review, we find that there is no denying the fact that BM is a complex system of value creation. However, scholars cannot agree on what its components are since it emerged from business practice recently and scholars frequently adopt idiosyncratic definitions that fit the purposes of their specific studies, which lacks the theoretical underpins and as a result are difficult to reconcile with each other.

Studies on the dynamic perspective of the BM are relatively rare, partly due to its debatable structure and also due to its research methodology. Existing researches are almost without exception qualitative case analysis which could not portray and explain the dynamic characteristics and internal mechanism of BM evolution.

The evolution of the BM is a complex dynamic process and shows rich dynamic characteristics, which is the integrated effect of surroundings and inter structure. In order to identify the mechanism and probe the evolutionary dynamics of BM, we have to build a scientific dynamic system model. Due to limited space, this article will focus on the various components of the BM and their interaction mechanisms, taking external environmental factors as given exogenous variables. We use the System Dynamics (hereafter SD) approach to establish the initial exploratory model of business model evolution system (hereafter BMES) building on the resource-based view. We use causal loop diagrams and stock and flow diagrams to reveal the interaction between the various elements within BMES, hoping to provide a new perspective and method for the current research.

162.3 Method

System Dynamics, initially established by Professor Jay W. Forrester at MIT in 1965, is an approach to understand the behavior of complex systems over time (Größler 2010). The SD model and its methodology put emphasis on endogenetic view and contend that the system's behavioral pattern and characteristics are determined by its inter feedback structure and feedback mechanism.

SD uses causal loops to describe the feedback structure. There are two basic causal loops, namely reinforcing loops (also called positive feedback loops) and balancing loops (also called negative feedback loops). Reinforcing loops have an even number of negative links and will generate behaviors of growth, amplify, deviation, and reinforce. Balancing loops have an odd number of negative links and tend to produce stable, balance, equilibrium and goal-seeking behavior over time.

Causal loop diagrams aid in visualizing a system's structure and behavior, and analyzing the system qualitatively. However, since mathematical relationships of different variables cannot be revealed by causal loop diagrams, stock and flow diagrams are introduced to perform a more detailed quantitative analysis. A stock is the term for any entity that accumulates or depletes over time. A flow is the rate of change in a stock (Wang 1995).

There are four steps in SD: (a) problem identification and goal setting; (b) SD model establishment, including causal loop diagrams for qualitative analysis and stock and flow diagrams for quantitative analysis; (c) SD model simulation and testing; (d) strategy choosing.

Causal loop diagrams and stock and flow diagrams are the key elements of SD (Zhang et al. 2010) and make SD different from other approaches to study complex systems which will be mainly discussed in the next section.

162.4 Model

The various variables involved in the process of BM evolution can be divided into two types: state variables and influencing variables. These variables and their mechanisms constitute a complex nonlinear dynamic feedback system referred as BMES. While the state variables are all endogenous, the influencing variables can be both endogenous and exogenous.

The creation of the state variables is essentially based on the understanding of BM. However, many scholars describe the concept of BM from different points of view and have not reached an agreement. This article examines the BM based on Penrose's resource-based view and contends that three core variables are included in the BM, namely the resources scale, management capabilities and value proposition, which can be well consistent with the essence of the BM. In addition, resources, capabilities and value proposition can interact with each other and the corresponding process is able to depict the evolution of BM. Continuing expansion in the resource scale and the improved capabilities allow the generation of remaining management capacities and remaining resources which make it possible and necessary for firms to discover new market opportunities and provide new value propositions, leading to the growth in the number of new customers.

However, a number of definitions in Penrose's theory are not clear, nor did she consolidate all the interactions mentioned into a clear logic. In this section, a model of BMES will be established, containing the state variables and influencing variables with their meanings and relationships elaborated. What is worth noting is that in this article, the system boundaries will be set within the firm while variables coming from political, economic, cultural, social, technological and market environment are considered as given external variables.

162.4.1 Model Structure

BMES is divided into three subsystems as shown in Fig. 162.1: the subsystem of resources scale, the subsystem of value proposition, the subsystem of management capability, which are respectively corresponding to the three state variables. These three subsystems connect with each other via variables and there is only one

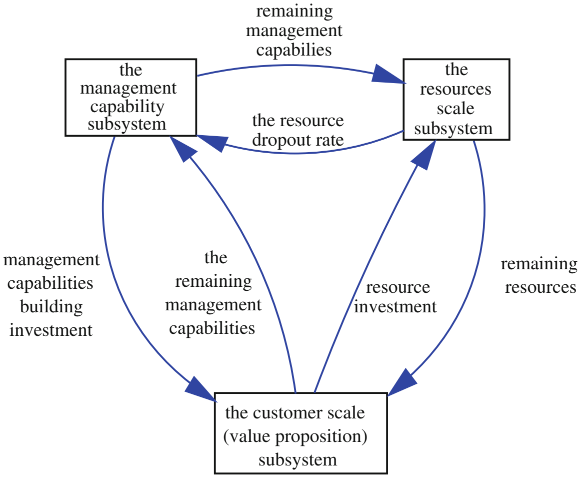


Fig. 162.1 The model structure of BMES

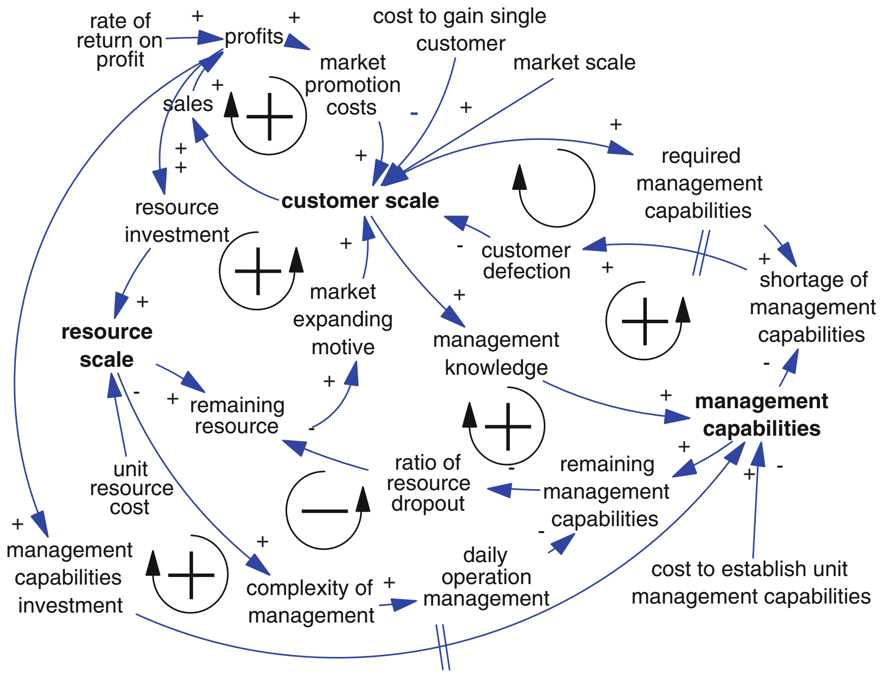


Fig. 162.2 The causal loop diagram of BMES model

negative feedback between the resource scale subsystem and the management capabilities subsystem.

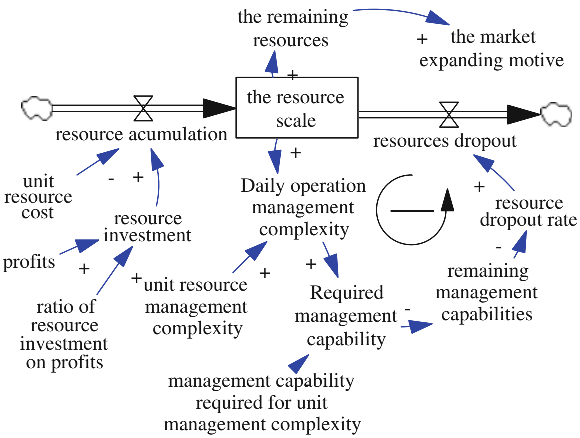
In summary, the main interactions between the three subsystems of business model can be displaced in one causal loop diagram, as shown in Fig. 162.2, including five enhancing loops and two balancing loops.

162.4.2 The Resources Scale Subsystem

The resources scale is a state variable, referring to the resources purchased from the external market or internally developed by firms, including physical resources (e.g., plant, capital), intangible resources (such as patents, trademarks), and knowledge resources (existing in personnel, files, or other similar media) (Benoît and Xavier 2010).

The complexity of daily operation management and the required management capability change in the same direction with the resources scale as shown in the Fig. 162.3. But the growth of resource scale will decrease the remaining management capabilities used to expand the resource scale, so that the growth rate will be slowed down. The negative feedback loop, "resource scale-remaining

Fig. 162.3 The resource scale subsystem



management capabilities-resource dropout rate-resource scale", reflects the constraint effect of management capabilities on the growth of the resource scale.

Two variables in this subsystem, "resource investment" and "remaining resources", are respectively connected with the "profits" and "market expanding motive" in the value proposition subsystem. Thus, a positive feedback loop is formed, that is "resource investment—resource scale—remaining resources—market expanding motive—the customer scale—sales—profits—resource investment", which reflects the positive relationship between resource scale and customer scale.

162.4.3 The Management Capability Subsystem

Management capability is a state variable referring to the managers' ability to improve and reconstruct the productive services provided by resources. As a gross variable, management capability has to deal with two tasks: one is to manage the daily operation of existing resources; another is to manage BM change. We assume that only after daily tasks have been finished, can the management capabilities be used to expand value proposition.

There are two sources to increase the management capability represented in the Fig. 162.4: one is the management capability investment, the other is the management knowledge gained from learning effects by providing more services for increasing customers.

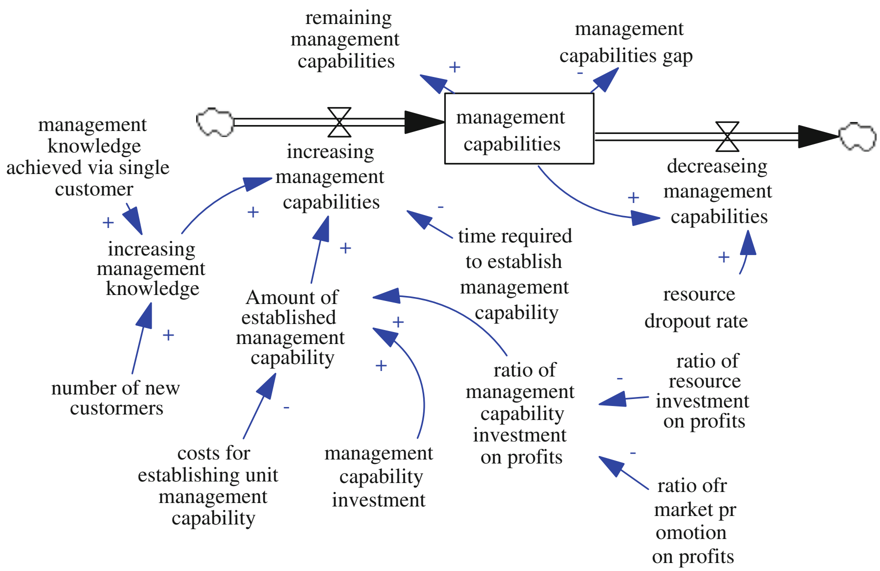


Fig. 162.4 The management capability subsystem

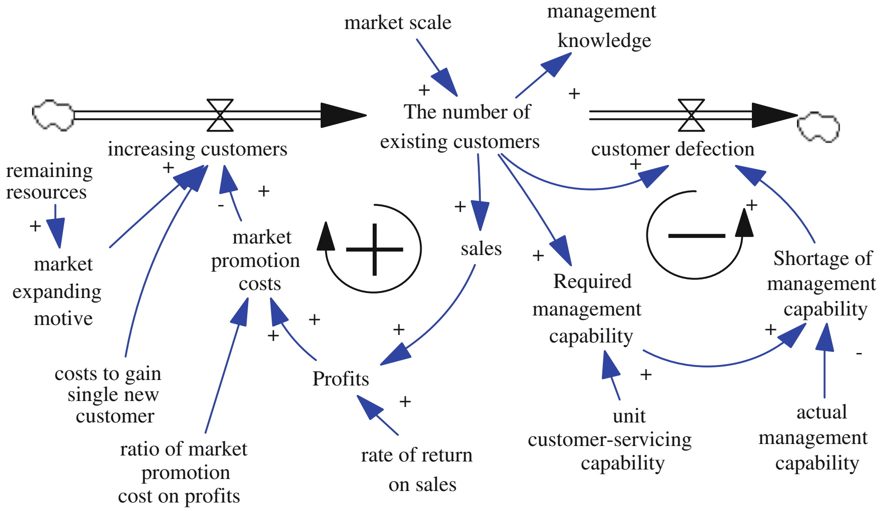


Fig. 162.5 The value proposition subsystem

162.4.4 The Value Proposition Subsystem

BM transforms the resources into products and services by management capabilities and delivers certain value proposition to customers. This value-creation process reveals the nature of BM. The value proposition will evolve which results in the changes in market scope and existing customers. So we adopt the number of customers to quantify value proposition

Figure 162.5 shows that the number of customers will increase infinitely due to the enhancing loop if there are no balancing loops. However, as the customer scale increases, the remaining management capabilities will be reduced and consequently the growth speed of customer scale will slow down. Meanwhile, the shortage of management capabilities, which would bring customer defection, will be highlighted. Besides, the total market scale is also an external constraining factor.

162.5 Conclusion

This paper builds a SD model to explore the internal structure of complex BMES and clarifies the meanings and functions of many vague concepts in Penrose's theory. We are hoping to help the practitioners gain a better understanding of the dynamic relationships between various promoting and constraining variables and improve the systematic thinking in the BM decision-making.

Since this paper is an exploratory study of SD evolution using SD approach, there are several limitations which should be paid attention to in the future research.

Firstly, although the SD model of BMES has been established, the model simulation was not carried out due to limited time and space. Therefore, the dynamic system behavior patterns had not been fully revealed.

Secondly, this paper focused on internal structure, which is essential to the system behavior. Consideration on the technical, social, political, and other external factors was inadequate which should be included in future research to gain a more comprehensive understanding.

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Chapter 163
An Empirical Study on the Influence of Independent Directors on Fund Performance in China Fund Management Company

Tiao-yan Hui and Fei-lan Lu

Abstract This paper makes an empirical study on the influence of independent director on fund performance, based on the data of the fund management company in China and its equity open-end Fund and the mixed open-end fund from 2005 to 2010. According to the descriptive statistics and linear regression analysis using SPSS13.0 software, the results show that: To the China's fund management company, the independent directors' proportion is low, and they are mainly master and doctor degree, economic management major and from the university research institutes; The higher of the proportion of the independent director, with senior professional titles, and form industrial and commercial enterprises, the higher the performance of the fund is; The education and professional of independent directors have no significant impact on fund performance.

Keywords The fund management company · Independent director · Fund performance · Empirical study

163.1 Introduction

The independent director is directors, who not be employed by the company or its affiliates and not be closely related to the company or its management through significant economic, family or other ties. In 1940 < Investment Company Act > was putted forward by United States, the proportion of independent

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E. Qi et al. (eds.), *The 19th International Conference on Industrial Engineering and Engineering Management*, DOI: 10.1007/978-3-642-38391-5_163,

directors in the Investment Company should not be less than 40 %. For the important role of the independent directors, it has received widely attention, and a lot of scholars have done researches on it about the number of independent directors, background characteristics, and so on. But, due to the research samples, research time, research method, we still do not get consistent conclusions.

Securities investment fund has become an invest manner and is developed largely in recent years. By the end of 2011, there are 914 securities investment funds in China, the scale is 2646.465 billion which has grown up 9.17 % over the last year. At the same time, various kinds of matters, such as Interests transmission, Tunnel Digging, Mouse storehouse take place usually. So how to improve the governance structure of the fund management company to protect the interest of investors is becoming emergent. The independent directors as an important governance mechanism in fund management companies are endowed with great expectations. According to the analysis of independent director's structure and its influence on fund performance, this paper hopes to promote the development of the fund management company healthily and rapidly in China.

163.2 Literature Review

Based on the principal-agent theory, resources dependence theory, and so on, domestic and foreign scholars make numerous studies on independent directors, but mainly focus on the listed company and the research for the fund management company is relatively lack. In 2001 year, the CSRC requested the fund management company to have independent directors and further requested there should be at least three or more independent directors which are more than the number of directors appointed by the company's largest shareholder, and the proportion of dependent directors should not be lower than one-third (Wei 2005).

The representative literature on the relationship between the structure of independent director and company performance is shown in the Table 163.1, especially for the fund company as shown in Table 163.2.

In all, the independent directors play a positive role in company performance, but as a result of the diversity of each research samples, research time, research methods, the research scope, the results are very different.

163.3 Hypothesis

(1) *The relationship between the proportion of independent directors and fund performance:* Director Independence is the foundation of decision-making and supervision for the board of directors. For the fund management company, usually, compared to association board of directors, driven by social reputation and long-term material interests of themselves, independent directors can supervise

Table 163.1 The list of research literature about general company

Author	Dependent variables	Data sources	Research conclusions
Zhang et al. (2011)	ROA	14 banks listed on shanghai and shenzhen stock 2006–2009	The independent director has significantly positive effect on performance to bank.
Fan and Li (2009)	ROE	109 listed companies in Guangxi 2002–2006	ROE is negative correlation with the proportion of the independent directors, but not significant
Meng (2010)	ROA, Tobin's Q	3740A-shares listed companies	The proportion of independent directors is weak related to company governance performance
Liu et al. (2009)	ROA	141 civilian-run listed companies 2004–2007	The proportion of independent directors is not an important factor to affect the company performance.
Li et al. (2009)	Tobin's Q	863 listed companies in manufacturing industry in cross-section from Japan 2001–2006	The independent board system has significant positive effect toward company performance.

Table 163.2 The research literature about the fund management company

Author	Dependent variables	Data sources	Research conclusions
Stephen and Yan (2007)	Expense ratios	6228 funds in 448 fund families in the CRSP database at the end of 2002	The percentage of independent directors is negatively related to expense ratios.
Xing and Song (2008)	Sharp ratio of the investment target after the Adjustment	25 fund companies in Shanghai 2005–2009	The proportion of independent directors is positive related to company performance.
Zhou (2008)	Annual net yield	53 closed-end funds in all the listed fund companies in 2006, which set up before December 31, 2005	The proportion of the independent directors with experience of finance, legal, financial work 5 years or more is a significant positive to fund performance.
He (2005)	Annual fund net income, Jenson index, Treynor index, Sharpe index, Tobin's Q, expense ratio	54 closed-end funds of 17 listed fund companies before December 31, 2002	The proportion of the professional independent directors is larger, the fund performance is better and the expense ratio is lower
Li (2010)	Fund return, fund's annual average rate of return more than fund industry	The fund companies had managed a full year by the end of 2009	The proportion of independent directors and with the professional knowledge have a significant positive correlation to company performance
Xiao and Peng (2010)	Annual net ratio of growth,fund's average annual rate of return more than fund industry's median, Jensen index	131 fund companies raised stock funds and mixed funds to the public before January 1, 2005	The proportion of independent directors has no significant influence on fund performance.
Wu (2006)	The year average revenue rate	47 stock funds in 2004	The proportion of independent directors has a significant positive correlation to fund performance.

managers effectually, make independent and impartial judgments, protect the interests of the fund holder and promote the fund performance. So, we put forward assumption 1:

H1: The proportion of independent directors is positive related to fund performance.

(2) *The relationship between the education of independent directors and fund performance:* < Administration of Securities Investment Fund Management Companies > issued by the CSRC on September 27 in 2004 required that: the board in the fund management company must have at least three independent directors who have experience of finance, law or financial more than 5 years, and have enough time and energy to perform their duties. This law is proposed new requirements to maintain the independence and effectiveness of the board of directors in the fund management company. The educational background is the symbol of human capital and it can embody people's ability and qualify to the work, so the higher the proportion of independent directors with high degree, the more it can improve the efficiency of management. So, we come up with assumption 2:

H2: The proportion of independent directors with high degree is positive related to fund performance.

(3) *The relationship between the major of independent directors and fund performance:* The major not only decides the skills of the individual have, but also influences their mode of thinking. Majoring in economic and management will provide a systematical study of economic, management and financial knowledge, which will help the independent directors to improve their ability of insight of macro-economic environment and analysis of enterprise management decision. Even though science and technology majors are stronger in logic, they lack of knowledge in the enterprise management, to a certain extent, which hinders their functions of the management decision, supervision and control. So, we put forward assumption 3:

H3: The proportion of independent directors in economic management major is positive related to fund performance.

(4) *The relationship between the professional title of independent directors and fund performance:* The professional title represents a level of person in academic or job, symbolizing a certain identity, affirming the ability of independent directors. Therefore, we proposed hypothesis 4:

H4: The professional title of independent directors is positive related to fund performance.

(5) *The relationship between the sources of independent directors and fund performance:* Based on the theory of check-and-balance ownership structure, the diversity of the board source is beneficial to balance the internal power and improve the performance of company. Fu (2008) have done empirical research on 336 companies about manufacturing in the Shanghai stock exchange, found differences in the source of directors can lead to diversity existing in the governance performance of listed companies (Fu 2008).This paper is divided the sources of independent into: schools, research institutions, accounting firm, law firms,

financial institutions and industrial-commercial enterprises. If the independent directors do not have some certain experiences, their own opinion cannot influence the board of directors to make decision, which will become "vase directors" or " favor directors ", and it will not do good for company management and performance. Therefore, the rich experience of independent directors has very great help to improve the company performance. So, we put forward hypothesis 5:

H5: The independent directors come from some industries have more practicality, such as accounting firm, law firms, financial institutions, which are positively related to fund performance.

163.4 Empirical Research

163.4.1 Sample and Data

The data is based on the fund management company in China and its equity open-end Fund and the mixed open-end fund from 2005 to 2010, eliminating the LOF and QDII. In order to ensure the integrity of fund dates, the fund must be established before the year of researched.

163.4.2 Definition of Variables

Research variables in this paper are composed of: dependent variables, independent variables, and control variables. Their descriptions are shown in Table 163.3.

163.4.3 The Descriptive Statistical Analysis

The Table 163.4 indicates that, in 2005–2010 the size of independent directors is changed little, the maximum and minimum are 6 and 2, of which more than 90 % independent directors in the fund management company are three or four, reached the requirement of the CSRC that the fund management company should have at least three independent directors.

The Fig. 163.1 shows, the degree of independent directors in the fund management company is mainly doctor, the proportion of it has increasing tendency, especially in 2010 it reaches at 44.0158 %. Master degree also goes up, but lower than that of the doctor degree. Only the proportion of bachelor degree is reduced year by year, from the highest 33.2258 % in 2005 to the lowest 23.9444 % in 2010, almost decrease by 10 % in six years. This shows the fund management

Table 163.3 Definition of variable

Type	Variables	Introductions
Dependent variables	Fund return	An annual average rate of return of the fund more than the fund industry
	Fund risk	The standard deviation of the return of fund
	Risk-adjusted fund performance	Adjusted sharp index, it is the ratio of fund return to fund risk
Independent variables	The proportion of independent directors	The ratio of independent directors in the board (PID)
	The educational background	The proportion of bachelor (BAC)
		The proportion of master (MAS)
		The proportion of doctor (DOC)
	The major	The proportion of economic management major (ECO)
		The proportion of law major (LAW)
		The proportion of science and technology major (SCI & TEC)
	The professional title	The proportion of senior title (SEN)
	The sources	The proportion of school and research institutions (SRI)
		The proportion of accounting firms (AF)
		The proportion of law firms (LF)
		The proportion of financial institutions (FI)
		The proportion of industrial–commercial enterprises (ICE)
Control variables	Fund scale	An annual average fund share (FS)
	Fund time	The time of fund established (FT)
	Bull market	The year of 2006, 2007, 2009, it is 1; others it is 0. (BULL)
	Bear market	The year of 2008, it is 1; others it is 0. (BEAR)

Table 163.4 Descriptive statistics of size of independent directors

Years	N	Min	Max	Mean	Std.
2005	35	2.00	6.00	3.5429	0.81684
2006	47	3.00	5.00	3.5319	0.62035
2007	52	3.00	6.00	3.4615	0.64051
2008	55	3.00	5.00	3.3636	0.52223
2009	58	3.00	5.00	3.3621	0.55245
2010	58	3.00	5.00	3.3793	0.58722

companies have more and more strict demand with independent director, the pursuit of highly educated is one of the means to be an independent director.

From the Fig. 163.2, we can see that, the majority of independent directors in the fund management company are mainly economic management and the annual average proportion reaches up to 62.552 % in 2005–2010. The proportions of law

Fig. 163.1 The degree of independent directors

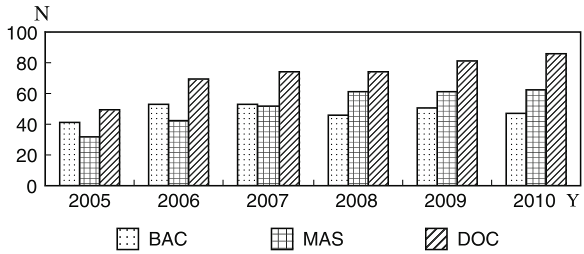


Fig. 163.2 The major of independent directors

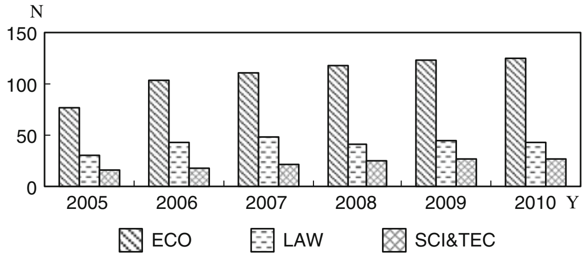
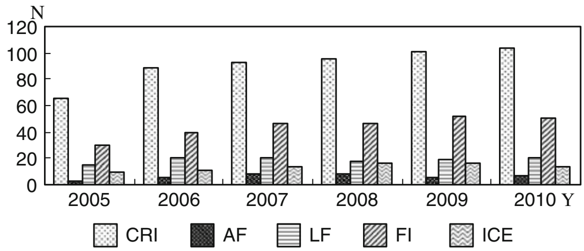


Fig. 163.3 The sources of independent directors



major are decreasing. In recent years, the irrational behaviors of some fund management companies in the pursuit of high return, the cases lead the shareholders to suffer loss can be found everywhere. This requires the fund management company to add more independent directors in science and technology major, and make its more reasonable judgments. Accordingly, the proportion of independent directors in science and technology major has a rising trend.

Figure 163.3 shows, independent directors from the college and research institutions make up more than half of the proportion in the fund management company, the following is financial institutions, and its proportion rises gradually in 2005–2010. And the others from accounting firms, law firms and industry and commerce enterprises accounts for only about 20 % of all the independent directors. Half of independent directors are from school and research institutions with less company operating experiences; it will lead to some problems on the function of independent directors in the fund management company.

163.4.4 Regression Analysis

Regression results are show in Table 163.5, among the variables of structure characteristics of independent director in fund management company, the proportion of the independent directors has a negative impact on the fund return, but not significantly, and at the 0.05 level, it has a significant negative correlation with the fund risk, also it is positively related to risk-adjusted fund performance, which is consistent with the existing literature. Now, the introduction of independent director plays a positive role to control fund risk under the condition of less effectively supervise and protection of the fund holder's interests, which can alleviate principal-agent problems between the fund holder and the fund management company. Meanwhile, relating to the internal director, the independent director have little knowledge on the company management and it is weak in supporting function of management decision, so it has a negative impact on the fund return, but the positive influence of its risk control exceeds the negative influence, thus it has positive influence to the risk-adjusted fund performance.

The education and major of independent director are not significantly influenced on fund performance, whether return, risk, or risk-adjusted fund performance. For the title of independent directors, the proportion of independent director who has a senior professional title has a negative influence with fund risk, which generally has a high status in society and practice experience, so they can control risk better. Besides, considering their own reputation, the independent director has the motivation to work harder and qualified for the role as an enterprise management supervisor.

The proportion of independent directors from industry and commerce enterprises is significantly positive correlation to fund return, and negative correlation to fund risk. This is mainly because of the independent director come from industry and commerce enterprise have no relationship with fund management companies, they can better ensure the objectivity of their supervision, and long-term practices enrich their working experience, helping fund management companies make better investment decisions from the point of view outside the financial enterprise, so they have some positive influence on the fund performance.

In addition, recent years the fund management companies in China do not have learning effect, the fund established time has negative influence on both the fund return and risk. It is maybe the longer time the fund operates, the more conservative its operation is, so the fund's incomes and risk are lower. Especially for the risk control, a fund which through a long-term experience, management method and system are relatively mature, so it has a significant negative effect on fund risks at the 0.05 level, but is not significant to the risk-adjusted fund performance. For the fund scale, it has a certain scale effect, the greater the scale, the higher the fund return, but more difficulty to management, the lower is the fund's flexibility, that are more apparent in bear market. So, fund size is positively related to fund risk, not significant to the risk-adjusted fund performance.

Table 163.5 The result of regression analysis

Model	Fund return			Fund risk			Adjusted performance		
	Coeff	t	Sig.	Coeff	t	Sig.	Coeff	t	Sig.
(C)		0.651	0.515		15.326	0.000		–0.096	0.924
PID	–0.029	–0.847	0.397	–0.110	–4.237	0.000	0.035	1.903	0.057
MAS	–0.063	–1.289	0.198	0.006	0.162	0.871	–0.017	–0.658	0.511
DOC	–0.046	–0.880	0.379	0.015	0.381	0.703	0.006	0.210	0.834
ECO	0.012	0.243	0.808	–0.023	–0.632	0.527	–0.004	–0.150	0.881
LAW	0.057	1.173	0.241	–0.016	–0.444	0.657	0.034	1.294	0.196
SEN	–0.033	–0.886	0.376	–0.079	–2.811	0.005	–0.015	–0.733	0.464
AF	0.009	0.276	0.782	0.011	0.429	0.668	–0.009	–0.474	0.635
LF	–0.022	–0.569	0.569	0.014	0.493	0.622	–0.028	–1.338	0.181
FI	0.039	1.015	0.310	–0.009	–0.309	0.757	0.006	0.271	0.787
ICE	0.079	2.286	0.022	–0.072	–2.791	0.005	–0.008	–0.436	0.663
FS	–0.028	–0.882	0.378	–0.088	–3.645	0.000	–0.003	–0.160	0.873
FT	0.065	1.985	0.047	0.158	6.362	0.000	0.009	0.512	0.609
BULL	0.062	1.734	0.083	0.379	14.099	0.000	0.565	29.449	0.000
BEAR	–0.019	–0.540	0.589	0.670	24.670	0.000	–0.414	–21.386	0.000
Modle-fitting degree	F = 1.748 Sig = 0.042			F = 58.873 Sig = 0.000			F = 186.686 Sig = 0.000		

Coeff is Standardized Coefficients

Finally, fund performance is influenced by market quotation significant in China. To bull market, fund return, risk and risk-adjusted fund performance are higher and its influence is significant at the 0.1 level. To bull market, fund return is low, but the influence is not significant, and because investment is more difficult, fund management companies often due to the loss of some stock, they can't sell them in time, hoping to earn profits with certain bets psychological, thus significantly high risk is presented, and at the 0.05 level it is significantly negative to the risk-adjusted fund performance.

163.5 Suggestions

Firstly, the proportion of independent directors should be increased. The empirical results show that the proportion of the independent directors has positive influence on fund performance, especially the risk control and the risk-adjusted fund performance. At present the average number of independent directors in the fund management company is 3.37, just meeting the requirement of CSRC to independent directors in the fund management company not less than 3. In 2010, the scale of independent director are 3, 4 and 5, corresponding the number of the fund management company are 39, 16 and 3, and the proportion of the fund management company are 67.24, 27.59 and 5.17 %, but the average proportion of independent director just 3.3793, and is far less than the requirement of two-thirds in the United States investment management company. Therefore, in the future the fund management company in China should further increase the proportion of the independent directors, perfect the mechanism of the hiring, and do the best to ensure its independence.

Secondly, the professional titles of independent director should be strengthened. The education background and major should not become the only standard to appoint independent directors in the fund management company. Independent director in the board of directors has the main function of supervision, exercise this responsibilities needs more rich work experience. Education background and major have little effect on this, the professional title is an important signal of ability, so in the choice of independent directors should pay more attention to the professional title in the fund management company.

Finally, the source of independent directors should be optimized (Ma 2010). Now the practice of independent directors in the fund management company are mostly academic directors and celebrity directors, these independent directors often have more famous, much positions, maxed affairs, but have little time and energy to handle corporate affairs, so they could not have effective function of supervision. The empirical results in this paper show that the independent director from industrial-commercial enterprises has effectively improved the company performance. So, in the choice of the independent directors should be required some enterprise or business experience, familiar with the laws and regulations, and possess the knowledge of capital market operation theory, it will makes them better to perform the duties of independent directors.

Acknowledgments Supported by the National Science Fund of China (NO: 70802047).

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Chapter 164
Research on Optimal Enterprise Contribution of Hunan Province Based on OLG Model

Ni Yang

Abstract Optimizing the enterprise contribution is the key factor for promoting the reforming of public pension system and insuring the dynamic balance of social security fund. This paper has made a research on optimal enterprise contribution of Hunan province based on OLG model. The empirical result showed that life expectancy growth would raise the optimal enterprise contribution, while population growth rate decline would reduce the contribution, and the latter factor made more influence. If both two factors were introduced in the equilibrium equation, the optimal enterprise contribution would be reduced from 20 to 10.04 %, when life expectancy growth raised from 73.8 to 77.2 and population growth rate declined. The research on optimal enterprise contribution provides theory basis and the policy support for macroeconomic policy making and pension reforming promoting.

Keywords OLG model · Optimal enterprise contribution · Pension reforming · Life expectancy growth · Population growth rate

164.1 Introduction

Optimizing the enterprise contribution is an important component of public pension reforming, which makes sense for economic development and social progress, and has effect on national saving, enterprises' operating costs, families' consumption structure, labor' supply and so on. With the development of population structure changing and population ageing turning seriously, how to get the optimal enterprise contribution has attract more and more attention.

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E. Qi et al. (eds.), *The 19th International Conference on Industrial Engineering and Engineering Management*, DOI: 10.1007/978-3-642-38391-5_164,

Hunan province has a large population, as the age population (65 years old and above) has reached 6.35 million by the end of 2009 accounting for 9.22 % of total population. Furthermore, the population aging of Hunan province has characteristics of speedy growth, large scale, "growing old before growing rich" and so on, which makes significant impact on dependency ratio, consumption structure and social security. Therefore, making proper mechanism for optimal enterprise contribution is an important premise for promoting the stability and development of social security in long run.

As a frequently used tool for public pension analyzing, overlapping generations model (OLG) could examine the influence of public pension on the whole macro economy through analyzing micro economic agents, based on the general equilibrium frame. The theory was advanced by Samuelson, and expanded to classic cross time dynamic model by Diamond (1965). Many scholars discussed the relation between social security mechanism and economic growth based the model from different aspect. For example, Barro (1974) and Romer (1986) discussed the influence of pay as you go pension on economic growth from bequests motivation and personal savings respectively. Casamatta (2000) constructed a two period OLG model to analysis the reallocation function of social security. Fanti and Gori (2007) analyzed the effects of the regulation of wages in a standard one sector OLG model of neoclassical growth extended to account for endogenous fertility decisions of households and unemployment benefit policies financed at balanced budget. Rausch and Rutherford (2010) developed a decomposition algorithm by which a market economy with many households may be solved through the computation of equilibria in OLG models. Moreover, many scholars explode the influence of population changing on economic development of OECD countries, such as Auerbach and Kotlikoff (1989), Neusser (1993), Hviding and Mérette (1998), Fougère and Mérette (1998), etc.

Public pension reforming has been launched in 1997 in China. In recent years, OLG model has been used for studying the transition cost, invisible debt, dynamic effectiveness during the pension reforming. For example, Bo (2000) explored the influence of different institutional arrangement on economic growth and Pareto efficiency. Yuan and Song (2000) made a conclusion that the personal saving rates in China was efficient while the macro savings rate was ineffective through constructing OLG model and simulation. Yuan and He (2003) discussed the possibility of dynamic inefficiency in free competition economic with the help of OLG model. Yang (2008) analyzed endowment insurance for enterprise employees based on OLG model, to get the optimum pension replacement rate in a general equilibrium frame. Wang et al. (2010) analyzed the economic effects of the occupational pension system from macroeconomic capital and output, microeconomic producers and microeconomic consumers based on OLG model. Li and Bai (2006) constructed an OLG model by GAMS software, whose input variable was population age changing, to illustrate the changing of social output, personal consumption and government revenue arise from population ageing in China. Huang and Sun (2005) analyzed the difference in informal institutions and consumption modes in OLG model, and made a theoretical analysis on households' consumption in the oriental culture and belief. Liu and Hao (2011) constructed a discrete time bilateral generation transfer model, and discussed the optimal investment structure and economic growth pattern. Lu (2011) constructed a three period OLG model, to explain the influence of population structure and income growth on personal savings in China.

This paper makes a research on the optimal enterprise contribution in partially funded endowment insurance of Hunan province based on OLG equilibrium framework. Combining the characteristics of population structure and economic growth in Hunan Province, parameter selection and model improvement has been analyzed. The rest has been arrangement as follows. Section 164.2 introduced the basic framework of OLG model and made a deriving of optimal enterprise contribution. Section 164.3 made an empirical research on the selection of optimal enterprise contribution in urban old-age insurance of Hunan province. And the Sect. 164.4 was the conclusion and future research suggestions.

164.2 Basic Framework of OLG Model and Deriving of Optimal Enterprise Contribution

This paper conducts research based on equilibrium framework raised by Yang (2010). Suppose that there are many persons, many enterprises and one government in an infinite closed economy. Personal life is finite, and experiences working period and retirement period. At the beginning of t, there are N_t persons become workingmen in the tth generation. The rate of population growth can be calculated as

$$n = \frac{N_t}{N_{t-1}} - 1 \tag{164.1}$$

The partially funded endowment insurance was introduced.

164.2.1 Basic Framework of OLG Model

Supposing everyone provide a unit nonelasticly labor while working, obtains income equals w_t, contribution rate for endowment insurance is τ, consumes c_{1t} and saves s_t. Furthermore, the individual consumes c_{2t+1} after retired, including the principal and interest of savings while working $(1 + r_{t+1})s_t$, the payments of funded personal account is $(1 + r_{t+1})g_t$, and the public pension is b_{t+1}. The person selected the pattern of savings and two periods consuming for pursuing utility maximizing.

$$\max_{\{s_t, c_{1t}, c_{2t+1}\}} U_t = u(c_{1t}) + \theta u(c_{2t+1}) \tag{164.2}$$

$$s.t. \quad c_{1t} = (1-\tau)w_t - s_t, c_{2t+1} = (1+r_{t+1})s_t + (1+r_{t+1})g_t + b_{t+1} \tag{164.3}$$

Parameter $\theta \in (0,1)$ presents discount factor. The utility function $u(.)$ is a monotonous increasing function of consumption, and a strict concave function, satisfying $u'(.) > 0$, $u''(.) < 0$. Enterprise produces homogeneous goods in competitive market, satisfying first order homogeneous production function $y_t = f(k_t)$, in which function k_t presents labor capital ratio. Enterprise contribution rate for endowment insurance is $\eta \in (0,1)$.

According to Euler theorem, interest rate equals to the marginal capital output, while $(1 + \eta)w_t$ equals to the marginal labor output, satisfying:

$$r_t = r'(k_t) \quad w_t = \frac{f(k_t) - k_t f'(k_t)}{1+\eta} \tag{164.4}$$

$$b_t N_t - 1 = \eta w_t N_t, \quad g_t = \tau w_t \tag{164.5}$$

The government takes enterprises' contribution as overall planning account, paying as public pension for current retirees; while personal's contribution as accumulated personal account, which would be drawn after retirement. Furthermore, the capital market would satisfy the following equation. That's the savings plus personal account of the t_{th} labor equals the capital stock at the beginning of $t + 1$ period.

$$s_t + g_t = (1+n)k_{t+1} \tag{164.6}$$

164.2.2 Dynamic Equilibrium and Its Stability Conditions

Supposing the dynamic system exists a stationary equilibrium which is single, stable and no oscillation.

A dynamic equilibrium equation could be obtained as follow.

$$\begin{aligned} & -u'\left(\frac{f(k_t) - kf'(k_t)}{1+\eta} - (1+n)k_{t+1}\right) + \theta[1 + f'(k_{t+1})] \\ & \cdot u'\left((1+n)k_{t+1}[1 + f'(k_{t+1})] + (1+n)\frac{\eta}{1+\eta}[f(k_{t+1}) - k_{t+1}f'(k_{t+1})]\right) = 0 \end{aligned} \tag{164.7}$$

164.2.3 Equilibrium Equation for Optimal Enterprise Contribution

In order to make the state of market economy reach the optimal state, policy parameters should be adjusted, to obtain optimal capital labor ratio.

From functions described above, we could obtain the equilibrium equation for optimal enterprise contribution.

$$\eta = \frac{\frac{p}{\rho}\cdot\frac{(1-\alpha)}{\alpha}\cdot(1+n-\rho)+\left[p\cdot(1-p)\cdot\frac{1+n}{\rho}-(1+p)\cdot(1+n)\right]}{\frac{1}{p}\cdot\frac{(1-\alpha)}{\alpha}\cdot(1+n-\rho)-\left[p\cdot(1-p)\cdot\frac{1+n}{\rho}-(1+p)\cdot(1+n)\right]} \quad (164.8)$$

According to the equation above, we could know that the optimal enterprise contribution would be influenced by survival probability of retirement P, social discount factor ρ, capital income share α and population growth rate n.

164.3 An Empirical Research on Optimal Enterprise Contribution of Hunan Province

This section discussed the optimal enterprise contribution of Hunan province through empirical research based on OLG equilibrium framework.

There are three steps for empirical. Firstly, parameters would be set according the population structure and economic development of Hunan province, and then social discount factor would be estimated. Secondly, the value of parameters would be brought in the equilibrium function. And the optimal enterprise contribution would be obtained with the supposing of population growth remaining unchanged. Lastly two variables, life expectancy growth and population growth rate decline would be introduced in the equilibrium framework, and the combined effect would be examined.

164.3.1 Set Parameters and Estimate Social Discount Factor

Parameter capital income share α is usually equals 0.3 for developed countries. While income of labor is lower in China, and Hunan province has a large population density. Therefore, parameter α is 0.36.

Urban population of Hunan province is adopted as population statistics caliber. According to the data announced by the Department of Economic and Social Affairs of United Nations, the life expectancy growth would be increased to 80.3 years old in 2055–2060. Therefore, the length of one period is set 27 years, which satisfying the condition "three periods time span should be equal or greater than life expectancy growth to guarantee survival probability P of retirement less than or equal to $1''$.

According to *Hunan province statistics yearbook 2007*, the urban population growth rate could be calculated $n = (2619.93/639.6) - 1 = 3.092$ during 1979–2006. The life expectancy of Hunan province was announced to 73.8 years old by Hunan province bureau, so survival probability of retirement could be calculated as $p = 73.33\ \%$.

Furthermore, according to relevant policies, the town enterprise contribution $\eta = 20\ \%$.

Parameter social discount factor could reflect social planners' preferences. Bringing all value of parameters in (164.8), we obtain that $\rho = 0.5458$.

164.3.2 Estimation of Optimal Enterprise Contribution with Population Growth Rate Fixed

With the promotion of living quality and improvement of medical conditions, the life expectancy is increasing. Because of the limitation of data available, we assume that the life expectancy in Hunan province is the same as the whole country.

According to the data announced by Department of Economic and Social Affairs of United Nations, we could obtain the life expectancy of Chinese in future 30 years (the data could be seen in Table 164.1).

Bringing the values of parameters set above in (164.8), including $\alpha = 0.38$, $n = 3.0962$, $\rho = 0.5458$, the optimal enterprise contribution could be obtained under different life expectancy.

According to Table 164.1, the optimal enterprise contribution increases along with the life expectancy ascend.

And in the next 25 years, the life expectancy in China would be increased from 73.8 to 77.2 years old. If population growth rate fixed, the optimal enterprise contribution would be promoted from 20 to 22.97 %.

Table 164.1 Estimation of optimal enterprise contribution (fixed population growth rate)

Period	Life expectancy	P	η
2015–2020	74.7	0.7667	0.2104
2020–2025	75.6	0.8	0.2189
2025–2030	76.4	0.8296	0.2251
2030–2035	77.2	0.8592	0.2297

Table 164 2 Estimation of optimal enterprise contribution (two variables changing)

Period	Life expectancy	n	η
2015–2020	74.7	2.3133	0.1916
2020–2025	75.6	1.6405	0.1714
2025–2030	76.4	1.1032	0.1363
2030–2035	77.2	0.7928	0.1004

164.3.3 Estimation of Optimal Enterprise Contribution with Population Growth Rate Decline

China has executed very strict one-child policy since 1980s, so human fertility declined rapidly, which is the main reason for population ageing. Low fertility, low mortality, low population growth rate, has been the main characteristic of the population of China. The changing of population growth rate would influence population age composition, social support rate, and then the optimal enterprise contribution.

Table 164.2 shows the result of the optimal enterprise contribution when both of the two variables, life expectancy growth and population growth rate decline have been brought in the equilibrium framework. According to Table 164.2, the optimal enterprise contribution declined while both of the two variables, life expectancy growth and population growth rate decline have been brought in the equilibrium framework.

In the next 25 years, the life expectancy in China would be increased from 73.8 to 77.2 years old and population growth rate would decline continuously, and then the optimal enterprise contribution would be declined from 20 to 10.04 %. Now that life expectancy growth would increase the optimal enterprise contribution and the changing of two variables make the optimal enterprise contribution decline, therefore we could obtain the conclusion that the population growth rate plays a more important role than life expectancy growth in the optimal enterprise contribution determine because of the large population bass.

164.4 Conclusion and Future Research Prospect

Accompanying with population structure changing and series problem of ageing population, reforming public pension, pushing forward harmonious development of social security, has becoming the focus of researches. The optimal enterprise contribution is one of the most important indexes, plays an important role for dynamic balance for social security fund. OLG model could bring the actions of personal, enterprises and the government into an equilibrium framework, and it is a useful tool for analyzing the influence of public pension reforming on macro economy.

This paper has discussed the optimal enterprise contribution of Hunan province based on the OLG model. Firstly, we have introduced the basic framework of OLG model and the deriving of optimal enterprise contribution; and then we have made an empirical research on the optimal enterprise contribution determination of Hunan province. Empirical results show that life expectancy growth would increase the optimal enterprise contribution while population growth rate decline would lower the optimal value. And the latter variable of population growth rate plays a more important role because of the large population base in China.

However, this paper discussed the optimal enterprise contribution adjustment caused by parameters changing based static equilibrium equations. How to constructing a general dynamic equilibrium system to describe the real state of pension operating and the dynamic changing of parameters based social optimization, would be one of the future research.

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Chapter 165
Comprehensive Experiment Design of Production Logistics Based on CDIO

Ying-de Li and Xiu-ju Lan

Abstract Production logistics engineer in manufacturing plant is one of the important potential employments for logistics engineering students. The training purpose of our school is to provide some professionals who are familiar with the production logistics and from the logistics engineering graduates. Based on the CDIO concept, a comprehensive experiment is designed, which include the production forecasts and orders issued, facilities planning, production line design, production planning and scheduling, quality control and analysis, just in time and material distribution, to simulate the production logistics in the typical manufacturing factory. We will put forward the experiment design, group and role allocation, experiment procedures, experiment result analysis, the effect evaluation and improvement and so on.

Keywords CDIO concept · Production logistics · Comprehensive and project-based experiment · Role exchange

165.1 Analysis of Teaching Problems

Production and Operation Management, Facilities Planning and Logistics are the important courses for the students whose major is the Logistics Engineering, the core contents of the two courses are closely related to actual operation of enterprises (especially the manufacturing plants) and are the core curriculum to cultivate production logistics professional (Zhang 2006). The two courses cover the market demand analysis, facilities planning and layout, logistics systems analysis and design, organization and design of flow line, production planning and control,

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E. Qi et al. (eds.), *The 19th International Conference on Industrial Engineering and Engineering Management*, DOI: 10.1007/978-3-642-38391-5_165,

quality control, work study and time study, business process reengineering, advanced manufacturing systems and so on, which have strong practical (Jiang 2006; Li and Chen 2008).

Among the many interesting facts we know about how experiences affect learning, one relates especially to CDIO (Qi and Wu 2010): Engineering students tend to learn by experiencing the concrete and then applying that experience to the abstract. Unlike their counterparts of yesteryear, many engineering students these days don't arrive at college armed with hands-on experiences like tinkering with cars or building radio (Li et al. 2011; Feng 2009). CDIO has open and accessible channels for the program materials and for disseminating and exchanging resources. CDIO collaborators have assembled a unique development team of curriculum, teaching and learning, assessment, design and build, and communications professionals. They are helping others to explore adopting CDIO in their institutions (Cheng 2006).

Current teaching model pays more attention on the basic theory (Xu 2003; Chen and Peng 2007), the teacher mainly use the lecture notes, the students are accepted the basic knowledge passively. It is lack of comprehensive, systematic experiment course, teachers and students are lack of communication deeply, the students are lack of real feeling to the knowledge, it is difficult to achieve the teaching effectiveness. Although the teacher use some auxiliary teaching material and tools (Xiao and Zheng 2008; Zhang and Bo 2004; Jian and Li 2008), such as cases study, video explore, basic understanding of practice, there are some problems in teaching model, which include as follows:

(1) In case study, there are some descriptive content, but there are lack of actual data, the case is far away from the practices, which is hard to attract the students interesting.
(2) The comprehensive video is lack of production logistics, the special subject of production logistics is lack, it is difficult to integrate the curriculum content closely.
(3) The understanding of the practice is too short a, it is difficult for students to understand the application of professional knowledge deeply. The existing curriculum design is limited to theoretical and lack of practices supporting.
(4) The experiment teaching software pay more attention on the solution of the model of production and management activities, not on the production logistics analysis which is play more roles on culturing. It is hard to achieve the teaching purpose which is to culture the applying and innovative ability.
(5) The knowledge and emotional experience of juniors are far away from the actual business operation, with the abstraction and boring the course knowledge, which lead to the lack of study interesting for students.

In response to these problems, it is necessary to design a comprehensive experiment on the logistics engineering and industrial engineering laboratory platform based on the CDIO engineering education philosophy (Bartholdi and Hackman 2008). The comprehensive experiment will integrate many courses to improve the understanding and application to the organization, design, operation and control for the production logistics in manufacturing factory (Frazelle 2002). The comprehensive experiment can attract the interesting in professional courses.

165.2 Experiment Objectives Design

The experiment purpose is to help the students to learn how to use the theory knowledge comprehensively. The experiment will provide a production process model by independent design, analysis and optimization for students to cultivate the independent analysis and problem-solving ability. The detail objectives include as follows:

(1) To change the single teaching method and improve the teaching effectiveness, which can improve the application of CDIO concept in the high education;
(2) To help the students to understand the production and operation in manufacturing enterprises deeply, to improve the understanding on basic theory and methods in courses, to reduce abstraction and boring feeling, and to attract the study interesting;
(3) To improve the recognize, understanding and application to the internal production logistics system of manufacturing plant, to enhance recognize and interesting on the production logistics jobs, to broaden the employment view and choice;
(4) To improve the application ability to solve practical problems with comprehensive knowledge, and to culture the creativity and teamwork ability.

165.3 Experiment Syllabus Design

165.3.1 CDIO Concept and Philosophy

Engineering education and real-world demands on engineers have in recent years drifted apart. Realizing that this widening gap must be closed, leading engineering schools in the USA, Europe, Canada, UK, Africa, Asia, and New Zealand formed the CDIO Initiative: A worldwide collaborative to conceive and develop a new vision of engineering education (Zhang 2006).

CDIO is an initialism for Conceive–Design–Implement–Operate, which is an innovative educational framework for producing the next generation of engineers. The framework provides students with an education stressing engineering fundamentals set in the context of Conceiving–Designing–Implementing–Operating real-world systems and products (Feng 2009; Cheng 2006). Throughout the world, CDIO Initiative collaborators have adopted CDIO as the framework of their curricular planning and outcome-based assessment.

The CDIO concept was originally conceived at the Massachusetts Institute of Technology in the late 1990's. In 2000, MIT in collaboration with three Swedish universities (i.e. Chalmers University of Technology, Linköping University and the Royal Institute of Technology) formally founded the CDIO Initiative. It became an international collaboration, with universities around the world adopting the same framework.

CDIO collaborators recognize that an engineering education is acquired over a long period and in a variety of institutions, and that educators in all parts of this spectrum can learn from practice elsewhere. The CDIO network therefore welcomes members in a diverse range of institutions ranging from research-led internationally acclaimed universities to local colleges dedicated to providing students with their initial grounding in engineering.

The CDIO Initiative is rich with student projects complemented by internships in industry, features active group learning experiences in both classrooms and in modern learning workshops/laboratories, and rigorous assessment and evaluation processes.

The CDIO Initiative's goals are to educate students to master a deeper working knowledge of the technical fundamentals, to educate engineers to lead in the creation and operation of new products and, to educate future researchers to understand the importance and strategic value of their work.

The collaborators maintain a dialogue about what works and what doesn't and continue to refine the project. Determining additional members of the collaboration is a selective process managed a Council comprising original members and early adopters.

165.3.2 Experiment Syllabus

Under the CDIO teaching concept, experiment includes many professional courses, relevant principles and theories, which includes the production demand analysis and forecast, facility planning and layout, flow line organization and balancing, through output analysis, production planning and schedule, quality control and statistical analysis, Just in Time system, *Kanban* system and so on. The experiment syllabus includes:

(1) To master the market demand analysis and forecast; to understand the JIT production model; to grasp the basic production planning methods and production analysis methods.
(2) To familiar with the general methods of facility planning and layout, to use these methods to analyze the production logistics system; and to know well the logistics equipment and the basic process of internal logistics and so on.
(3) To grasp the assembly line design and balancing method, know well about the application of line balancing software and tools; to use the general standard

time method and tools; to understand the important role of the assembly line organization and management in manufacturing system.

(4) To master the common tools and statistical software in quality control and analysis; to understand the impact on the production of the quality fluctuations; to understand the basic quality management knowledge and concepts, such as the qualified rate, sample testing, pass-through rate, rework rate, downgrade management and so on.

(5) To understand the organization, design, operation and control system in manufacturing plant, to improve the interesting in study; to help students to grasp the core operation process of manufacturing plants comprehensively and systematically.

165.4 Experimental Instructions

165.4.1 Experiment Roles

The experiment includes the background and roles design and setting. The experiment background is a children toys manufacturing plant, which has complete organization, flexible assembly lines and production facilities, the production mode is the JIT system. The third parts supplier can provide all the materials in the BOM.

There are 7 roles, including one teacher and 10 students (the ID is from S1 to S10), the initial roles setting is in the Table 165.1.

165.4.2 Experiment Procedure

The comprehensive experiment procedure flow is shown in the Fig. 165.1 and the detailed procedure is shown in the Table 165.2.

165.5 Experiment Implementation

Experiment goes into the teaching guideline as an independent course; the experiment needs 12 h totally, with group exchange model to allocate the time. For example, there are about 30 students in the Logistics Engineering classes, all the students can be divided into three groups, and there are 10 members in each group. Each group needs 2 h in the laboratory, this procedure will repeat three times for each group. The role setting can be exchanged at each time based on the needs and interesting. The difficulty will increase gradually.

Table 165.1 Experiment roles

Role	Actor	Responsibility
Customer	Teacher	Supplying the demand information dynamitic and negotiate with the manufacturer
Market	S1	Team leader, Collect the market demand information, capacity analysis and confirm the orders; organize production meeting and record the production data; responsible for the production process design and implementation
Production planning	S2	According to orders and production conditions, draw up the production planning tasks, track and adjust the production schedule in real-time
Assembly line	S3–S7	Student 3, 4 and 5 are responsible for assembly tasks, Student 6 and 7 are responsible for the take-apart task. The allocation can be adjusted dynamically based on the orders
Material Supplier	S8	Responsible for the material supply based on the JIT and *Kanban* model
Distribution	S9	Optimize the delivery route and the products and disassembled parts distribution
Quality	S10	Responsible for production line quality inspection, statistical analysis and keeping improvement

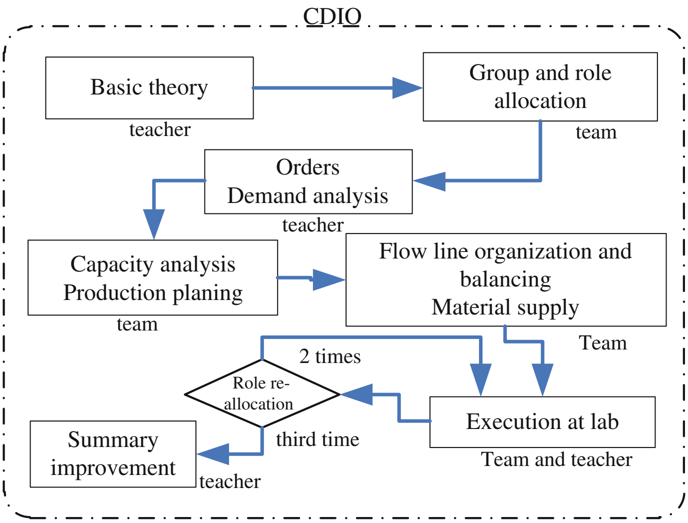

Fig. 165.1 The produce flow of the experiment

Table 165 2 Experiment detail steps

Step	Tasks
Step 1 (2 h)	Introduce the experiment theory, principle, procedures, tasks; students ask questions; Students are divided into three groups, each group includes 10 students, set the role for each student; Teachers provide the production data and orders; Students discuss and decide whether or not to take the orders; the team leader will allocate the tasks among the team to fulfill the order-demand
Step 2 (2 h)	Group take the production preparation meeting to analysis the capacity and draw up the detailed production planning, finally, publish the task to the assembly line Change the laboratory layout based on the demand After receiving the production task, assembly group put forward the layout and organization, including task assignment, balancing, material supply, product distribution Suppliers give the materials supply planning to ensure the operation; Distributor explore the product distribution planning
Step 3 (6 h)	Do the experiment at the lab First time, the teacher will participate the whole process an give some advice on-site, students will fulfill the experiment independently at the second and third time. The team leader (S1) is responsible for the organization Each student should be responsible to the team leader, and complete their own tasks The above three steps are repeated three times, the group members can change the role ate each experiment based on their interests and practice. The difficulty will be improved gradually
Step 4 (2 h)	Summary the experience and communication; Hand in the report document, show the PPT, do some experience exchangement; Give some advices to improve the experiment; Teacher reviews and scores each group and each student

165.6 Conclusion

We do some tests in the class Logistics Engineering 2008 at Zhejiang University of technology from September 2011 to December 2011. The results show that we have made a perfect improvement on teaching; the single teaching method has been changed. The students generally reflected that they understand of the basic theory through project-based experiments deeply, their interesting to study have been increased greatly. They learned the practice knowledge and the horizons of employment have been broadened greatly.

Comprehensive experiment course achieved a perfect teaching effectiveness and teaching evaluation, the total score was 98.73, the teaching resources index, teaching content index, teaching methods index, teaching effectiveness index and teaching services index were 9.85,9.88,9.87,9.85 and 9.88 respectively. The experiment results show that the comprehensive experiment has a strong maneuverability and practice value.

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Chapter 166
Improved Grey Forecasting Model for Taiwan's Green GDP Accounting

Shin-li Lu, Ching-I Lin and Shih-hung Tai

Abstract This paper applies the grey forecasting model to forecast the green GDP accounting of Taiwan from 2002 to 2010. Green GDP accounting is an effective economic indicator of human environmental and natural resources protection. Generally, Green GDP accounting is defined as the traditional GDP deduces the natural resources depletion and environmental degradation. This paper modifies the original GM(1,1) model to improve prediction accuracy in green GDP accounting and also provide a value reference for government in drafting relevant economic and environmental policies. Empirical study shows that the mean absolute percentage error of RGM(1,1) model is 2.05 % lower than GM(1,1) and AGM(1,1), respectively. Results are very encouraging as the RGM(1,1) forecasting model clearly enhances the prediction accuracy.

Keywords Grey theory · Forecasting · Green GDP accounting

166.1 Introduction

Energy consumption and the threat of global warming have drawn nation and international attention. In 1992, the Commission for Sustainable Development of the United Nation signed the convention to pursue equilibrium between ecological reservation and economic development. In 1997, Taiwan's government promulgated an Article 10 amendment of Taiwan's Constitution to support environmental

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E. Qi et al. (eds.), *The 19th International Conference on Industrial Engineering and Engineering Management*, DOI: 10.1007/978-3-642-38391-5_166,

and ecological protection. To implement this policy, the Executive Yuan's Environmental Protection Administration (EPA) invited relevant departments to discuss Taiwan's green Gross Domestic Product (GDP) accounting under the System of Integrated Environmental and Economic Accounting (SEEA) led by the United Nations and the World Bank. An initial effort has been made to collect required data and coordinate with pertinent departments to establish a database for green GDP accounting and then officially released Taiwan's green GDP accounting by the Directorate General of Budget, Accounting and Statistics (DGBAS).

Green GDP is a very important indicator to reflect the real domestic wealth, which tries to take into account some important determinants of human welfare and therefore is believed to be a better indicator of a country's welfare than the traditional GDP. With regard to the measurement of the green GPD accounting, Yue and Xu (2008) and Yue et al. (2009) classified as two main types. Type I green GDP accounts GDP minus the cost of environmental quality degradation and natural resources depletion, but it ignored the value of natural ecosystem services. As Heal (2007) and Xu et al. (2010) pointed out that the value of direct ecosystem services need to consider in green GDP, which is type II green GDP accounting. Currently, the SEEA framework has been adopted for compiling Taiwan's green GDP accounting, which is similar to Type I green GDP accounting. The system, introduced by UN and the World Bank, is supported by major international organizations and environmental specialists and widely adopted by more than 20 countries including the United States, Japan, South Korea and Canada.

The depletion of Taiwan's natural resources include the depletion of groundwater, crude oil, natural gas, coal and gravel as determined by the net price method, which means exploitative gain minus exploitative cost. Factors such as over-fishing, illegal exploitation of coral reefs and excessive land development have not been included in natural resources depletion. According to the DGBAS in Taiwan, the natural resources depletion was reduced from NT$ 20.70 billion of 2002 to NT$ 18.19 billion of 2010. The depletion of groundwater continued to the top of the list of 2010, decreasing by 10.95 % from 2002, to represent 80.65 % of the natural resources depletion.

The estimation of Taiwan's environmental degradation has been taken by the maintenance cost method, which means the act of pollution without taking any preventive measures is applied. Currently, the DGBAS only accounts for water, air and solid waste pollution in calculating environmental degradation, while noise pollution, soil pollution and greenhouse effects are temporarily left out since most countries have not taken into account such categories. Environmental degradation throughout Taiwan in 2010 totaled NT$ 63.4 billion, up 4.52 % compared to the 2002 of NT$ 60.66 billion. The findings show that the degradation by water pollution in 2010 at NT$ 35.1 billion, the highest among three categories, to represent 53.61 % of the environment degradation. The government has stepped up its efforts in improving the water pollution from major sources of industrial and residential discharges. The degradation of water pollution has obviously declined 10.07 % since 2002. With rapid industrial and commercial developments, however, the degradation of air pollution has increased 28.51 % since 2002. Through reduction, recycling and proper disposal of the solid waste in the past years, the degradation of solid waste is much less than those of water and air pollution.

In 2010, there was NT$ 13.61 trillion created in GDP, but negative impact on environment was accompanied by a high economic growth. One is depletion of natural resources totaled NT$ 18.19 billion and the other is environmental degradation up to NT$ 65.47 billion. Consequently, the green GDP accounting is NT$ 13.53 trillion, up by 30.97 percent compared to NT$ 10.33 trillion in 2002. The dramatic growth in green GDP accounting may attribute to the increasing environmental awareness of Taiwanese and the policy implementation by the government. Accordingly, one of main concerns in this article is to construct forecasting model to forecast green GDP accounting of Taiwan. The proposed model not only can reflect how much degree paid on environmental protection but support government to draft pertinent policies for Taiwan's environmental issues.

Time series models are widely used in predicting and acquiring management information. A large number of observations are required to understand the pattern and choose a reasonable mathematical model for time series process. Unfortunately, only a little data are obtained over time and simultaneously we are interested in speculating succeeding observations in the future. Neither statistical methods nor data mining techniques are suitable for exploring the small observation problem. The grey system theory, originally developed by Deng (1982), effectively deals with limit data and uncertain information. Since then, the grey system theory has become popular when we have only incomplete information and also successfully applied to various fields such as transportation (Pai et al. 2007), energy (Hsu and Chen 2003; Akay and Atak 2007), financial (Chang and Tsai 2008; Huang and Jane 2009; Kayacan et al. 2010), social and economic (Shen et al. 2009), engineering (Li and Yeh 2008) and so on. Above mentioned articles, the grey system theory is utilized in this work to forecast green GDP accounting of Taiwan.

166.2 Methodology

166.2.1 Original GM(1,1) Forecasting Model

The aim of this article is to construct a green GDP accounting forecasting model based on grey system theory. Unlike statistical methods, this theory mainly deals with original data by accumulated generating operations (AGO) and tries to find its internal regularity. Deng (1986) has been proven that the original data must be taken in consecutive time period and as few as four. In addition, the grey forecasting model (GM) is the core of grey system theory and the GM(1,1) is one of the most frequently used grey forecasting model. The GM(1,1) model constructing process is described as follows:

Step 1: Denote the original data sequence.

$$x^{(0)} = \left(x^{(0)}(1), x^{(0)}(2), x^{(0)}(3), \ldots, x^{(0)}(n)\right), \quad n \geq 4 \tag{166.1}$$

Step 2: Use AGO to form a new data series.

$$x^{(1)} = \left(x^{(1)}(1), x^{(1)}(2), x^{(1)}(3), \ldots, x^{(1)}(n)\right),$$

where $x^{(1)}(1) = x^{(0)}(1)$ and

$$x^{(1)}(k) = \sum_{i=1}^{k} x^{(0)}(i), \quad k = 2, 3, \ldots, n \tag{166.2}$$

Step 3: Calculate background values $z^{(1)}$

$$z^{(1)}(k) = (1-\alpha)x^{(1)}(k-1) + \alpha x^{(1)}(k), \quad \alpha \in (0, 1) \tag{166.3}$$

Step 4: Establish the grey differential equation.

$$\frac{dx^{(1)}(k)}{dt} + ax^{(1)}(k) = b \tag{166.4}$$

where a is the developing coefficient and b is the grey input.

Step 5: Solve Eq. (166.4) by using the least square method and the forecasting values can be obtained as

$$\begin{cases} \hat{x}^{(1)}(k) = \left(x^{(0)}(1) - \dfrac{b}{a}\right)e^{-a(k-1)} + \dfrac{b}{a} \\ \hat{x}^{(0)}(k) = \hat{x}^{(1)}(k) - \hat{x}^{(1)}(k-1) \end{cases} \tag{166.5}$$

where

$$[a, b]^T = (B^T B)^{-1} B^T Y \tag{166.6}$$

$$Y = [x^{(0)}(2), x^{(0)}(3), \ldots, x^{(0)}(n)]^T \tag{166.7}$$

$$B = \begin{bmatrix} -z^{(1)}(2) & 1 \\ -z^{(1)}(3) & 1 \\ \vdots & \vdots \\ -z^{(1)}(n) & 1 \end{bmatrix} \tag{166.8}$$

166.2.2 Residual GM(1,1) forecasting model

The residual modification GM(1,1) model, called RGM(1,1), first developed by (Deng 1982). The differences between the original series, $x^{(0)}$, and the GM(1,1) model forecasting values, $\hat{x}^{(0)}$, are defined as the residual series. Hence, the absolute values of the residual series $\varepsilon^{(0)}$ can be represented as:

$$\varepsilon^{(0)} = \left(\varepsilon^{(0)}(2), \varepsilon^{(0)}(3), \varepsilon^{(0)}(4), \ldots, \varepsilon^{(0)}(n)\right), \tag{166.9}$$

where

$$\varepsilon^{(0)}(k) = \left|x^{(0)}(k) - \hat{x}^{(0)}(k)\right|, \quad k = 2, 3, \ldots, n. \tag{166.10}$$

Execute the Steps 1–5, a RGM(1,1) forecasting model can be established and the forecasting values $\hat{\varepsilon}^{(0)}(k)$ be:

$$\hat{\varepsilon}^{(0)}(k) = \left(\varepsilon^{(0)}(2) - \frac{b_\varepsilon}{a_\varepsilon}\right)(1 - e^{a_\varepsilon})e^{-a_\varepsilon(k-1)}, \quad k = 3, 4, \ldots, n \tag{166.11}$$

Considering the residual modification on GM(1,1) model can improve the predictive accuracy of the original GM(1,1) model.

166.2.3 Adaptive GM(1,1) Forecasting Model

Li and Yeh (2008) proposed the trend and potency tracking method (TPTM) to acquire concealed information, and then construct a triangular trend and potency (TP) function with an asymmetrical domain range. TP values of the existing data are determined by ration rule of a triangle and represented the current datum's intensity close to the central location. The detailed procedure of computing TP values is described by Li and Yeh (2008).

Moreover, the background value is the most important factor which affects the model's adoption and precision. Many researchers generally regard each datum as having equal importance, and set $\alpha = 0.5$ in Eq. (166.3) to compute the background value. However, Li et al. (2009) discussed the influence of α and renamed Eq. (166.3) as

$z^{(1)}(k) = x^{(1)}(k-1) + \alpha x^{(0)}(k), \quad \alpha \in (0, 1), \quad k = 2, 3, \ldots, n.$

Clearly, the influence from α to the background value mainly comes from the newest data. Therefore, the Adaptive GM(1,1), known as AGM(1,1), are presented by Li et al. (2009) and described as follows:

Step 1–2 are same as original GM(1,1).

Step 3: Calculate the TP values by TPTM

$$\{TP_i\} = \{TP_1, TP_2, \ldots, TP_n\}, \quad i = 1, 2, \ldots, n \tag{166.12}$$

Step 4: α_k is computed by

$$\alpha_k = \frac{\sum_{i=1}^{k} 2^{i-1} TP_i}{\sum_{i=1}^{k} 2^{i-1}}, \quad k = 2, 3, \ldots, n \tag{166.13}$$

Step 5: Calculate background values.

$$z^{(1)}(k) = x^{(1)}(k-1) + \alpha_k x^{(0)}(k), \quad \alpha \in (0,1) \tag{166.14}$$

Step 6: Establish the grey differential equation and estimate the developing coefficient a and the grey input b by least square method to obtain forecasting value of AGM(1,1).

166.3 Empirical Studies

To demonstrate the precision and stability of grey forecasting method, the relevant green GDP accounting provided by DGBAS are examined in this study. The historical annual data of original GDP accounting, natural resources depletion, environmental degradation and green GDP accounting from 2002 to 2010 are presented in Table 166.1.

166.3.1 Formulating the Three Compared Models

(1) Original GM(1,1)

The original data sequence is obtained as $x^{(0)} = [103.30, 106.18, \ldots, 135.32]$ based on the green GDP accounting in Taiwan. The parameters of a and b of original GM(1,1) model are estimated by the least-square method through the

Table 166.1 Values of the relevant green GDP accounting from 2002 to 2010 (NT$ Billion)

Years	GDP accounting	Natural resources depletion	Environmental degradation	Green GDP accounting
2002	10411.63	20.70	60.66	10330.27
2003	10696.25	20.29	57.59	10618.37
2004	11365.29	21.07	67.14	11277.08
2005	11740.27	19.55	66.64	11654.08
2006	12243.47	18.58	66.14	12158.75
2007	12910.51	18.58	67.23	12824.70
2008	12620.15	18.07	65.39	12536.68
2009	12481.09	17.60	63.20	12400.28
2010	13614.22	18.19	63.40	13532.62

Eqs. (166.2)–(166.4). ($a = -0.029, b = 105.00$). The original GM(1,1) forecasting model is listed as follow:

$$\hat{x}^{(0)}(k) = \left(x^{(0)}(1) + \frac{105.001}{0.029}\right)\left(1 - e^{-0.029}\right)e^{0.029(k-1)}, \quad k = 2, 3, \ldots, n$$

(2) Residual GM(1,1)

The residual data sequence is built by Eq. (166.10). Repeat the Eqs. (166.2)–(166.4) to estimate the parameters of a and b of RGM(1,1) model ($a = 0.128$, $b = 5.374$). The RGM(1,1) forecasting model is listed as follow:

$$\hat{\varepsilon}^{(0)}(k) = \left(\varepsilon^{(0)}(2) - \frac{5.374}{0.128}\right)\left(1 - e^{0.128}\right)e^{-0.128(k-1)}, \quad k = 3, 4, \ldots, n$$

(3) Adaptive GM(1,1)

Original data sequence $x^{(0)}$ is adopted to establish the TP values by Li et al. (2009). In order to emphasize the effect of the newest datum, the weight is changed in the background value. Different weights, α_k, are calculated as {0.52,0.66,0.79, 0.87,0.83,0.85,0.87,0.75} in accordance with TP values, {TP} = {0.45,0.54, 0.77,0.90, 0.94,0.79,0.86,0.89,0.64}. Finally, the parameters of a and b of AGM(1,1) model are estimated by least square method. ($a = -0.027$, $b = 104.594$). The AGM(1,1) forecasting model is listed as follow:

$$\hat{x}_A^{(0)}(k) = \left(x_A^{(0)}(1) + \frac{104.594}{0.027}\right)\left(1 - e^{-0.027}\right)e^{0.027(k-1)}, \quad k = 2, 3, \ldots, n$$

166.3.2 Results

The predicted results obtained by the original GM(1,1), residual GM(1,1) and adaptive GM(1,1) model are presented in Table 166.2 and Fig. 166.1. To measure the forecasting performance, mean absolute percentage error (MAPE), is used for evaluation of these models. The results indicate that the RGM(1,1) has the smallest MAPE (2.05 %) compared with original GM(1,1) and AGM(1,1) (3.25 and 2.32 %, respectively). Therefore, RGM(1,1) model not only can reduce the forecasting error effectively, but enhance the precision of a grey forecasting model. However, the absolute percentage error (APE) of the GM(1,1), RGM(1,1) and AGM(1,1) models in 2007 are 6.99, 4,39 and 5.14 %, respectively, which is higher than its MAPE.

Table 166.2 Forecasting values and errors of green GDP accounting (NT$ 0.1*Trillion)

Years	AV[a]	GM(1,1)		RGM(1,1)		AGM(1,1)	
		FV[b]	Error (%)[c]	FV	Error (%)	FV	Error (%)
2002	103.30						
2003	106.18	106.42	0.23			108.94	2.60
2004	112.77	109.50	2.90	114.57	1.60	111.99	0.69
2005	116.54	112.67	3.32	117.13	0.51	115.12	1.22
2006	121.58	115.92	4.65	119.86	1.42	118.34	2.66
2007	128.24	119.28	6.99	122.74	4.29	121.65	5.14
2008	125.36	122.72	2.10	125.77	0.33	125.05	0.24
2009	124.00	126.27	1.83	128.95	4.00	128.55	3.67
2010	135.32	129.92	3.99	132.29	2.24	132.15	2.34
MAPE[d]			3.25		2.05		2.32

[a] *AV* Actual value

[b] *FV* Forecasting value

[c] Error $= |FV_k - AV_k|/AV_k$

[d] MAPE $= \frac{1}{n}\sum_{k=1}^{n}[|FV_k - AV_k|/AV_k]$

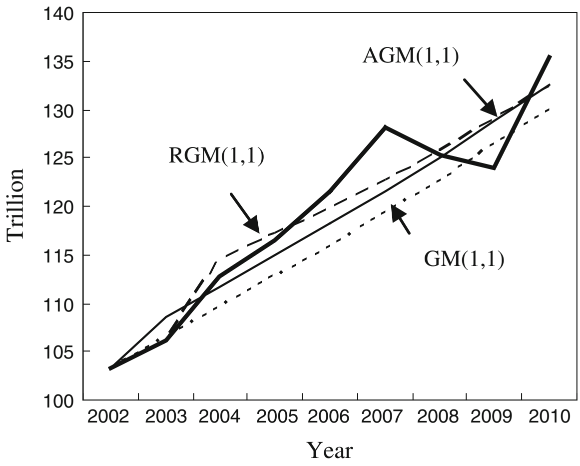

Fig. 166.1 Actual values and forecasting values for green GDP accounting of Taiwan from 2002 to 2010

166.4 Conclusions

Numerous forecasting methods have been widely used, including the time series analysis, regression analysis and artificial neural networks. They need a large amount of data to construct a proper forecasting model. With the life cycle of products, however, data collected are limit. Adopting traditional forecasting methods with a few uncertain and insufficient data to build forecasting model is unsuitable. Therefore, in order to obtain a highly accurate forecasting model with limit data, Deng (1986) first presented the grey forecasting model from grey theory to overcome the problem facing a few data. Accordingly, the goal of this paper is to forecast the green GDP accounting of Taiwan by original GM(1,1) model and compare to residual GM(1,1) and adaptive GM(1,1) model.

To measure the performance of the GM(1,1), RGM(1,1) and AGM(1,1) models, the criteria of MAPE is adopted. Empirical results indicate that the RGM(1,1) forecasting model has the lowest MAPE, 2.05 %, among three models. That is, RGM(1,1) forecasting model has a high prediction validity of forecasting the green GDP accounting in Taiwan. The findings serve as a basis for government decision making to make Taiwan become Green Islands both economically and environmentally.

The results are very encouraging as they show that green GDP accounting represented the human welfare is increasing during the last decade. More important, natural resources depletion and environmental degradation are debit entries to green GDP accounting, which represent negative environment impacts rising from the economic developments achieved. Therefore, in order to pursue a high human welfare and sustainable development of ecosystem, Taiwan government and Taiwanese must cooperate together to execute pertinent environmental policies.

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Chapter 167
Simulation Research of the Fuzzy Torque Control for Hybrid Electrical Vehicle Based on ADVISOR

Bo-jun Zhang, Yu Wang and Jia-tian Guo

Abstract The simulation model of the super-mild hybrid electrical vehicle is established through the simulation software ADVISOR. The fuzzy logic torque distribution controller of motor and engine is designed. The drive cycle selects Urban Dynamometer Driving Schedule (UDDS). The simulation results show that the fuzzy torque controller of motor and engine can properly distribute the torque. The fuel economy and emission performance are improved.

Keywords ADVISOR · Hybrid electrical vehicle · Simulation · Torque control

167.1 Vehicle Simulation Model

The simulation model of the super-mild hybrid vehicle is established through the simulation software ADVISOR. This Model is shown in Fig. 167.1.

The backward simulation and forward simulation can be used in ADVISOR. The backward simulation can calculate the engine and motor output power. Forward simulation is to be after the backward simulation, it can use the engine and motor power along with backward simulation passing in the opposite direction. The actual speed of vehicle is calculated by the forward simulation (Wipke et al. 1999). Every module in the vehicle simulation model contains a simulink simulation module. We can modify the parameters in the M-file for data input (Zeng et al. 2004).

The parameters in the M-file of vehicle module are modified according to the parameters of the entire vehicle, such as:

veh_gravity = 9.81; % m/s^2

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E. Qi et al. (eds.), *The 19th International Conference on Industrial Engineering and Engineering Management*, DOI: 10.1007/978-3-642-38391-5_167,

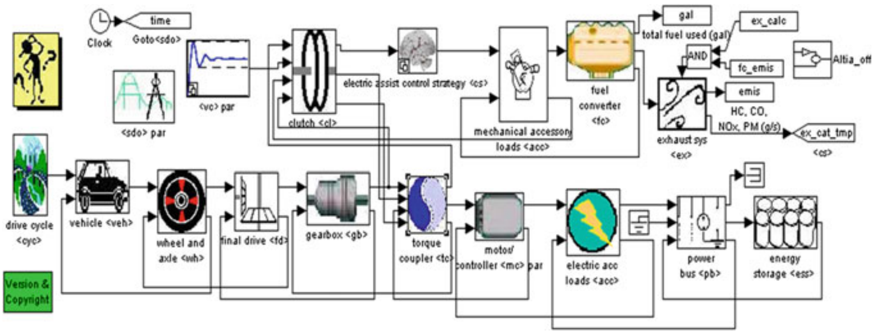

Fig. 167 1 The super-mild hybrid vehicle simulation model

veh_air_density = 1.2; % kg/m^3
veh_mass = 865; % (kg)
vehicle_height = 1.380; % (m)
vehicle_width = 1.590; % (m)
veh_CD = 0.38;
veh_FA = 1.7; % (m^2)
veh_wheelbase = 2.365; % (m)

167.2 Torque Fuzzy Logic Control

The super-mild hybrid electrical vehicle has no pure electric operating mode. Motor only be used for idle starting, stopping, power compensation and recycling braking energy, so the motor torque control will affect the vehicle performance (Zhang et al. 2010; Deng et al. 2004; Fan and Wu 2004; Liang and Wang 2001).

The output torque of the engine can be divided into two parts: One is used to drive the vehicle, the other is used to drive the generator for the battery charging. The input/output torque of the motor can balance the relationship between engine torque and vehicle required torque, which controls the engine working point along the economic curve (Schouten et al. 2002; Lee and Sul 1998). When the engine output torque is lower than the vehicle required torque, the motor will make up the difference. When the engine output torque is higher than the vehicle required torque or the vehicle is in deceleration braking condition, the extra engine output torque or the recovery of deceleration energy can drive generator for battery charging (Schoutena et al. 2002, 2003; Kheir et al. 2004; Poursamad and Montazeri 2008; Baumann et al. 2000). The fuzzy controller not only improves the vehicle fuel economy but also makes the battery SOC value to be in the high efficiency range.

Take the differential values between the vehicle required torque and the engine output torque (Tc), and battery SOC values to be input variables. Take the torque

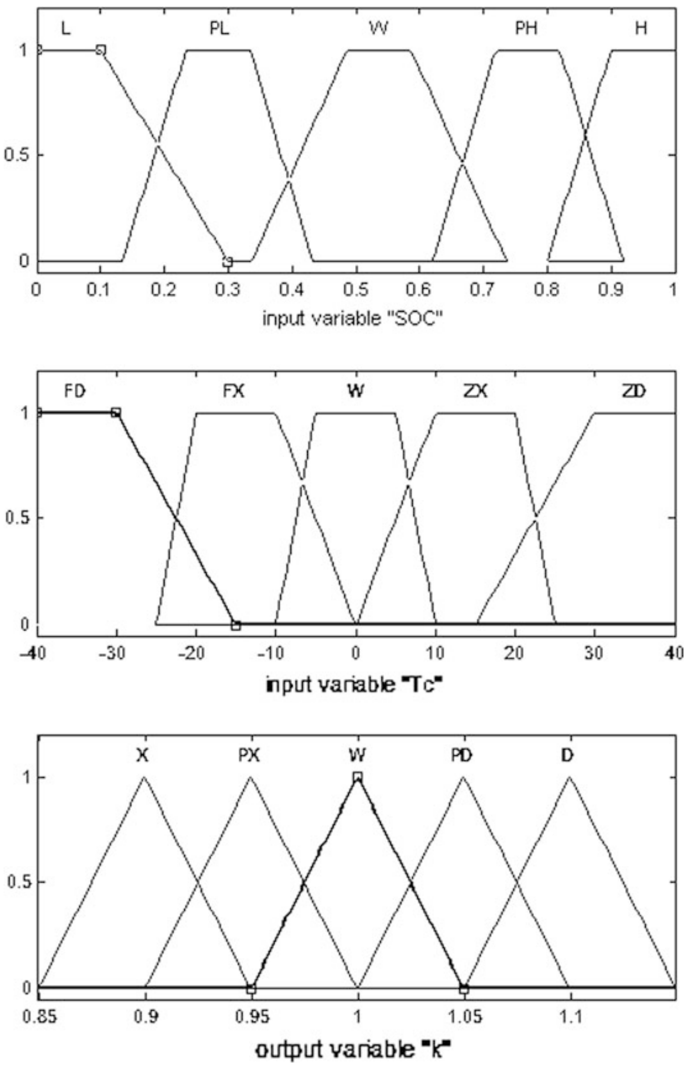

Fig. 167.2 Membership function

adjustment parameter to be output variables. The membership function is shown in Fig. 167.2.

Input and output variables of the fuzzy sets are as follows:

The fuzzy set for the SOC is: {L, PL, W, PH, H}.

The fuzzy set for the Tc is: {FD, FX, W, ZX, ZD}.

The fuzzy set for the V is: {X, PX, W, PD, D}.

Where: L represents low, PL represents partial low, W represents moderate, PH represents partial high, H represents high, FD represents negative bigness, FX

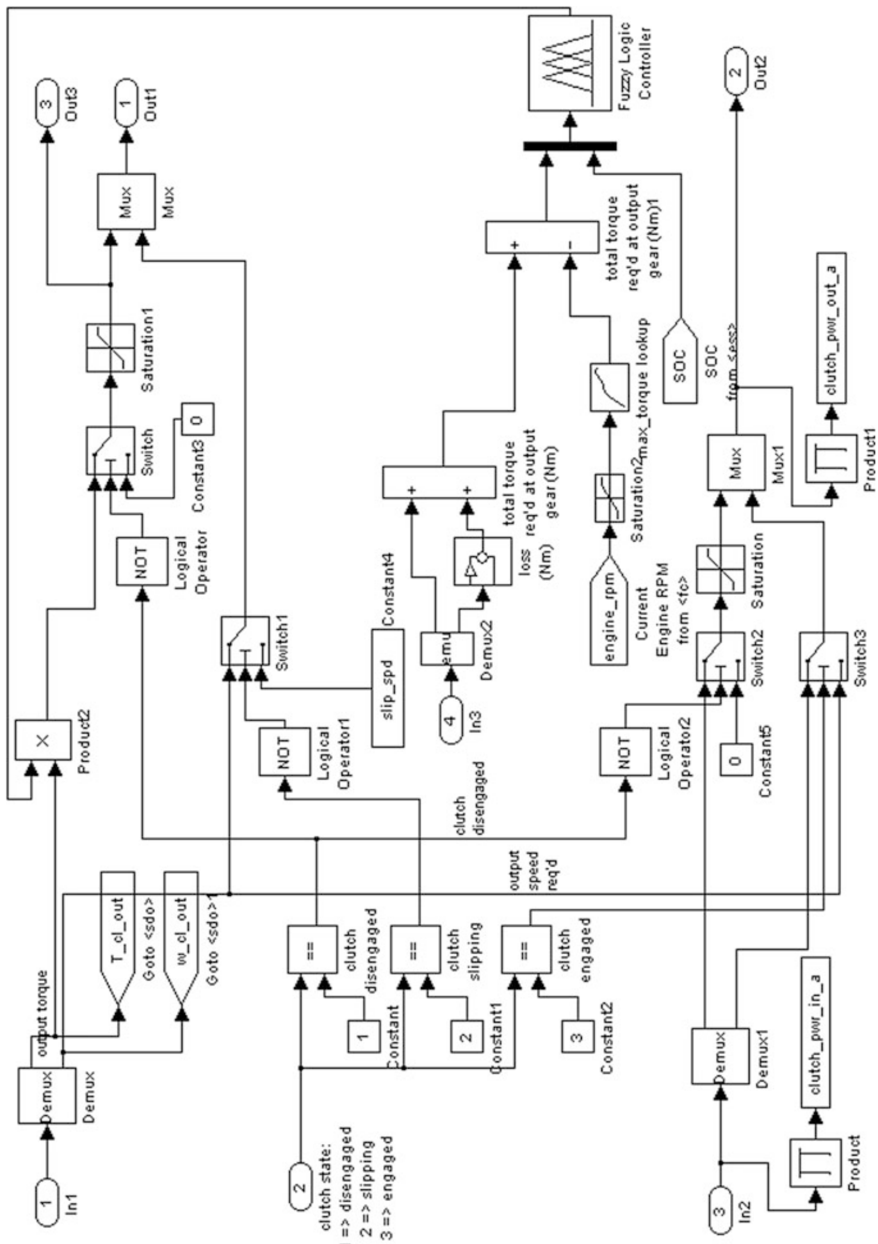

Fig. 167.3 Clutch control

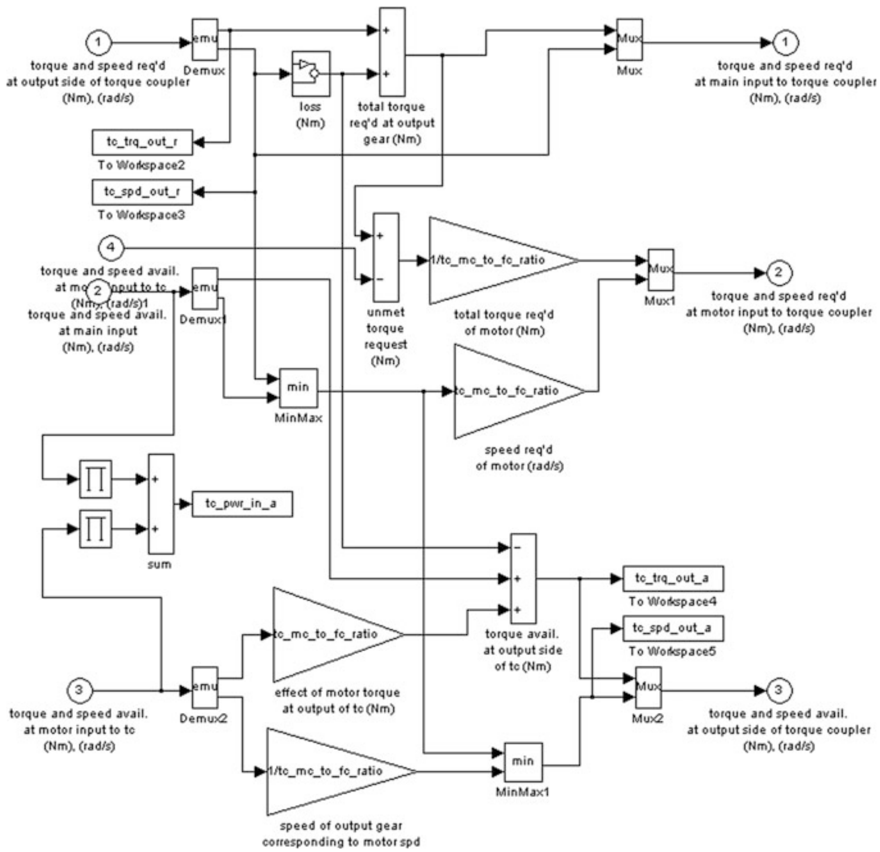

Fig. 167. 4 Torque control

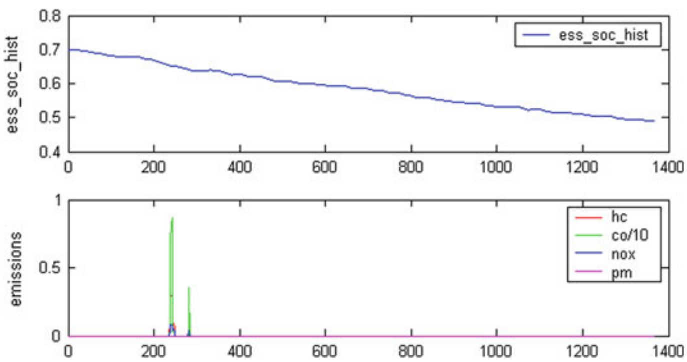

Fig. 167.5 Simulation results

Table 167.1 Engine fuel economy and emissions

Torque controller	Fuel economy (L/100 km)	Emissions (g/mile)		
		HC	CO	NO_X
Without fuzzy controller	0.47	0.422	10.82	0.113
With fuzzy controller	0.35	0.33	6.456	0.113

represents negative smallness, ZX represents positive smallness, ZD represents positive bigness, X represents smallness, PX represents partial smallness, PD represents partial bigness, D represents bigness.

25 fuzzy control rules are designed to describe the relationship between input and output. There are some rules to illustrate its function, IF is the premise and THEN is the conclusion:

a. IF(Tc is W) THEN (k is W)
b. IF(SOC is L) and (Tc is FX) THEN (k is W)
c. IF(SOC is PL) and (Tc is FD) THEN (k is X)
d. IF(SOC is H) and (Tc is ZX) THEN (k is X)
e. IF(SOC is PH) and (Tc is ZD) THEN (k is PD)

…

The modules of <cl> and <tc> realize the fuzzy logic torque control, as shown in Figs. 167.3 and 167.4.

167.3 Simulation Result

The simulation results are shown in Fig. 167. 5.

The engine fuel economy and emission values are shown in Table 167.1.

The simulation results show that the battery SOC value can be maintained in the high efficiency range. And the fuel economy of the engine has been improved, the HC and CO emissions have been lower.

167.4 Conclusion

The ADVISOR simulation model and the fuzzy logic torque controller are established. The fuzzy logic torque controller is realized through the clutch and torque control module. The fuzzy torque control strategy can more effectively distribute the motor and the engine operating range. The fuel economy of the vehicle has been improved and the emissions have been lower.

Acknowledgments This dissertation is under the project support of Natural Science Foundation of Tianjin (09JCYBJC04800).

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Chapter 168
Vulnerability Analysis and Assessment System of Natural Disaster

Jiang Shen, Jing Huang, Tao Li and Man Xu

Abstract With regard to the overall vulnerability of the complex natural disaster system, correlation of disaster-inducing factors, disaster environment and disaster bearing objects was analyzed, natural disaster forming efficiency was simulated, and vulnerability mechanism of natural disaster was researched using disaster-inducing factor-vulnerability chain and vulnerability curves. Assessment decision-making model of natural disaster vulnerability was built. Through constructing three index systems, natural disaster vulnerability was assessed by disaster risk degree, vulnerability of disaster bearing objects and risk loss degree.

Keywords Natural disaster · Vulnerability · Disaster risk degree · Risk loss degree

168.1 Introduction

According to the research of Janssen (2005), vulnerability appeared 939 times in 2,286 authoritative publications in the past 30 years, especially in natural disaster emergency management research and government documents, attracting researchers and policy makers' concern. In natural disaster research, natural disaster vulnerability was defined as factors decided by nature, society, economy, environment, enhancing community sensitivity facing disaster. From the disaster point of view, vulnerability referred to characteristics easy to be damaged or

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E. Qi et al. (eds.), *The 19th International Conference on Industrial Engineering and Engineering Management*, DOI: 10.1007/978-3-642-38391-5_168,

Table 168.1 Characteristics and performances of natural disaster vulnerability

Characteristics	Performances
Numerous types	A total of seven categories, 20 kinds, including rainstorm and flood, drought, tropical cyclone, frost, hail, fog, sandstorms and so on
Wide range	Occurred throughout the year, in the mountain, plains, plateau, island, river, lake, sea and air
High probability	Drought, floods and typhoons, and other disasters occurred every year
Long duration	The same disaster often occurred quarter after quarter, year after year
Concurrent	Some disasters occurred in the same period, such as thunderstorm, hail, high wind, tornado were often a concurrent phenomenon
Significant chain reaction	Weather and climate conditions were often able to cause or worsen floods, landslide, and plant pests and so on
Severe damage	121.3 million people were killed from 1947 to 1980, caused by natural disasters according to United Nations announcement

injured by natural disasters, reflecting the affordability of various types of disasters. Various characteristics and performances of natural disaster vulnerability were shown in Table 168.1.

The frequent occurrence of natural disasters and serious effects of secondary disasters caused the focus of the overall vulnerability of complex systems of natural disasters. In the large complex system, the more complex the system, the more obvious vulnerability to natural disasters. Coupled with the dispersion of the system, it was a must from an overall perspective to assess the vulnerability of natural disasters.

168.2 Research Status of Natural Disaster Vulnerability

Global disaster research program had a major impact on disaster risk assessment index system, such as Disaster Risk Index (DRI) scheme, the world first global scale human vulnerability assessment index system with spatial resolution to the countries. Domestic scholars focused on single disaster with risk assessment system based on index.

(1) *Natural disaster risk assessment.* The Disaster Risk Hotspots Plan by Columbia University and ProVention Union established three risk assessment indexes and disaster risk maps of hazard-prone areas (Arnold et al. 2006). European Spatial Planning Observation Network elaborated multiple risk assessment index methods on the potential risk of a particular area (Greiving 2006). The U.S. Federal Emergency Management Agency and National Institute of Building Sciences developed the HAZUS model, a standardized national multi-hazard loss estimation method.
(2) *Vulnerability assessment.* Vulnerability analysis methods were mainly two ways: the index system and the vulnerability curve. Index system method,

constructed the model through index optimization, weight assignment, and assessment result of a single disaster or multi-disaster was a relative value more applicable in the lack of quantitative parameters or data limited circumstances, such as the pressure release model (Blaikie and Cannon 1994), the vulnerability model (Cutter 1996). The disadvantage of rough assessment results and poor operability could be solved by vulnerability curve (Shi et al. 2009), such as the ANUFLOOD model developed by Australian Resources and Environment Research Center (Gissing and Blong 2004).

168.3 Natural Disaster Vulnerability Mechanisms

Natural disaster vulnerability mechanism was an input–output of operational efficiency analysis model of a complex giant system. In the process of natural disasters, disasters were the run results of a regional disaster system, also an input–output system. The formation of disasters as output factors could be regarded as the working result of a regional disaster system as an input factors, including disaster-inducing factors, disaster environment and disaster bearing objects, and natural disaster vulnerability was the level of disasters forming efficiency. The greater the vulnerability, the higher the disaster efficiency, and the easier to form a serious disaster.

Through collecting the relative data of basic information of the regional context of natural disasters and disaster bearing objects, characteristic information of risk factors, vulnerability information and historical disaster information, based on the analysis method of historical disaster, index system and vulnerability curve, natural disaster risk sources were identified and the refined three dimensional natural disaster vulnerability mechanism model of was constructed as Fig. 168.1.

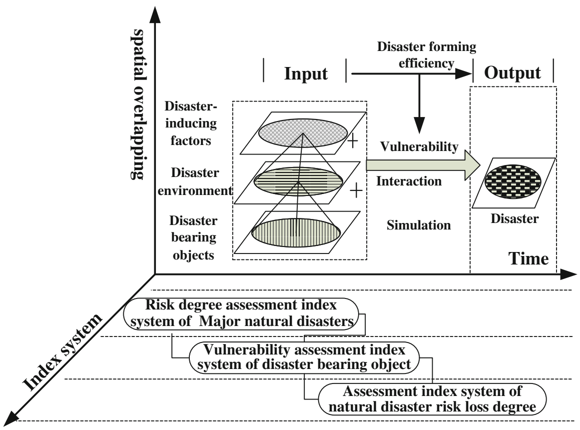

Fig. 168.1 Three dimensional natural disaster vulnerability mechanism model

(1) *Disaster-inducing factor-vulnerability chain.* Through analyzing the internal and kinetic characteristics of the natural disaster risk bearing objects (population, community, region, infrastructure, environment, etc.), the expected loss under disasters was determined, and the regularity of natural disaster vulnerability was described using disaster-inducing factor-vulnerability chain.
(2) *Regularity model and threshold of vulnerability.* In order to improve the accuracy of risk assessment, whether disaster bearing objects were in disasters and disaster characteristics were specific and visual using scenario simulation method to simulate disaster scenarios and optimize exposure factors. Vulnerability regularity and threshold could be the modeled, such as the regularity of the vulnerability of mechanism model in three dimensions of natural disasters and vulnerability curve analysis, such as intensity-loss curve, strength-loss rate curve and intensity-per unit area curve.

168.4 Assessment Decision-Making Model of Natural Disaster Vulnerability

Assessment decision-making model of natural disaster vulnerability was constructed according to the requirements, guidelines, targets and layers of the disaster loss assessment, comprehensive index system. For the main features of the major natural disasters, an assessment index system of natural disaster risk was established, including the target layer, rule layer and scheme layer.

Assessment of disaster risk degree, vulnerability of disaster bearing objects and risk loss degree were included in index system of natural disaster risk. In disaster risk degree assessment, the natural properties of the natural disasters were set as the basic starting point, and the intensity and the likelihood of risk factors were determined by analyzing the past frequency and intensity of risk factors. Vulnerability of disaster bearing objects, the loss tendency faced with natural disaster risk, was determined by sensitive natural, social, economic and environmental factors and interaction. Risk loss assessment evaluated the disaster loss in a certain risk. The details included the following three assessment index systems.

168.4.1 Risk Degree Assessment Index System of Natural Disaster

According to risk degree assessments and indexes of main meteorological disasters, geological disasters, pests and disease disasters, risk degree assessment index system of natural disasters was constructed based on historical data for disasters combining each disaster with corresponding disaster bearing object types, considering the disaster intensity, the disaster probability of and environmental conditions.

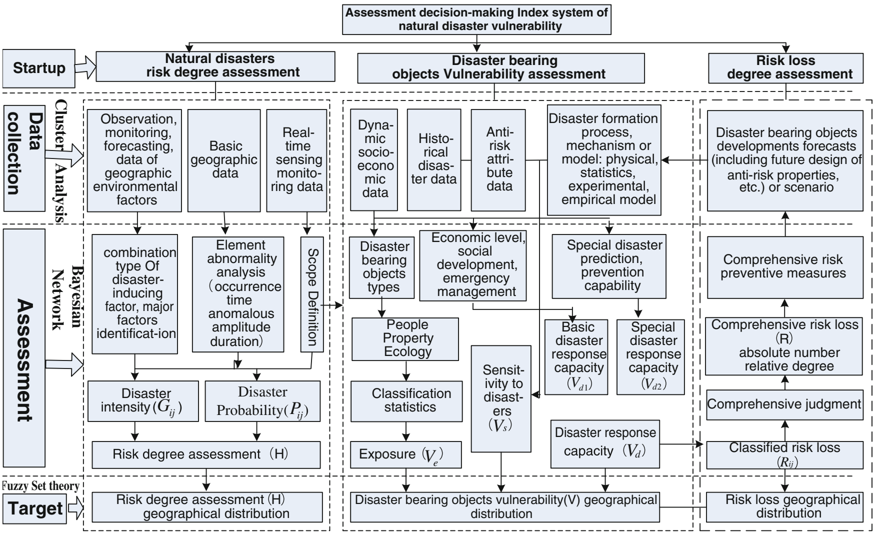

Fig. 168.2 Assessment decision-making model of natural disaster vulnerability

(1) *Disaster intensity* (***G***) *assessment.* ***G*** was determined by the variability degree of natural factors (such as the magnitude degree, the size of wind, temperature or precipitation anomaly degree) or attribute index of natural disasters' influence(such as seismic intensity, flood intensity).

(2) *Disaster probability* (***P***) *assessment.*
P was determined by the natural disaster occurrence number of the intensity in a certain period, represented by probability or frequency (Fig. 168.2).

168.4.2 Vulnerability Assessment Index System of Disaster Bearing Objects

Considering previous disasters and future trend, associated with social and economic and disaster statistics system, vulnerability of disaster bearing objects was assessed from physical exposure, sensitivity to disasters and socio-economic and cultural disaster response capacity in favor of national, regional and community development strategy and mitigation decision-making principles.

(1) *Physical exposure* (V_e) *assessment.* $\boldsymbol{V_e}$ indexes was divided into quantitative and value types based on specific types and characteristics of disaster bearing objects. The assessment process was:
Step 1: fix the minimum assessment unit.
Step 2: determine the number of disaster bearing objects in each minimum assessment unit.

Step 3: set the influence sphere of disaster bearing objects.
Step 4: assess the physical exposure.

(2) *Sensitivity to disasters* (*Vs*) *assessment.* In view of the numerous disaster bearing object types, disaster bearing objects were mainly divided into population, housing, crops, livestock, and the road systems for the assessment of sensitivity to disasters.
(3) *Regional disaster response capacity* (V_d) *assessment.* V_d assessment consisted of basic disaster response capacity index (human index, financial index and material resources index) and special disaster response capacity index (disaster prediction capability index, engineering disaster response capacity).

168.4.3 Assessment Index System of Regional Natural Disaster Risk Loss Degree

(1) *Risk loss assessment methods of single disaster.* Adopting the analogy of historical scenarios, physical simulation and experimental method and expert scoring, disaster bearing objects were classified as demographic, economic property and ecological systems to do population risk assessment, disaster risk assessment of property loss and ecosystem loss degree assessment under specific disaster.
(2) *Risk loss assessment methods of Multi-disaster.* On the basis of risk loss assessment of single disaster, considering regional development, personal safety and property security of residents, different natural disasters of different power sources and characteristics were set in a regional system. The assessment was divided into two levels. The first level was independent multi-disaster risk loss assessment of the three types of disaster bearing objects based on the assessment of the risk of loss considering risk loss and grade assessment. The second level was integrated assessment of the three types of bearing risk body based on the integration of assessment of the risk.

168.5 Conclusion

Certain disaster situation was formed through the interaction of disaster-inducing factors, disaster environment and disaster bearing objects, and vulnerability was to measure the disaster formation efficiency. In the thesis, the natural disaster vulnerability analysis method was put forward using vulnerability theory to analyze the vulnerability mechanism of complex natural disaster systems with consideration of comprehensive natural disasters. The proposed vulnerability assessment system could enrich the urban disaster risk assessment system and disaster risk management system, having important scientific significance in risk emergency management with risk prevention as the core, city's public safety, and the sustainable development of cities.

Acknowledgments This paper is supported by National Natural Science Foundation of China (Grant No. 71171143), Tianjin Research Program of Application Foundation and Advanced Technology (Grant No. 10JCYBJC07300), Key Project of Science and Technology supporting program in Tianjin (Grant No. 09ECKFGX00600), and FOXCONN Group.

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Chapter 169
Application of Actuarial Model in the Forecast of Maternity Insurance Fund's Revenue and Expenditure: A Case Study of Tianjin

Li-ping Fu, Jun Liu, Xue-zhen Chu and Jin-li Fan

Abstract To explore the way how to build up China's urban and rural childbirth insurance system, the crucial point is to carry out mutual helping function given by the maternity insurance fund and make sure its sustainable use. Guided by the principles and methods of demography and actuarial science, this paper forecasts and calculates people who are insured by Tianjin employees' maternity insurance and urban and rural maternity insurance, and their fund of revenue and expenditure, and draws relevant conclusions so as to provide scientific references for the collection of Tianjin's urban and rural unified maternity insurance fund, and formulation of relative payment standards.

Keywords Balance of urban and rural · Maternity insurance fund · Forecast of revenue and expenditure · Actuarial science

169.1 Introduction

Basically speaking, China's maternity insurance system is only for the employees', a large amount of rural women and urban non-professional women are out of the coverage, which is beneath social justice. Therefore, in order to promote the optimization and development of social security system, it is necessary to explore

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E. Qi et al. (eds.), *The 19th International Conference on Industrial Engineering and Engineering Management*, DOI: 10.1007/978-3-642-38391-5_169,

and build up unified maternity insurance system of urban and rural. The establishment of such unified system means the maternity insurance will cover not only employed women, but also unemployed women, and in turn, maternity insurance funds need to perform its mutual helping function. However, the revenue of Tianjin employee's maternity insurance funds is largely greater than its expenditure since the year 2005. Due to too much balance of its accumulation and its gradual annual increase, the efficiency of maternity insurance fund is quite low and its function and effect has not been fully carried out. In a consequence, the analysis and forecast of Tianjin maternity insurance fund's revenue and expenditure will be helpful to digest overmuch redundancy, which will benefit not only the rational allocation of maternity security resources between different groups, but also the realization of fairness between groups and the harmonious and stable development of our society.

169.2 Actuarial Model

169.2.1 Model Construction of the Population and Insured Group

(1) Population module (Fang and Sun 2008)
Basic data consists of regional total population and urban and rural population structured by gender and age, the death rate of urban and rural population differentiated by gender and age, the death rate of insured people differentiated by gender and age and the birth rate of urban and rural differentiated by age.
Quantity of urban employed population:

$$\begin{aligned} A_x &= \text{urban economically active population} - \text{unemployed population} \\ &= \text{urban economically active population} \times (1 - \text{b}) \\ &= \text{working age population } (15\text{–}64) \times \text{a} \times (1 - \text{b}) \end{aligned} \tag{169.1}$$

According to above, A_x is the quantity of urban employed population; a is the labor force participation rate, a = urban economically active population (both employed and unemployed)/working age population, b is the registered urban unemployment rate.
New birth population in t

$$\mathrm{B_t} = \sum_{\mathrm{x}=i}^{n} \mathrm{L}_{t,x}^{f} \cdot f_{t,x} \tag{169.2}$$

In the above formula, $\mathrm{L}_{t,x}^{f}$ is the quantity of women aged x in the year t; $f_{t,\,x}$ is the birth rate of childbearing age women, $Li_{t,x}$ is the total amount of live birth by women aged x in the year t.

As a result of Tianjin maternity insurance is limited by national family planning policy, women who give birth under age 20 cannot enjoy the treatment, so i is valued from 20,…, 49.

(2) Calculation module of insured people
This model not only forecasts the rural people, but also considers the differences between urban and rural from many aspects. It calculates insured employees and retirees by the method of adding stock and incremental.
Urban employed population:

$$A_x = \sum_{x=15}^{64} L_x \cdot \alpha \cdot (1 - b) \tag{169.3}$$

L_x is the quantity of urban permanent resident population aged x (differentiated by gender); α is the labor force participation rate; b is the urban registered unemployment rate.

The quantity of employees:

$$\mathrm{E}_{\mathrm{x,t}} = E_{x-1,\,t-1} \cdot (1 - q_t^{x_e}) + (A_{x,t} - \mathrm{E}_{\mathrm{x,t}}) \cdot \delta - E_{x-1,\,t-1} \cdot \eta \tag{169.4}$$

In the above formula, $q_t^{x_e}$ is the death rate of employees aged x in the year t (differentiated by gender), $1 - q_t^{x_e}$ is the survival probability; δ is the new insured proportion, $e_{x,0}$ is the number of new insured population aged x in base period, $A_{x,0}$ is the urban employed population aged x in base period, $E_{x,0}$ is the urban insured employees aged x in base period, η is the ratio that employees switch to retirees, $RE_{x,0}^n$ is the new added number of retirees aged x in base period, $E_{x,0}$ is the number of employees aged x in base period.

The quantity of retirees:

$$\mathrm{RE}_{\mathrm{x,t}} = \mathrm{RE}_{x-1,t-1} \cdot (1 - q_t^{x_{RE}}) + E_{x-1,t-1} \cdot \eta \tag{169.5}$$

$q_t^{x_{RE}}$ is the death rate of retirees aged x in the year t (differentiated by gender), $1 - q_t^{x_{RE}}$ is the corresponding survival rate.

169.2.2 The Income Module

$$In_t = R(0) + \sum_{t=1}^{T} (CR(t) \cdot (\sum_{x=15}^{65} E_{x,t} \cdot WA_{x,t} \cdot \kappa)) \cdot V^t \tag{169.6}$$

In this module, $R(0)$ is the surplus of fund in base period, $CR(t)$ is the collection rate in the year t, $E_{x,t}$ is the average quantity of employees aged x in the year t, $WA_{x,t}$ is the average pay cost wage of employees aged x in the year t, and κ is the rate of collection and payment. V^t is the discount rate.

169.2.3 The Expenditure Module

$$Ex_t = \sum_{t=1}^{T} (\sum_{x=20}^{49} \mathrm{L}^f_{t,x} \cdot f_{t,x} \cdot \mu_{0,x} + \sum_{x=20}^{70} \mathrm{L}^f_{t,x} \cdot j_{t,x} \cdot o_{0,x}) \cdot V^t \tag{169.7}$$

$\mu_{0,x} = \frac{TPa^1_{0,x}}{L^f_{0,x} \cdot f_{0,x}}$ is the average birth medical expenses and allowance (quota) of birth women aged x in base year; $L^f_{0,x}$ is the insured women aged x in base year; $f_{0,x}$ is the birth rate of insured women aged x in base year; $TPa^1_{0,x}$ is the expenditure fees of insured female employees aged x in base year; $j_{t,x} = T_{t,x}/L^f_{t,x}$ is the family planning level of women aged x in the year t; $T_{t,x}$ is the total number of women aged x who are under birth control; $L^f_{t,x}$ is the quantity of insured women aged x in the year t; $o_{0,x} = \frac{TPa^2_{0,x}}{L^f_{0,x} \cdot j_{0,x}}$ is the average expenditure (quota) of family planning women aged x in base year; $j_{0,x}$ is the family planning rate of insured women aged x in base year; $TPa^2_{0,x}$ is the family planning expenditure fees of insured female employees aged x in base year.

169.3 The Measurement and Parameter of Tianjin Urban and Rural Unified Maternity Insurance Fund

169.3.1 The Coverage of Population

(1) Women of childbearing age

In 2010, the quantity of childbearing aged women who are birth insured employees are 873,800, who are medically insured urban and rural residents are 1.2613 million. So the total amount is 2.1351 million, and over 446,500 women of childbearing age are not insured (Tianjin Bureau of Statistics 2006–2011).

(2) The quantity of births

The quantity of births is 70,300 that are complied with Tianjin family planning policy in 2010, among which 33,300 are urban residents, 37,000 are rural residents, and 16,100 are from other places (Tianjin Statistics Information 2010). In recent years, the rate of family planning is between 98.28 % and 99.21 % in the whole city.

(3) The quantity of birth insured people

In 2010, 28,300 women who are covered by employees' maternity insurance enjoyed the birth treatment and 20,500 childbearing women are subsidized by urban and rural residents' medical insurance, total 48,800. There are over 21,500 childbearing women who are not maternity insured (Tianjin Municipal Birth Insurance System Documentation 2006–2011).

169.3.2 Fund Revenue

(1) The insured people
This number is calculated according to the employee's maternity insurance, the urban and rural medical insurance coverage range and every year's growth level. On the basis of 228 million insured employees in 2010, the employee's maternity insurance has increased gradually, with average annual growth rate 86,000. In 2010, the number of urban and rural maternity insured people is 2.2696 million according to non student adult residents (from age 20 to 60).
(2) Social insurance base
Maternity insurance is calculated in accordance with the employees' age, gender, the proportion of per capita base pay of last year's social average wage, and infer from the social average wage growth rate, then calculate as per proportion between per capita base pay differentiated by age and gender, and last year's social average wage (Chi et al. 2009). Urban and rural residents' maternity insurance is calculated as 12 Yuan per year per capita quota.

169.3.3 Fund Expenditure

(1) The number of Generational women determination
The staff maternity insurance is calculated by the summation and the change of birth rate. Base on the summation of birth rate on the year of 2009, concerning the progressive increase, 2–3 %; Urban and rural residents maternity insurance is calculated by the summation of 2010, concerning the progressive increase, 2–3 %; The number of Family planning of staff maternity insurance, Urban and rural residents maternity insurance is determinate by the birth rate on 2010, concerning the progressive increase, 3–6 %; The determination of unemployed spouses of birth medical treatment accord to the difference of the correlation data between male and female staff who are 20–49 years old, referring to the group of 20–35 years old. According the female ages to calculate the fertility number, considering the data coincidence to calculated the fertility number and determinate as its 80 %.
(2) Per capita cost determination
Among staff maternity insurance, it includes family planning, antenatal care, maternity medical expenses per capita cost by age, and then multiplied by the corresponding number of treatment received. It calculates the average standard neonatal care costs for 500 Yuan.

According to the requirement of the Social Insurance Act of China, maternity benefits in accordance with the age of the maternity insurance of workers divided by the number of days of maternity leave 30.4 for the month, and then it results by multiplied the annual average pay wages for employees of enterprises to be. Female staff maternity benefits calculated in accordance with currently approved days of maternity leave (Social Insurance Act of China). Male benefit days calculated in accordance with 7 days of maternity leave.

Subsidies for family planning are distributed according to a 66 % of abortion and induced labor and an average 15 days for maternity leave. Based on the analysis of the data from the past 6 years, the percentage of abortion and induced labor in birth control operations in Tianjin is 45–59 % and the figure is showing a growing momentum. So we adopted 66 % when calculating the subsidies.

The number of people who receive maternity insurance is calculated on the basis of the birth rate of the total number of rural and urban residents who were covered in medical care in 2010 and the payment is 80 % of the maternity insurance of workers for people of all ages. In the charges for birth control, the number is calculated as the number of people who are covered in medical care for rural and urban residents multiplied by planed birth rate of corresponding worker and the charges are the same as the staff maternity insurance fee.

169.4 Maternity Insurance Fund Forecast

According to Tianjin birth insurance database of basic data, and by using the "Tianjin statistical yearbook"(Tianjin Bureau of Statistics 2006), "the fifth population census data of Tianjin" (Tianjin Statistics Bureau 2001) and China life insurance industry experience life table (National Bureau of Statistics of China Payment and Employment 2009–2011), use the fund of medical treatment insurance actuarial analysis model "MIFA12, by forecasting the five years the population growth rate (including the birth rate and mortality, net migration rate), ginseng protect growth rates, wage growth, the total fertility rate, plan and other important short-term level parameter value, and run outlook the birth insurance fund operation prospect for the actuarial forecast and analysis from 2011 to 2015." The feasibility assumptions anticipate reality, and take the neutral level. Model parameters adjustment factor mainly use gradually recursion method and correction method in advance (Song 2009).

(1) Overall Balance

According to the present basic operation model calculation, since 2011, the urban and rural birth insurance fund has been in overall revenues and expenditures current balance level with accumulated balance continuously increased. The balance situation summary for Table 169.1.

Table 169.1 Urban and rural birth insurance fund balance

Years	Fund income			Fund expenditure			Current balance	Cumulative balance
	Staff childbirth	Urban and rural childbirth	Total amount	Staff childbirth	Urban and rural childbirth	Total amount		
2011	6.70	0.27	6.97	4.90	0.80	5.70	1.27	12.01
2012	8.03	0.28	8.31	6.62	0.82	7.44	0.87	12.88
2013	9.42	0.28	9.69	7.43	0.86	8.28	1.41	14.29
2014	10.88	0.28	11.15	8.16	0.89	9.05	2.11	16.40
2015	12.41	0.28	12.69	8.91	0.92	9.82	2.87	19.27

Unit Billion Yuan

Through Table 169.1, about the maternity insurance fund revenue part, from 2011 to 2015 total revenue increase $572 million, nearly increasing of 82.07 %, with an average annual growth rate of 10.78 %, including staff maternity insurance revenues grew 11.14 %, urban and rural maternity insurance revenues grew 0.62 %. In 2015, staff maternity insurance revenue share on behalf of 97.79 %, urban–rural income accounting for 2.21 % of birth insurance.

On the side of outlay of Maternity insurance fund, the total outlay increases average 9.94 % per year from 2011 to 2015. Including staff maternity insurance fund increase average 11.06 %, town and country maternity insurance fund increase average 2.37 % per year. The total outlay of fund in 2015 is 0.98 billion dollars; staff maternity insurance occupies 90.73 %, town and country maternity insurance occupies 9.27 %. The expenses and receipts, growth rate and the ratio of staff maternity insurance fund exceed earning of town and country maternity insurance fund to a large extent.

Because of the calculation, which is for the accrual basis of analysis and forecast, the corresponding output is also accrual, so that The Fund income and expenditure does not correspond exactly to the current cash under the system of accounting and statistics reports. Appropriate predictions should be reflected through the accounting statements of the current mode after 1–2 years.

(2) Maternity Insurance Fund Expenditures

Each year the staff maternity insurance amount is summarized as shown in Table 169.2.

Through Table 169.2, during 2011–2015, the payment amount annual increase for 13.8 %. In 2015, the staff maternity insurance cost 891 million Yuan, paid from the main categories it's including antenatal check fee of $34 million, accounting for 3.82 %; Growing medical expenditure of $126 million, accounting for 14.14 %; Maternity allowance $601 million, accounting for 67.45 %; Male staff maternity allowance of $37 million, 4.15 %; Family planning allowance of $58 million, 6.51 %; all above five accounted for 96.07 %.

The urban and rural birth insurance payments case summary in Table 169.3.

Table 169.2 Staff maternity insurance fund expenditures in 2001–2015

Years	Subtotal	Antenatal examination cost	Birth medical treatment cost	Birth allowance	Neonatal care	Male staff allowance	No spouse employment growth	Family planning	Family planning allowance
2011	4.90	0.30	1.06	2.90	0.17	0.14	0.05	0.08	0.18
2012	6.62	0.32	1.18	4.18	0.18	0.26	0.05	0.09	0.37
2013	7.43	0.33	1.21	4.82	0.18	0.30	0.05	0.09	0.44
2014	8.16	0.33	1.24	5.40	0.19	0.34	0.05	0.10	0.51
2015	8.91	0.34	1.26	6.01	0.19	0.37	0.05	0.10	0.58

Unit Billion Yuan

Table 169.3 The childbirth grant expenditure of urban and rural medical insurance in 2011–2015

Years	Subtotal	Prenatal examination	Childbirth medical care	Family planning	Newborn care
2011	0.80	0.12	0.54	0.07	0.07
2012	0.82	0.13	0.54	0.06	0.08
2013	0.86	0.14	0.57	0.07	0.09
2014	0.89	0.14	0.59	0.07	0.09
2015	0.92	0.15	0.61	0.07	0.09

Unit Billion Yuan

According to the Table 169.3, the expenditure of urban and rural childbirth insurance has an annual average increase of 2.37 % in 2011–2015. By 2015, the expenditure of urban and rural childbirth insurance will increase to 92 million Yuan. Within this total prenatal examination expenditure as proportion of 16.30 % is 14 million; Childbirth Medical Care as proportion of 66.30 % is 59 million; Family Planning as proportion of 7.62 % is 7 million; Newborn Care as proportion of 9.78 % is 9 million.

169.5 Conclusion

(1) The rate and balance of payments can fund in this paper and imposed or paid based on the prediction of fund income. From 2011 to 2015, from the absolute value to see current balance, accumulated balance continuously increased, could realize the sustainable usage; From the relative amounts to see, birth insurance fund income annual growth rate is 10.78 %, birth insurance fund total spending the average annual growth of 9.94 %, after that plan, birth insurance fund basically comply with "payment to fix the receive, balance the basic balance" principle. Under this principle, deal with the fund collection and use of scientific investigation and measurement, the determination of reasonable seized proportion, in principle should be controlled in the proportion between 0.6 % and 0.7 %, which can steadily absorb balance fund.

(2) The worker bears insurance fund collection-payment, growth rates and that accounts for a fund income is far greater than the proportion of urban and rural birth insurance fund income. The worker bears insurance fund income growth rate is flat and the urban and rural birth insurance fund spending growth rate than income growth, after that plan as a whole, urban and rural insurance fund spending part can by as a whole fund after agreed to pay, to reflect fund each other function.

(3) During 2011–2015, the workers' childbirth insurance amount paid the average annual growth of 13.8 %, the proportion of the birth grant is bigger; the urban and rural childbirth insurance amount paid the average annual growth of

2.37 %, the proportion of birth medical treatment is larger. So it can improve birth insurance treatment by the payment standard to effectively mediation fund balance rate.

Project Subject: Tianjin medical insurance research board project; A research on the issue of building up unified urban and rural maternity insurance system.

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Chapter 170
Study on Process Reengineering of Medium and Small Coal Machine Manufacture Enterprises

Jing-wen An and Zhi-qiang Zhang

Abstract Based on the theory and method of process reengineering, this paper implemented process engineering on JY company which is a coal machine manufacture enterprise. On the basis of analysis, diagnosis and optimization on existing process, process system and organizational structure were reengineered, and related management system were establish. That shows that BPR is an important way for medium and small coal machine manufacture enterprises to standardize enterprise management, enhance organization and coordination flexible, promote enterprise competition ability.

Keywords Medium and small enterprises · Coal machine manufacture enterprise · Process reengineering

170.1 Introduction

Since the 1980s, with the rapid development of the world economy and technology, the uncertainty of the enterprise survival environment is increasing, the competition which enterprises are facing is also becoming increasingly fierce, which mainly reflected in the competition of variety, quality, price, time and service. Only the one who has advantages in these five respects can survive and develop. Enterprises used a lot of advanced management methods and manufacturing technology, and the comprehensive using of these technology and methods, indeed, has improved and enhanced the enterprises' competitiveness (Yue 2005). However, among them, process reengineering is the most effective method to improve the competitiveness of the enterprise in terms of the point of strategy.

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E. Qi et al. (eds.), *The 19th International Conference on Industrial Engineering and Engineering Management*, DOI: 10.1007/978-3-642-38391-5_170,

Business Process Reengineering (BPR) in developed country are widely applied, some big companies such as IBM, HP, Siemens, and other enterprises implemented BPR, have made outstanding achievements, and business regards it as an important strategy to achieve competitive advantage as an industrial management revolution. In our country, the implementation of BPR also has successful cases, such as the Haier group to apply internal market chain management in the whole group via BPR, establish business flow, logistics and the product, which is the successful model of BPR implementation (Dong 2008). The small and medium-sized enterprises are in small scale, simple organizational structure, less management level, easier communication and simple external environment, these features are conducive to the implementation of process reengineering.

By using BPR thoughts and methods on JY company as an example, this paper states that the enterprises especially the small and medium sized enterprises whose standardization management is weak and the organization flexibility is poor, after the systematical analysis and careful arrangement and recreate process, can effectively standardize enterprise management, enhance the organization and coordination flexibility and promote enterprise competition ability.

170.2 Process Reengineering Theory

170.2.1 The Concept of Process Reengineering

After 1990s, 3C (Custom, Competition, Chang) have made the uncertainty of market demand increased greatly, further more the enterprises are facing a rapid changing and unpredictable buyer's market, the traditional production and management pattern already unable to react to the market, it is in this circumstance, in the beginning of 1990s, American Dr. Hamor proposed management thinking "business process reengineering", and then in the United States and other industrialized countries, made the core management revolution of the "business process reengineering" (Yue 2005).

Ha defined process reengineering as:" the fundamentally rethink and completely redesign of enterprise business process in order to improve enterprise cost, quality, service and speed significantly." BPR emphasis on improving process and customer needs and satisfaction, the use of advanced information technology, manufacturing technology and modern management means, maximizing the technical function integration and management function integration, to break the traditional functional organization structure, building a new process of organizational structure, so as to realize the improvement of enterprise in cost, quality, service, speed, and other aspects and enhance the enterprise market reaction rate and the market adapt greatly (Dong 2008).

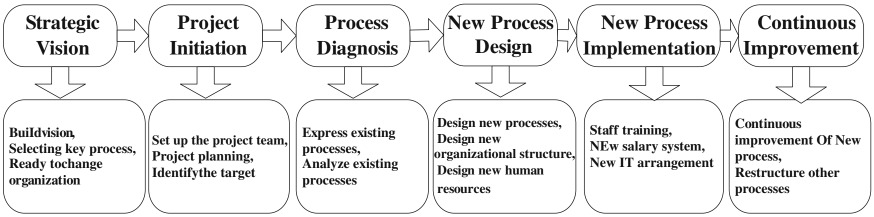

Fig. 170.1 Model figure of process reengineering implementation

170.2.2 Process Reengineering Steps

Successful implementation of enterprise process engineering and establishing implementation plan is very importantly, the implementation of the plan is the strategic planning implementation of process reengineering. Different scholars' summarization of BPR implementation stage and stage classification are different, but the general ideas are basically the same. The key is to grasp the principle and contents of various stages (Qi and Wang 2005). The model figure of process reengineering implementation (Wang 2005) (see Fig. 170.1).

170.2.3 Ways of Process Reengineering

170.2.3.1 New Reengineering Method

This method makes us to rethink the way of product and service providing designing process in a white paper fundamentally. The new method will start from the target, and gradually pour push, process should be designed to reach the requirements of the organization. This method is profound, dramatic, high risky and has big resistance, and may bring huge cost if the reform fails (Zeng 2008).

170.2.3.2 Gradual Transformation Method

Through the systematic analysis of the existing process, this method is to create new process based on the existing process. This method is efficient, advance step by step, and has a lower risk of resistance and smaller interference to the normal operation. Many big companies at home or abroad regard continuous improvement as important part of their enterprise culture, through the work of the hundreds of thousands of small changes, the huge performance improvement can be gradually accumulated.

170.3 JY Company Condition

170.3.1 Company Introduction

JY company was founded in 1960s, after 30 years of development, the efforts of several generations. JY company has owned total assets of nearly forty million yuan, 20 mu of land, nearly one hundred sets equipment and 280 workers, and JY company is one of professional production manufacturer of China's coal mine integrated production mechanization equipment.

Company mainly manages manufacture, technical development, technically services of industrial electrical and mechanical equipment. Operation mode is manufacture and sale primarily. The main products of JY company are mining emulsion pump and its accessories, spary pump station and its accessories, etc.

170.3.2 Present Situation and Problem Analysis

JY company predecessor is a branch factory of one machinery company, mainly supplies mainly corporation with all kinds of accessories of hydraulic and independent product such as emulsion pump and spray pump. After decades of construction and development, facilities, product level, personnel quality have improved greatly. However, the head office management system reform had finished, the branch factory restructured into a company in 2008, which brought this factory with the opportunities and challenges. At the background of the financial crisis and the integration of the coal mine in recent years, the pump industry competition is intense, and the weak basic management all lead to poor product quality, slow weak customer demand response, which had made the company lost a large market share in crisis edge.

Through the methods of field inspection, related personnel's communication, special problem research and material consultation, the following key problems were found out.

170.3.2.1 Organization Structure Aspect

JY Company used strict linear function structure under original workshop management mode, Which had not adapt to the need greatly to increase production flexibility, speed up the external market response and strengthen internal management; Departments responsibility divided was unclear, nonstandard and imbalance, lacked of effective communication cooperation mechanism between departments, and organizational operation efficiency is not high. In the end responsibilities and interests were unequal, and the management ranges were too big, which lead to low management efficiency.

170.3.2.2 Management Process Aspect

The responsibilities of process units were not clear, cooperation degree is not high, and the processes were lack of flexibility, standardization, systematization. The design and implement of Management process all existed problems, and the setting of department and key position were not reasonable which all led some management process missing or fuzzy, and some processes often appear as "short circuit" in the implementation process, so the phenomenon of dispute over trifles and shuffle arose.

170.3.2.3 Management Aspect

Enterprise basic management is weak, because the existing extensive management mode seriously restricted the expansion of enterprise production capacity and the enhancement of benefit; reform task was Serious, because the company equity structure changed, and the company's leadership adjusted hugely, and the reform referred to benefit pattern adjustment. So this reform will affect stability and spread to development if carelessly a bit.

170.3.2.4 Other Aspects

Ability crisis were increasingly serious, because of the company's development and the change of external environment, equipment ability, management level, workshop area, process layout and technical strength, human resources, enterprise culture and so on all would not meet the demands of the new situation. And there is a big gap among many domestic industry pump companies on the capital strength technical level, management experience and product quality.

From the above analysis, we can conclude that current business process and organization structure of JY company had been difficult to adapt to the new market competition environment needs. Faced with such serious situation, if not decisively reform, JY company might face survival crisis soon. Although the risk of internal management changes was high, but in the present situation, the risks of no reformation would be greater than the risks of implementing reformation. Therefore, the implementation of the new process reengineering was at a better time.

170.4 Implementation of Process Reengineering on JY Company

170.4.1 Goals and Principles of Process Reengineering

On the basis of the analysis of the internal and external market environment and according to the company management status, strategic objectives and reengineering ideas, the objective of process reengineering was made sure to construct "smooth process, efficient organization, hard working personnel" process management system, ensure the strategy implementation of JY company successfully.

At the same time to ensure the smooth implementation of the process reengineering, four core principles were established: with process as the core principle, people oriented principle, customer oriented principle, quality first principle.

170.4.2 Implementation of Process Reengineering

170.4.2.1 Establishment of Framework

With the best process management practice and theory, and considering the practical situation, JY company's overall processes were divided into two classes: business process and management process. According to the feature of specific production and functional management, the first process framework of JY company was formed (see Fig. 170.2).

Meanwhile, on the basis of the framework, the second and the third process were set up, and nine first processes and fifty-six second processes and third processes were set up preliminary (Electricity Group Co. 2008).

170.4.2.2 Determination and Optimization of Key Processes

Through the special conference and the matrix analysis method, the determined key processes include six key processes: production management, quality management, financial management and so on. On the basis of full understanding and analysis to the key process, we should find and research the sickness of existing process, and then to design process (Hui et al. 2000).

Take the process of production optimization for example.

170.4.2.3 Design Plan of Organization

Business process reengineering request to establish process firstly, and then according to the new organizational structure of flat process to streamline

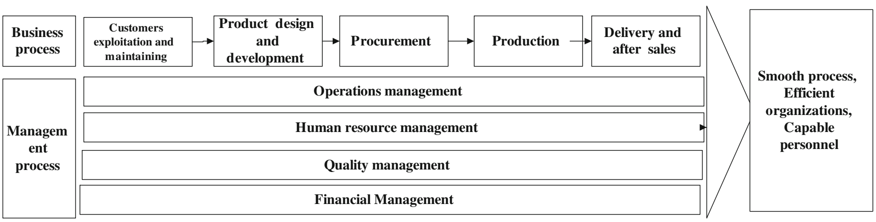

Fig. 170.2 The first process framework of JY company

management level, reduce the management cost and delegate management, and the new decision point is located in the business process execution place.

According to the analysis of the status and combined with external best practices and the reality of JY company, firstly, the organization frame structure design carried through on the basis of framework system optimization of JY company and according to "streamline organization, personnel optimization" principle. Secondly, the organization department functions boundary was determined and department responsibility was written. Then the fixation of posts and staff was determined based on the design of organizational structure. Finally, key position introductions were established (Figs. 170.3, 170.4, 170.5 and 170.6).

Any reform and innovation of management must carry out on system level, which is an important principle to get rid of the rule by men for modern enterprise, especially modern china enterprise, so process reengineering as an important management innovation is no exception. At the same time process reengineering is an system engineering, need each aspect provide guarantee for this to set up process management, evaluation, compensation and other enterprise management system, to effectively ensure the smooth implementation of the process reengineering.

170.5 Effect

From may 2010 the beginning of carrying out the above process reform plan to may 2011, through the continuous reform optimization, temporary workers reduce by 30 %; Organization operation efficiency and production efficiency increase obviously, pump production cycle reduces seven days; Product quality and customer satisfaction improve significantly. Due to the implementation of the new assessment method and salary system, the worker enthusiasm is remarkably improved, labor productivity increases by 20 %, the per capita wage of worker increases by 16 %, annual output value increases by 21 % and profits growth rate is up to 28 %. These show that the effect of BPR on JY company is obvious.

170.6 Conclusion

This paper systematically analyzed the management status of the JY company and existing problems, used the method of combining theory with practice, and put forward the implementing method of JY company process reengineering. Through the study, the conclusions are as follows:

(1) The right process reengineering can make the enterprise operation efficiency and economic benefit, product and service quality and customer satisfaction increase hugely. Promoting process reengineering on the small and medium

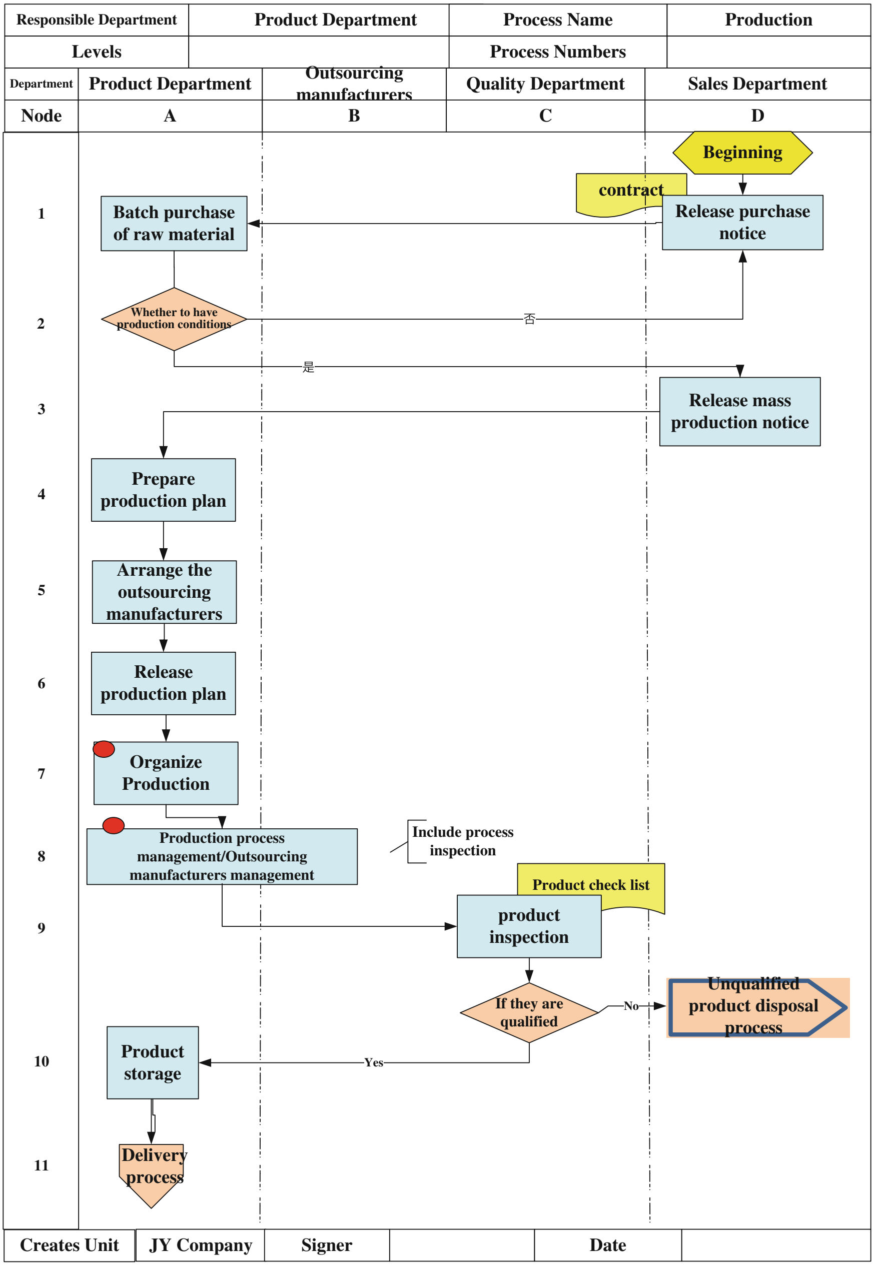

Fig. 170.3 Original production management process

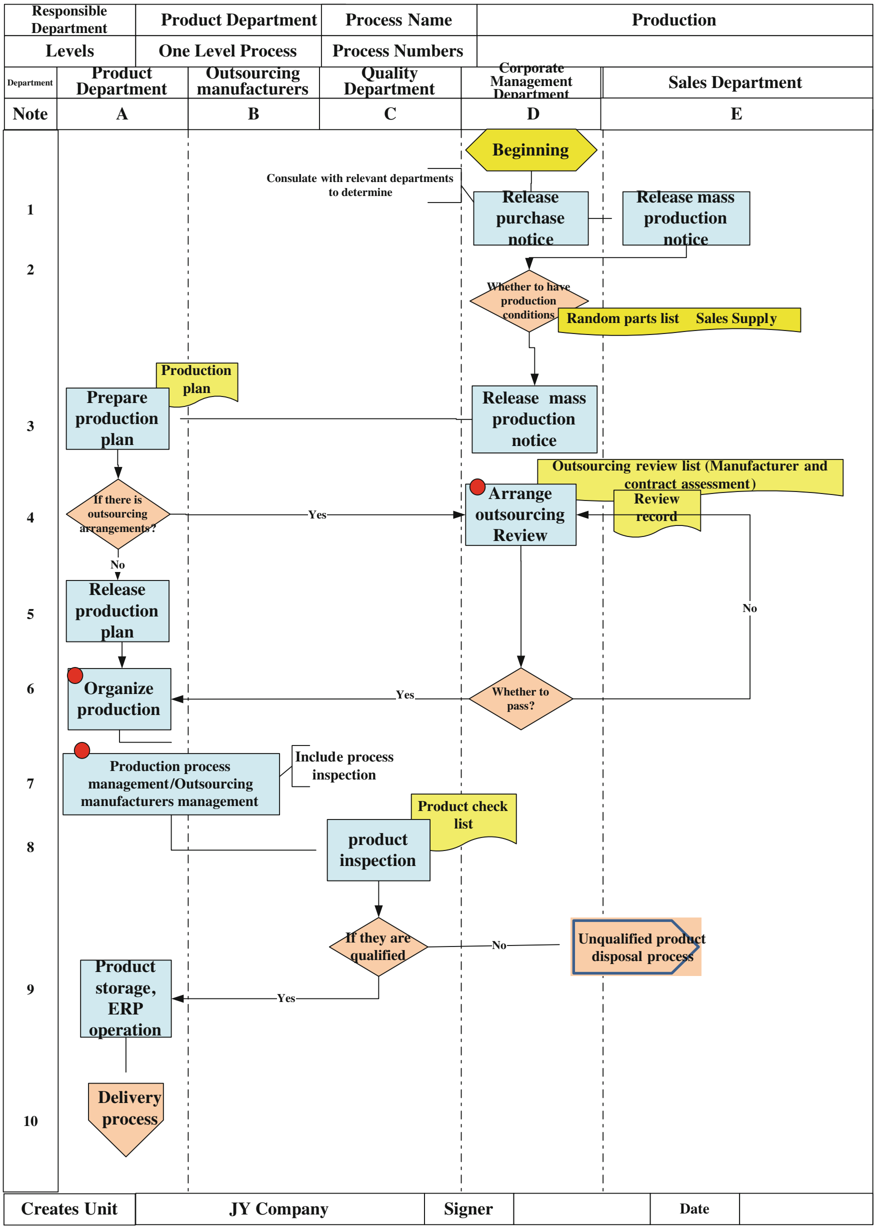

Fig. 170.4 Optimized production management process

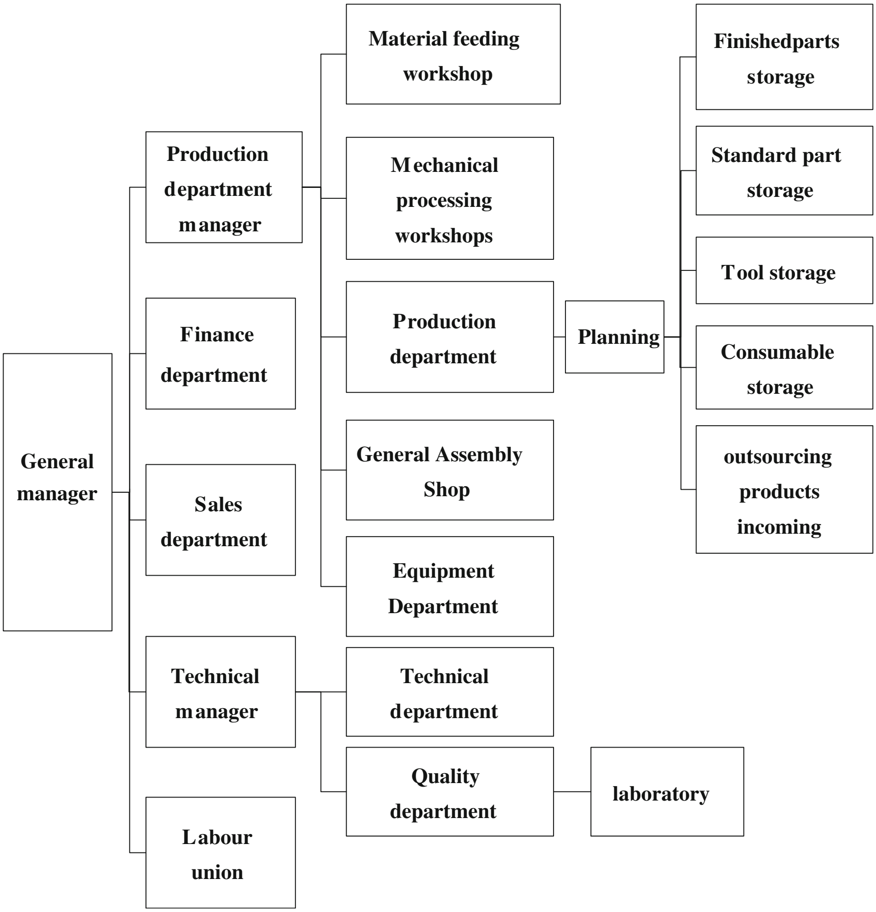

Fig. 170.5 Original organization structure

sized enterprises similar to JY company is the need for small and medium sized enterprise to change development mode, realize leaping development, increase enterprise flexible, improve economic and social benefits and realize strategic objective.

(2) BPR so far is just a thought, but not be called a theory. Because as a kind of innovation theory, BPR is far from mature, internal mechanism of BPR and deep understanding of the essential rule are far from established. And advanced thinking and theory are not enough to bring the success to practice. Not perfect method system and lack analysis tools are all obstacles factors to effective BPR in practice. Therefore enterprises in practical application avoid blind imitation by all means, and should combine BPR with IE and other management methods, only that can we guarantee the success of the process reengineering (Hanuner and ChamPy 1993).

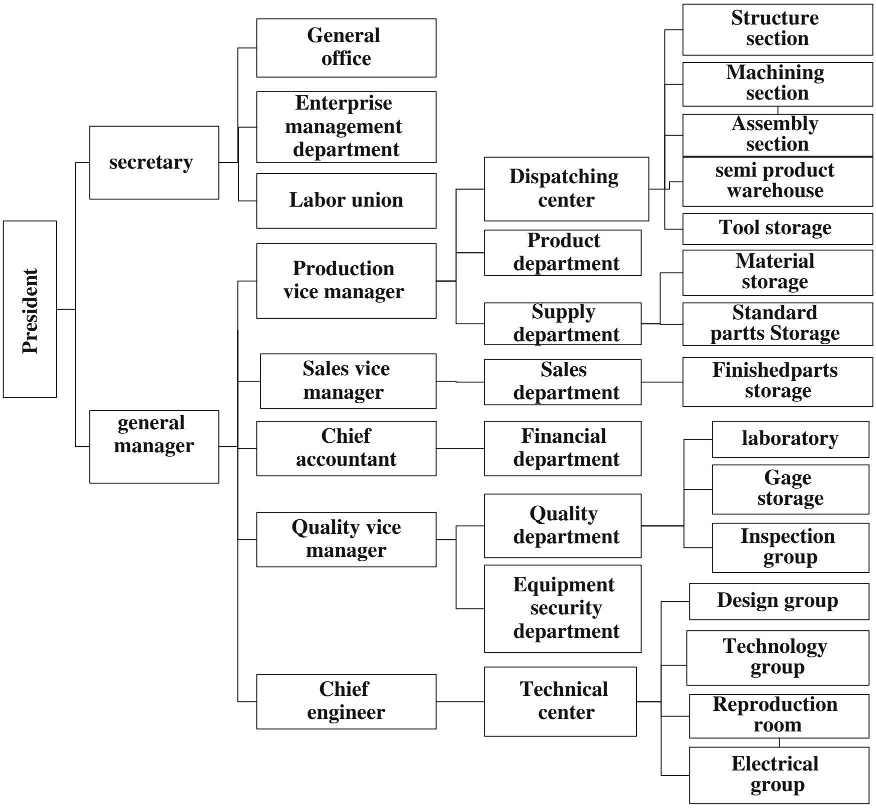

Fig. 170.6 Optimized organization structure

(3) The practice of JY company business process reengineering proved that the method of this paper for enterprise process reengineering has certain directive significance, and can reduce mistakes, improve the efficiency, ensure smooth completion of the business process reengineering (Mei and Teng 2004; Huang and Mei 2003).

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Chapter 171
The Increase and Decrease Connecting Potential Analysis on Urban and Rural Residential Land of Tianjin

Guo-bin Lin and Shuo Hao

Abstract *Research purpose*: probe into the technical routes and methods of CUR (connecting the increase of urban construction with the decrease of rural residential land) potential calculation. Research method: quantitative analysis method. Results: according to this calculation method and technical route, the empirical analysis on CUR potential of Tianjin, the CUR potential coefficient is 1.25 and the CUR potential balance is 4936.60 hm^2 in as yearly planning goals. This states that Tianjin can meet the demand of new town construction land occupying plough in target planned years through CUR performance. *Research conclusions*: to find the technical route and measure and calculated methods of CUR potential based on overall plan of land utilization its result would reflect the actual area, tightly integrating with land use control, be useful data references for other places applying for CUR experimental unit, distributing CUR quota, developing CUR items, lay the foundation for working out land reclamation planning and provide quantitative data and references for land and resources management departments to develop, innovation CUR policy.

Keywords CUR · Calculation methods · Technical route · Potential calculation

171.1 Introduction

In June of 2008, the Ministry of land and resources issued "connecting the increase in Urban construction with the decrease in Rural residential land management approach", and it symbolized that our country CUR (connecting the increase of

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E. Qi et al. (eds.), *The 19th International Conference on Industrial Engineering and Engineering Management*, DOI: 10.1007/978-3-642-38391-5_171,

urban construction with the decrease of rural residential land) pilot work which was formally incorporated into the course that runs lawfully. With the further development of the CUR, CUR with the Chinese characteristic of land use in China has gradually become the research focus in the field of land management and preliminary already formed with CUR policy interpretation (Shao and Li 2009; Feng et al. 2011; Li and Wang 2009; Gong 2012), CUR pattern design (Wang and Zhu 2007; Li et al. 2007; Qv et al. 2011; Wang and Wang 2009), CUR benefit evaluation (Mai 2008; Gan and Zhou 2008; Yuan 2011), CUR potential analysis (Xu and Wang 2009; (Yu 2011) and so on as the core content of the theoretical system. However the CUR potential and space layout analysis research is few. The few studies are mostly lack of potential calculation of system thinking, ignoring the potential to link with the general plans for land use and the calculation results with the overall land use planning are out of line, bad practicality. In the future, based on the overall land use planning of CUR potential calculation will be one of the most important research directions. It can provide useful data references for other places applying for CUR experimental unit, distributing CUR quota, developing CUR items, lay the foundation for working out land reclamation planning and provide quantitative data and references for land and resources management departments to develop, innovate CUR policy.

171.2 The Theoretical Foundation of CUR

China's CUR policy was introduced when urbanization and industrialization were advanced ceaselessly, the construction of new socialist countryside is just unfolded. The core of this policy includes two aspects: The former is mainly for the expansion of the city and the latter, in the present stage of our country, is mainly through consolidation rural residential land to achieve. The CUR potential analysis is theoretical and practical work and must have corresponding theoretical basis guiding to make it more scientific, forward-looking and practical. This paper argues that related theoretical basis mainly includes land use planning theory, sustainable development theory, location theory, and rent theory.

171.2.1 Land Use Planning Theory

Land-use planning is ahead of schedule arrangement for a certain area of land use in the future, which is land resource allocation and reasonable organization of land-use comprehensive technical and economic measures in time and space on the basis of the regional social economics development and land natural history characteristics (Wang and Han 2002). The land use planning on the one hand as science and technology is the productive force to provide support for human reasonable and orderly use for land, on the other hand as the land in the sectors of the national economy in the means of distribution industries, belonging to the category of production relation. In CUR, the rural residential land consolidation is the one involving engineering technique, management, administrative, economic, and legal and other fields, and complicated system engineering, in which the establishment of rural residential land consolidation planning is one of the most important contents. In planning the preparation of the process, land planning plays an important guiding role of theory. Its preparation should include the following aspects: target; current analysis; feasibility analysis and evaluation; selection model; preparation and evaluation of different alternatives depend on the economic and social, environmental analysis; choosing satisfactory solution; drawing and writing program.

171.2.2 Sustainable Development Theory

Sustainable development not only satisfy the demand answers and not harm future generations demand, but also conforms to the local population interests and to the interests of the global population. Here mainly includes the following means:

(1) *Efficient development.* Not only refer to the efficiency of economic sense, but also contains natural resources and environment in the profits and losses of the composition.
(2) *Sustainable development.* The economic and social development cannot exceed the carrying capacity of the environment and resource, and we must make the natural resource consumption rate be lower than the rate of regeneration resources.
(3) *Equitable development.* Contains the generation of transverse intergenerational equity and intergenerational vertical equity, and people living in contemporary word cannot damage offspring's survival and development conditions due to their own development needs.
(4) *Common development.* The Earth is a complex giant system, between various subsystems are interaction, as long as a sub system happen problems, will directly or indirectly affect other subsystems and influences the whole system function, therefore, the sustainable development is common development.

Coordinating the contradiction between supply and demand of land is the eternal theme of sustainable utilization of land resources. In the CUR work, we must always adhere to the concept of sustainable development. That is to say the work must ensure the use of land on the basis of the ecological security and social stability and ensure the land ecological environment allows the limits of land consolidation.

171.2.3 Location Theory

Location theory is about the place of human economics activities and the theory of space economic ties. The positions of the spatial distribution of Social economic activity include geographical location, economic position and traffic position. These positions connecting organically work together to regional space, forming the superiority of difference of land location. Land is the places of all human activities. Different human activities can produce different types of land using. Plot has not only azimuth and distance attributes, but also social economic activities and the spatial distribution law which closely ties to geographical elements.

About the economic benefit of the land, the influence of the location factor mainly is embodied in the following respects:

(1) *Accessibility.* Locations with good accessibility can enter the location strongly.
(2) *The distance from the central of business district.* The closer from the central business district, the location is better and the land using efficiency is higher.
(3) *Materialized labor inputs.* The more social materialized labor is used, the value of land using is greater and the economic benefit is much higher.
(4) *Agglomeration benefits and its complementary with each other.* Cluster can make the enterprise to get comprehensive benefit. When multiple or related enterprises get together, it forming the mutual complement of organic whole, they can get more profit than scattered arrangement.

The location of the project is the embodiment and application of the location theory. On the one hand, the rural residential areas in the CUR turns into cultivated land again and the cultivated land for building a new area turns into urban construction purposes, realizing the change of the space position of the land use, making the land use become more reasonable; On the other hand, for the choosing of the new site, also need the region whose location is in good, and can gain maximum benefit.

171.2.4 Rent Theory

Differential rent theory provides theory basis for the analysis of urban and rural construction land increase or decrease the peg operation mechanism. Differential rent theory is the part of the excess profit a rebound by the operating better land belonging to the land owners. The difference of land's natural conditions and the monopoly to the right of land using combine differential rent. In accordance with the formation condition, the differential rent can be divided into differential rent I and differential rent II. Differential rent I produced in different land fertile degree and geographical location and differential rent II because in the same block continuous investment leads to higher labor productivity. Differential rent I is the basis and the premise of differential rent II.

In the CUR work, one of key jobs is to set up the reasonable corresponding relation between new build (CUR demand area) and removed the old district (CUR supply area). Among them, the CUR supply areas mainly develop consolidation of rural construction land potential, provide town construction land index, and the CUR demand as key areas of urban construction. In theory, differential rent lower land unsuitable for construction, so we should reclaim the differential land rent lower local rural construction land as plough and high places of differential rent for the priority of the arrangement for the new building.

171.3 The CUR Potential Measure Technical Route

CUR potential is to calculate possibility and the size of a regional implementation CUR policy, according to the prediction of the target planed year demand of urban construction land and land consolidation potential of rural residential area. Measuring CUR potential is the foundation of developed for CUR plan, is the basis of the CUR index distribution. In this paper, we used CUR potential coefficient and CUR potential balance to represent the size of the CUR potential. In numerical, the CUR potential coefficient is equal to the ratio between CUR supply and the demand in target years, as followed (171.1). The CUR potential balance is equal to the difference between CUR supply and demand in target years, as followed (171.2).

$$r = S_g / D_g \tag{171.1}$$

$$Q_y = S_g - D_g \tag{171.2}$$

In (171.1) and (171.2): r is CUR potential coefficient, Q_y is CUR potential balance, S_g is CUR supply ability in target years and D_g is CUR demand in target years.

Mainly consists of the following three steps to calculate the CUR potential:

Step 1: Calculate urban construction land CUR demand based on the urban construction land utilization and planning in target years.
Step 2: Calculate consolidation of rural residential land CUR supply ability based on the rural dweller dot utilization and planning in target years.
Step 3: Calculate the CUR potential.

171.3.1 Urban Construction Land CUR Demand Calculation

The CUR demand is depending on the urban construction land demand through the CUR model to meet based on all levels general land use planning scheme and the regional economic social development. In this paper the calculation of CUR demand is as followed (171.3):

$$D_g = D_z - D_x \tag{171.3}$$

In (171.3), D_g is CUR demand, D_z is additional construction land quota occupied farmland index in target years, and D_x is new construction land occupation of cultivated land control indexes which determined by "The overall land use planning (2006–2020)

171.3.2 The Calculation of Consolidation of Rural Residential Land CUR Supply Ability

The consolidation of rural residential land CUR supply ability is that in various practical constraints, the capacity of consolidation rural residential land providing land to CUR work based on the overall planning of land use. The calculation of CUR demand is as followed (171.4):

$$S_g = \alpha\left[S_q - (S_x - S_h)\right] \tag{171.4}$$

In (171.4): S_g is the ability of CUR supply, S_q is rural residential land readjustment potential, S_x is Rural residential area of current situation, S_h is rural residential planning area and α is newly increased cultivated land coefficient.

The concrete calculation process is as follows:

Step 1: Calculation of rural residential land readjustment potential, based on the rural residents utilization.
Step 2: Calculation of rural residential planning in target years CUR supply ability based on the land use of rural residential area planning.

171.4 Empirical Analysis

171.4.1 The General Situation of Research Area

Tianjin is the biggest coastal open city in North China, within the eastern Eurasian Continental Bridge bridgehead, and is located in the northeast of the north China plain, the Bohai economic center, which are good location conditions. At the end of 2008, the city's population was 9,688,700, of which agricultural population was 3,806,000 and non agricultural population was 5,882,700. According to Tianjin 2008 current land-use change survey results, the city's land area was 1,191,731.9 hm^2. Among that, agricultural land area was 692,670.95 hm^2, accounting for 58.12 % of the total land and plough area was 441,089.72 hm^2 among agricultural land, representing the city's total land area of 37.01 %; The total area of land for construction was 368,188.81 hm^2, accounting for

30.90 % of the total land area, in which rural residential land was 88,192.45 hm^2, representing the city's total land area of 4.70 %; The size of unused land was 130,872.15 hm^2, accounting for 10.98 % of the total land area and mainly in Baodi District, Ninghe County, Dagang District, Wuqing District, Jinghai County and other places.

171.4.2 Tianjin Town Construction Land CUR Demand Estimates

CUR demand in Tianjin district and county is as shown in Table 171.1, according to the formula (171.3), "Tianjin city land uses overall planning (2006–2020)" and the second land survey data of Tianjin city. We can see from it that in target planed years, Tianjin by CUR to meet the need of the town construction land of cultivated land occupied index will be 19,905.19 hm^2, CUR needs at most will be Wuqing District, as high as 3,454.1 hm^2, accounting for 17.35 % of all CUR demand, followed by Jinghai County will be 3,295.13 hm^2 accounting for 16.55 % of all CUR demand, CUR needs the least will be Binhai New Area, only 515.28 hm^2, accounting for 2.59 % of all CUR demand.

Tianjin Binhai New Area should pay future efforts to become North China portal opening to the outside world, a high level of modern manufacturing and research conversion base, the northern international shipping center and the international logistics center, and gradually become the economic prosperity, social harmony, environmental beautifully and ecological livable city. Therefore, the "Tianjin city land uses overall planning (2006–2020)" gives more new construction land occupation of farmland index, to provide security for its economic

Table 171.1 CUR demand table in Tianjin district and county

District and county name	New construction land of cultivated land occupied index (hm^2)	New construction land of cultivated land occupied control index (hm^2)	CUR demand (hm^2)	Proportion (%)
Binhai New Area	2723.48	2228.17	515.28	2.59
Dongli	3572.79	2145.1	1427.69	7.17
Xiqing	3018.17	1482.6	1535.57	7.71
Jinnan	3558.03	1482.6	2075.43	10.43
Beichen	2967.41	1198.7	1768.71	8.89
Wuqing	5094.40	1640.3	3454.10	17.35
Baodi	3488.97	1703.4	1785.57	8.97
Ninghe	2925.19	883.3	2041.89	10.26
Jinghai	4430.73	1135.6	3295.13	16.55
Jixian	2826.03	820.2	2005.83	10.08
Total	34605.19	14700.00	19905.19	100.00

development, strategic position, while in rural residential land readjustment potential larger region gives fewer new construction land occupation of cultivated land index. For the part of new construction land occupation of farmland indexes cannot meet the needs of social and economic development of the area, the needs must rely on the CUR work to meet. This suggests that the CUR policy has now become the city of Tianjin land important macro-control means.

171.4.3 Calculation Consolidation of Rural Residential Land of Tianjin CUR Supply Ability

There are two steps to calculate consolidation rural residential land in Tianjin CUR supply ability according to (171.4) and above listed 2.2 calculated steps.

(1) *Calculation of Tianjin rural residential land consolidation potential in the planning target years.* This study uses the method from Song et al. (2006) to calculate Tianjin rural residential land readjustment potential, the calculation is as (171.5) and (171.6):

$$Si = Sx - (At \times Mt)R \tag{171.5}$$

$$Mt = G/Qt \tag{171.6}$$

In (171.5) and (171.6): Si is rural residential land consolidation potential, Sx is current situation of rural residential area, At is the average standard of homestead land in the target years, Mt is households in the target years, R is the proportion of residential land in the target years, G is rural population in the target years, Qt is household scale in the target years.

Calculate Tianjin rural residential land consolidation potential according to the (171.5), (171.6) after determining household scale, the average homestead area, the proportion of residential land in Tianjin counties and the results would be in Table 171.2. From Table 171.2, rural settlements obviously regional differences exist in Tianjin districts consolidation potential. Suburban districts and Binhai New Area developed area, rural residential land readjustment potential is relatively lower, because of the more developed economies, higher urbanization level, the higher rural residential land saving and intensive use level. Conversely, some undeveloped economy, urbanization level is lower, and along with the economic and social development in the future, the rural residential land consolidation potential is higher. Dongli district rural residential land readjustment potential is minimum as 0 hm^2 according to the "Tianjin city land uses overall planning (2006–2020)". In addition, Binhai New Area rural residential land consolidation potentiality is lower, as 3,540.61 hm^2 and Beichen is 695.67 hm^2. Baodi is the highest as 13,910.79 hm^2, followed by Jixian and Wuqing, which are 13,228.82 and 11,935.65 hm^2 respectively.

Table 171.2 RURAL residential land readjustment potential in Tianjin district and county (unit: hm^2)

District and county name	Arrangement potential
Binhai New Area	3540.61
Dongli	0
Xiqing	6970.12
Jinnan	7837.01
Beichen	5695.67
Wuqing	11935.65
Baodi	13910.79
Ninghe	5141.57
Jinghai	9676.31
Jixian	13228.82
Total	77936.56

Label Dongli district rural residents are without arrangement potential because it is planning rural residential area is 0 hm^2 in the target years, according to the Tianjin city land uses overall planning (2006–2020)

(2) *Calculation of CUR supply ability in Tianjin in the target years.* According to the CUR case in Tianjin districts, Tianjin CUR rural dweller dot reclamation newly cultivated land coefficient between 0.80 and 0.92 in the demolition of the old district. Considering relevant expert opinions, this study identified each involving agricultural district newly cultivated land coefficient is 0.85, in addition to Jixian. Comprehensive determination of newly increased cultivated land coefficient is 0.5, because Jixian is located in mountainous terrain district, which is the northernmost ecological area of Tianjin, the main target land use is ecological conservation and bearing the development of tourism and many rural residents is not suitable for land reclamation. By (171.4), we can calculate each distinct and county CUR supply ability as Table 171.3. Tianjin CUR supply capacity is 24,841.79 hm^2, among them, Baodi 6,966.34 hm^2, Jixian 4,506.96 hm^2 followed by Ninghe, Wuqing and Jinghai; The CUR and supply capacity of Jinnan, Binhai New Area and Beichen is lesser, Dongli is 0 hm^2. The space link differences of each area county's CUR ability of reflecting the differences of the various districts and counties in Tianjin economic development level, the industrialization, the urbanization process. The counties' supply capacity with high levels in the industrialization, the urbanization level, economical and intensive utilization of land is poor; Otherwise, is strong.

171.4.4 The Potential Estimates of Tianjin CUR in Planning Target Years

According to (171.1) and (171.2), we can calculate the CUR ability of the Tianjin each area county's planning target years, specifically seen in Table 171.4. From the Table 171.4, we can see the Tianjin's potential CUR coefficient of planning target years is 1.25, a CUR for 4,936.60 hm^2 potential balances, which shows through the CUR work, Tianjin can meet the demand of new town planning target years construction land occupying cultivated land, and there's a balance potential index. However we can see from the various districts and counties' CUR potential coefficient, different areas' county CUR has bigger space potential differences, such as Jixian, Ninghe, Baodi, Jinghai and other rare counties have bigger CUR potential, but Dongli, Beichen, Jinnan Xiqing districts, this four suburban areas, and Binhai New Area's CUR potential is small. In order to effectively regulate the imbalance of CUR potential between each district and county and realize the coordinated development among different levels regions, we should divide the whole city into different CUR areas and distribute the balance CUR potential index, according to the CUR potential coefficient.

Table 171.3 CUR supply ability in Tianjin district and county (unit: hm^2)

District and county name	CUR supply ability
Binhai New Area	287.97
Dongli	0
Xiqing	1064.8
Jinnan	216.41
Beichen	524.34
Wuqing	3715.19
Baodi	6966.34
Ninghe	4054.72
Jinghai	3505.07
Jixian	4506.96
Total	24841.79

Table 171.4 Cur potential coefficient and cur potential balance of each district and country

Area county name	CUR potential coefficient	CUR potential balance (hm^2)
Binhai New Area	0.56	−227.31
DongLi	0	−1427.69
Xiqing	0.69	−470.79
Jinnan	0.10	−1859.02
Beichen	0.30	−1244.37
Wuqing	1.08	261.09
Baodi	3.90	5180.77
NingHe	1.99	2012.83
JingHai	1.06	209.94
Jixian	2.25	2501.13
Total	1.25	4936.60

171.5 Conclusion

The CUR is an effective method in speeding up new countryside construction, developing urban and rural together, optimizing the structure of land using and improving the land intensive using. In the process of implementing, the potential estimation is the basis and the premise of land layout measure; need to choose a scientific and reasonable index to represent the size of the potential. Building the CUR potential measurement method and the technical route is based on the general land use, and the calculated result can reflect the actual area, tightly integrated in land use control, which would be useful data references for other places applying for CUR experimental unit, distributing CUR quota, developing CUR items, laying the foundation for working out land reclamation of planning, and providing quantitative data and references for land and resources management departments to develop, innovative policy for CUR.

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Chapter 172
Study on Re-Evaluation of Technological Innovation Efficiency Based on the C^2R Improvement Model in Zhongguancun High-Tech Enterprises

Jing-wen An, Sen Zhang and Guang-lin Sui

Abstract To begin with, this paper studied the relative efficiency of the Innovation Efficiency of 10 major High-tech industries in Zhongguancun. The study found that 7 of the 10 high-tech industries in Zhongguancun are relatively effective in their Innovation Efficiency. They are industries of electronic information, advanced manufacturing, new energy, new materials, modern farming, ocean engineering and nuclear application. Then this article introduced the virtual optimization of DMU based on the C^2R model, which re-evaluated the relative effectiveness of the above-mentioned seven industries. Then this paper gave some suggestions to improve the innovation efficiency of these industries.

Keywords Zhongguancun · High-tech Industries · Data envelopment analysis · DEA · Virtual decision making units

172.1 Introduction

The innovation efficiency of the high-tech industries in Zhongguancun demonstration industrial park is the conversion efficiency of input–output of production factors. It reflects the capacity of the industrial park to utilize technological resources and develop high-tech industries, as well as the quality and standard of the Zhongguancun innovation system. The Zhongguancun National Self-innovation Demonstration Park (hereafter referred to as “Zhongguancun”) is China’s first self-innovation park, a leading area of high-tech industries and the hotbed of the strategic newly emerging industries. In the new stages of the twenty-first century, a re-evaluation of the innovation efficiency of the Zhongguancun high-tech

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E. Qi et al. (eds.), *The 19th International Conference on Industrial Engineering and Engineering Management*, DOI: 10.1007/978-3-642-38391-5_172,

industries can help government better plan new industries, utilize resources, raise efficiency and promote industrial restructuring.

172.2 DEA Model

172.2.1 C^2R Model

Data Envelopment Analysis is a nonparametric comprehensive evaluation method to analyze the relative effectiveness of the DMU featured by high input and output (Wei 2004). It has been widely used to assess the efficiency of technology innovation within the same category of DMU (Che and Zhang 2010; Cheng and Chen 2009). Usually DEA can be divided into C^2R model and B^2C model, both of which conduct horizontal comparison and analysis to different DMUs at the same time. The C^2R model is as follows (Xu et al. 2009):

$$(D)\begin{cases} \min\ \theta - \varepsilon\left(\sum_{i=1}^{m} S^{-} + \sum_{r=1}^{s} S^{+}\right) = v_d(\varepsilon) \\ s.t. \\ \sum_{j=1}^{n} X_j\lambda_j + S^{-} = \theta\, X_0 \\ \sum_{j=1}^{n} Y_j\lambda_j - S^{+} = Y_0 \\ \lambda_j \geq 0, j = 1, 2\cdots\cdots, n \\ S^{+} \geq 0, S^{-} \geq 0 \end{cases} \tag{172.1}$$

Within the (D) model, θ represents the effective value of DMU_0, which is the effective use of the input against output. $X_j = \left(x_{1j}, x_{2j}, \cdots, x_{mj}\right)^T, j = 1, 2, \ldots, n$ represents the input of DMU, $Y_j = \left(y_{1j}, y_{2j}, \cdots, y_{sj}\right)^T, j = 1, 2, \ldots, n$ represents the output of DMU. S^{+}, S^{-} stands for the slack variable, which is supposedly bigger than zero. λ_j stands for composition ratio of DMUj within the DMU composition (Wang and King 2009).

172.2.2 Improved DEA-C^2R Model

In actual DEA evaluation processes, most of the DMU are relative effective, and only a few of the DMUs are invalid. This is because there are too many indexes and too few DMUs, making the analysis result less practical (Duan 2007). In this case, it should be made further analysis to the relative effective DMUs to evaluate the efficiency. There are many ways of sequencing in the DEA evaluation, and this paper adopts the virtual unit method (Duan 2007; Hua and Tao 2011; Liu and Song 2010).

Within the virtual unit method, a virtual decision making unit DMU_{n+1} is introduced to replace the normal DMU_0 within the General model of constraint conditions so as to distinguish the different degrees of different DMUs. Suppose the input and output of DMU_{n+1} is $(x_{i,n+1}, y_{k,n+1})$, $x_{i,n+1} = \min\limits_{1 \le j \le n} x_{ij} (i = 1, \cdots, m)$ $y_{k,n+1} = \max\limits_{1 \le j \le n} y_{kj} (k = 1, \cdots, s)$. The virtual decision making unit DMU_{n+1} is the best decision making unit among the valid DMUs. It's compared the efficiency value of virtual DMU with the efficiency value of other DMUs. If the DMU show a value that is approximate to the virtual DMU, then the value is high. The evaluation process can be achieved by inputting valid DMU, or by introducing a virtual DMU_{n+1}. The result can be calculated through $(D_{\varepsilon 1})$ (Liu and Song 2010).

$$(D_{\varepsilon 1}) \begin{cases} \min[\theta - \varepsilon(\hat{e}^T s^- + e^T s^+)] \\ s.t. \sum\limits_{j=1}^{n+1} \lambda_j x_j + s^- = \theta\, x_0,\ j = 1, 2, \cdots, n+1; j \neq j_0 \\ \sum\limits_{j=1}^{n+1} \lambda_j y_j - s^+ = y_0,\ j = 1, 2, \cdots, n+1; j \neq j_0 \\ \lambda_j \ge 0, j = 1, 2 \cdots, n+1 \\ s^+(s_1^+, s_2^+, \cdots, s_s^+) \ge 0,\ s^-(s_1^-, s_2^-, \cdots, s_s^-) \ge 0 \end{cases} \tag{172.2}$$

The sequence of efficiency value from $(D)_\varepsilon$ is the sequence of quality of the decision making unit DMU_{j0}. If the DMU value ≤ 1, the bigger the value is, the better the quality of this DMU_{j0}.

The DMU efficiency value $(D_{\varepsilon 2})$ can be calculated after the introduction of the virtual DMU_{n+1}.

$$(D_{\varepsilon 2}) \begin{cases} \max[\alpha + \varepsilon(\hat{e}^T s^- + e^T s^+)] \\ s.t. \sum\limits_{j=1}^{n+1} \lambda_j x_j + s^- = \theta\, x_0, j = 1, 2, \cdots, n+1; j \neq j_0 \\ \sum\limits_{j=1}^{n+1} \lambda_j y_j - s^+ = y_0, j = 1, 2, \cdots, n+1; j \neq j_0 \\ \lambda_j \ge 0, j = 1, 2 \cdots, n+1 \\ s^+(s_1^+, s_2^+, \cdots, s_s^+) \ge 0, s^-(s_1^-, s_2^-, \cdots, s_s^-) \ge 0 \end{cases} \tag{172.3}$$

The sequence of efficiency value from $(D)_\varepsilon$ is the sequence of quality of the decision making unit DMU_{j0}. If the value is ≥ 1, the smaller the value is, the smaller the gap between it and the virtual DMU, thus the better the quality of the DMU_{j0}.

This paper firstly evaluates the DMU through C^2R and B^2C model within the DEA method. Then the paper introduces the virtual processing unit DMU_{n+1}. The effectiveness of the DMU is calculated through the efficiency evaluation of the valid DMU.

172.3 Case Study of the Effectiveness of the Innovation Efficiency of Zhongguancun High-tech Industries

172.3.1 Establishment of the Indicator System

This paper studied the innovation efficiency of the Zhongguancun innovation system and the research results of relative scholars, took into consideration the representativeness and accessibility of these indicators. As a result, the paper selected 6 indicators as the evaluation criteria of the innovation efficiency of Zhongguancun high-tech industries. Among these six indicators, three are input indicators and three are output indicators (He et al. 2010; Wang 2008; Xie 2011; Quan et al. 2008).

Among the input indicators are: proportion of technology staff in the industry I_1, total expenditure of the technological innovation I_2, proportion of technology expenditure in the total revenue I_3. I_1 stands for the input intensity of technology staff, which is the ratio of technology staff against the total staff. I_2 stands for the activity of technological innovation of the industry. I_3 stands for the level and intensity of the industry independent innovation (Zhang and Liu 2008; Li and Xie 2010).

Among the Output indicators are: quantity of the patent accredit O_1, proportion of new product sales revenue accounted for product sales revenue O_2, proportion of new product sales revenue accounted for gross value of industrial output O_3. O_1 stands for the industry innovation important output value; O_2 stands for the rate of new product sales, the contribution degree of industry enterprise technology innovation into new products on enterprise value creating; O_3 stands for the transformation ability of the industry technology innovation (Zhang and Li 2009).

172.3.2 Selection of Data

All of the evaluation indicators used in this article in assessing the innovation efficiency of Zhongguancun high-tech industries are objective. The data used here are mainly from the Annual Book of Zhongguancun High-tech Industrial Park and the Annual Book of Zhongguancun National Demonstration Park of Self-innovation. Part of the data is from statistical data of the website of Zhongguancun National Demonstration Park of Self-innovation from 2006 to 2010 (http://www.zgc.gov.cn/tjxx/). And part of the data is through calculation of these existing data. Therefore, these data are highly objective and credible.

This paper treats the high-tech industries of Zhongguancun as a high-input and high-output system. Decision variables (DMU_j, j = 1, 2,…,10) are the 10 high-tech industries of Zhongguancun Demonstration Park. Because of the different time-lag between input and output of the innovation (Wang et al. 2009), the DEA efficiency analysis only uses the average figure of the indicator data in the Annual Book of the 11th five-year plan period.

172.3.3 Evaluation of DEA-B^2C Model

This paper utilizes the DEA input–output returns to scale B^2C model, puts the data of Table 172.1 into the model and gets the result through DEAP 2.1. The innovation efficiency value of the 10 key high-tech industries is shown in Table 172.2. Since the DEA method is a relative evaluation method, the DEA value in Table 172.2 just stands for its degree of the relative effectiveness (Wang et al. 2009).

It can be seen from Table 172.2 that the biggest overall DEA value is 1, the smallest being 0.454 and the average value being 0.913. Among the innovation efficiency evaluation of Zhongguancun high-tech industries, 7 industries (electronic information, advanced manufacturing, new energy, new material, and modern agriculture, ocean engineering and nuclear application) have an innovation efficiency value of 1. This means that 70 % of the DMUs are effective while 30 % (environment protection, biomedicine and aerospace) of these are not. Generally speaking, most of the high-tech industries are relative effective in terms of innovation efficiency.

172.3.4 Evaluation of the Improved DEA-C^2R Model

It can be seen from the results of the C^2R and B^2C model that industries with relative effective innovation efficiency account for a bigger share. In order to

Table 172.1 Statistical indicators of the 10 high-tech industries of Zhongguancun in the 11th 5-year plan period

Industries	I_1 (%)	I_2 (billion Yuan)	I_3 (%)	O_1 (item)	O_2 (%)	O_3 (%)
Electronic information	39	36.159	13	2764.00	61	83
Biomedicine	25	1.945	8	378.20	41	45
New material	25	2.493	7	676.00	66	88
Advanced manufacturing	25	4.133	6	1022.00	42	51
Aerospace	40	1.751	37	51.80	53	62
Modern agriculture	24	0.427	6	71.00	70	97
New energy	30	2.643	4	439.80	77	103
Environment protection	34	1.029	15	227.60	63	113
Ocean engineering	27	0.075	14	11.60	20	24
Nuclear application	45	0.275	12	67.20	79	69

Table 172.2 Innovation efficiency value of Zhongguancun high-tech industries

Field of technology	Overall efficiency	Pure technical efficiency	Scale efficiency	Returns to scale
Electronic information	1.000	1.000	1.000	crs
Biomedicine	0.718	0.973	0.738	irs
New material	1.000	1.000	1.000	crs
Advanced manufacturing	1.000	1.000	1.000	crs
Aerospace	0.454	0.600	0.757	irs
Modern agriculture	1.000	1.000	1.000	crs
New energy	1.000	1.000	1.000	crs
Environment protection	0.957	1.000	0.957	drs
Ocean engineering	1.000	1.000	1.000	crs
Nuclear application	1.000	1.000	1.000	crs
Average value	0.913	0.957	0.945	

distinguish the efficiency value of these industries, a virtual unit DMU_{11} was introduced to re-evaluate the innovation efficiency, as is shown in Table 172.3.

Suppose $\varepsilon = 10^{-6}$, a C^2R model based on the input of Archimedes infinitesimal C^2R model is established. The C^2R model of DMU1 is as follows:

$$(D_{\varepsilon 1})\begin{cases} \min[\theta - \varepsilon(s_1^- + s_2^- + s_3^- + s_1^+ + s_2^+ + s_3^+)] \\ s.t. 0.39\lambda_1 + 0.25\lambda_2 + 0.25\lambda_3 + 0.24\lambda_4 + 0.3\lambda_5 + 0.27\lambda_6 + 0.45\lambda_7 + 0.24\lambda_8 - s_1^- = 0.24 \\ 361.59\lambda_1 + 24.93\lambda_2 + 41.33\lambda_3 + 4.27\lambda_4 + 26.43\lambda_5 + 0.75\lambda_6 + 2.75\lambda_7 + 0.75\lambda_8 - s_2^- = 0.75 \\ 0.13\lambda_1 + 0.07\lambda_2 + 0.06\lambda_3 + 0.06\lambda_4 + 0.04\lambda_5 + 0.14\lambda_6 + 0.12\lambda_7 + 0.04\lambda_8 - s_3^- = 0.04 \\ 2764\lambda_1 + 676\lambda_2 + 1022\lambda_3 + 71\lambda_4 + 439.8\lambda_5 + 11.6\lambda_6 + 67.2\lambda_7 + 2764\lambda_8 - s_1^+ = 2764 \\ 0.61\lambda_1 + 0.66\lambda_2 + 0.42\lambda_3 + 0.7\lambda_4 + 0.77\lambda_5 + 0.2\lambda_6 + 0.79\lambda_7 + 0.79\lambda_8 - s_2^+ = 0.79 \\ 0.83\lambda_1 + 0.88\lambda_2 + 0.51\lambda_3 + 0.97\lambda_4 + 1.03\lambda_5 + 0.24\lambda_6 + 0.69\lambda_7 + 1.03\lambda_8 - s_3^+ = 1.03 \\ \lambda_j \geq 0, j = 1, 2 \cdots, 8 s^+(s_1^+, s_2^+, s_3^+) \geq 0, s^-(s_1^-, s_2^-, s_3^-) \geq 0 \end{cases} \tag{172.4}$$

After calculation by Matlab, the following results are innovation efficiency of Zhongguancun high-tech industries. See Table 172.4.

It's known that virtual evaluation unit is the best decision making unit. Therefore, we can rank the innovation efficiency of Zhongguancun high-tech industries in the following sequence: new energy > modern agriculture > new material > electronic information > nuclear application > advanced manufacturing > ocean engineering. In terms of economies of scale, industries of new energy, modern agriculture and ocean engineering are in the best condition, while all other industries have witnessed an increasing trend of returns to scale.

Based on the DEA-C^2R, it can get the invalid input indicator slack variable value and output indicator slack variable value of the 7 high-tech industries in Zhongguancun Demonstration Park. See Table 172.5 (the input residual value and insufficient output value is zero, which is nothing in the table).

Table 172.3 Indicators of virtual DMUs

DMU	I_1 (%)	I_2 (million)	I_3 (%)	O_1 (item)	O_2 (%)	O_3 (%)
DMU_{11}	24	75	4	2764	79	103

Table 172.4 Evaluation of DEA efficiency C^2R when combined with virtual DMUs

DMU	θ (initial)	θ (after improvement)	1–4	5	6–7	8	9	$\frac{1}{\theta}\sum_{j=1}^{n}\lambda_j$
Electronic information	1	0.615		0.000		1.000	1.000	1.626
New material	1	0.820		0.000		0.854	0.854	1.042
Advanced manufacturing	1	0.510		0.000		0.532	0.532	1.042
Modern agriculture	1	0.942		0.000		0.942	0.942	1.000
New energy	1	0.999		0.187		0.813	1.000	1.000
Ocean engineering	1	0.253		0.000		0.253	0.253	1.000
Nuclear application	1	0.533		0.000		1.000	1.000	1.876

Table 172.5 Value of input–output slack variables

DMU	S_1^-	S_2^-	S_3^-	S_1^+	S_2^+	S_3^+
Electronic information		0.61	0.31		0.30	0.24
New material		0.05	0.18	0.61	0.02	0.00
Advanced manufacturing		0.06	0.07	0.16		0.05
Modern farming		0.01	0.15	0.92	0.07	0.00
New energy	0.13	0.06		0.68	0.03	0.00
Ocean engineering	0.02		0.19	0.25		0.03
Nuclear application			0.18	0.98		0.41

Table 172.6 Input residual value and insufficient output value

DMU	S_1^- (%)	S_2^- (billion Yuan)	S_3^- (%)	S_1^+ (item)	S_2^+ (%)	S_3^+ (%)
Electronic information		22.1767	40		18	20
New material		1.987	23	1685.476	15	
Advanced manufacturing		0.2695	90	447.468		38
Modern agriculture		0.3315	19	2531.99	44	
New energy	60	2.568		2324.2	20	
Ocean engineering	80		25	688.147		21
Nuclear application		0.0717	24	2696.8		34

According to the projection analysis theory, it got the input residual value and the insufficient output value of the seven high-tech industries of Zhongguancun Demonstration Park, which is relatively invalid. See Table 172.6 (the input residual value and insufficient output value is zero, which is nothing in the table).

172.4 Conclusion

Through the DEA analysis of innovation efficiency of the high-tech industries in the Zhongguancun industrial park, It can be seen that:

172.4.1 Electronic Information

The efficiency value of the electronic information industry is 0.615 as evaluated through the DEA, ranking the fourth in the seven high-tech industries, with an economy of scale of 1.626 and an increasing trend. In 2010, electronic information industry accounted for 46.29 % of the Demonstration Park. It also accounted for the largest proportion of technological expenditure in the 11th five-year plan period, almost 2.5 times as the other 9 fields. This shows that electronic information industry is No. 1 pillar industry of Zhongguancun Industrial Park, with the most active innovation but relatively low innovation efficiency. According to Table 172.6, on condition that the input does not change, it should reduce the technological expenditure by 22.1767 billion Yuan, and the input intensity be reduced by 40 %. And while maintaining a constant input, it should raise the proportion of sales revenue of new products in total sales revenue and total industrial output by 18 and 20 % respectively, an effective efficiency.

172.4.2 Advanced Manufacturing

As the second largest industry in Demonstration Park, the advanced manufacturing industry has an evaluation efficiency of 0.51 after DEA evaluation, ranking the 6th with a scale efficiency value of 1.042 and a growing scale. Its revenue accounts for 11.89 % of the Zhongguancun Demonstration Park. Therefore, it should, in accordance with the plan of upgrading manufacturing industrial clusters, with the output unchanged, cut technological expenditure by 269.5 million Yuan, or reduce 90 % of its input intensity. And while maintaining a constant input, it should increase 447.468 items of patents and raise the proportion of new products sales revenue in total sales revenue by 38 %.

172.4.3 New Energy

As a growth point of the industries in the Demonstration Park, the new energy industry has an efficiency value of 0.999 after DEA evaluation, ranking the first, with a scale efficiency of 1 and a constant return to scale. In 2010, the revenue of the new energy industry accounts for 10.93 % of the industrial park. Therefore, in accordance with the plan of developing new energy, with the output unchanged, it should reduce the proportion of technological staff by 60 %, cut the technological budget by 2.568 billion Yuan. While remaining a constant input, it should increase the patent authorization by 2324.2 pieces and the proportion of new products sales revenue by 20 %.

172.4.4 New Material

As a fast growing industry, the new material industry gets an efficiency evaluation value by 0.820 % after DEA evaluation, ranking the third, with a scale efficiency of 1.042 and increasing trend. In 2010, the new material industry accounted for 6.73 % of the total revenue in the industrial park. So, while maintaining a constant output, it should cut the technological budget by 1.987 billion Yuan; reduce the budget input intensity by 23 %. And while maintaining a constant input, it should increase patent authorization by 1685.476 items and the proportion of new products sales revenue by 15 %.

172.4.5 The Modern Agriculture Industry

The modern agriculture industry gets an efficiency evaluation value by 0.942, ranking the second, with a scale efficiency of 1 and a constant return to scale. In 2010, modern agriculture industry accounted for 0.76 % of the total revenue in the Demonstration Park. Though the proportion is small, this industry is essential to the people's wellbeing. So, while maintaining a constant output, it should cut the technological budget by 331.5 million Yuan; reduce the budget input intensity by 19 %. And while maintaining a constant input, it should increase patent authorization by 2531.99 items and the proportion of new products sales revenue by 44 %.

172.4.6 Nuclear Application

The nuclear application industry gets an efficiency evaluation value by 0.533, ranking the 7th, with a scale efficiency of 1 and an increasing return to scale. In 2010, modern agriculture industry accounted for 0.17 % of the total revenue in the Demonstration Park. Despite a tiny proportion, this industry is strategically important to the national economy. So enough attention should be paid to this industry. While maintaining a constant output, it should cut the technological budget by 71.7 million Yuan; reduce the budget input intensity by 25 %. And while maintaining a constant input, it should increase patent authorization by 2696.8 items and the proportion of new products sales revenue by 34 %.

172.4.7 Ocean Engineering

The ocean engineering industry gets an efficiency evaluation value by 0.253, ranking the 8th (the last place) with a scale efficiency of 1 and a constant returns to scale. In 2010, modern agriculture industry accounted for 0.17 % of the total revenue in the Demonstration Park. Given its strategic importance, enough attention should be paid to this industry. While maintaining a constant output, it should cut the proportion of the technological staff by 80 %; reduce the budget input intensity by 24 %. And while maintaining a constant input, we should increase patent authorization by 2696.8 items and the proportion of new products sales revenue by 34 %.

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Chapter 173
Research on the Strategic Management of Small and Medium Enterprises in China

Xin Zhu and Ying Li

Abstract The goal of this paper is to analyze the status and the need strategic management in SMEs in China, and make analysis on the problems and countermeasures for the implementation of strategic management in SMEs. Firstly, we make an analysis about the importance of SMEs for China's economic development, and analyze the need for SMEs to implement strategic management. Secondly, we make an introduction about the step of the implementation of strategic management for the SMEs, and divide the implementation process into five steps. Then, we make a discussion about the existing problems during implementation of strategic management for the SMEs in recent China. We find that the lack of skills, the lack of consideration of macro environment, and the speculative mentality are the main obstacles for the implementation of strategic management for SMEs. Finally, we put forward the corresponding suggestions and recommendations for the implementation of strategic management for SMEs.

Keywords Strategic management · SMEs, recommendations

173.1 Introduction

Since the reform and opening policy in 1978, the number and scale of Small and Medium Enterprises (SMEs) have prospered for a long time with the rapid development of private economy in China. The SMEs increasingly become an important pillar of China's economic development. According to the introduction of National Development and Reform Commission, the number of SMEs in China

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E. Qi et al. (eds.), *The 19th International Conference on Industrial Engineering and Engineering Management*, DOI: 10.1007/978-3-642-38391-5_173,

has reached more than 4200 million, accounting for over 99.8 % of total number of enterprises. The number of SMEs registered by the business sector reached 460 million, and the number of self-employed households reached more than 3800 million in the end of 2009. The value of final goods and services created by the SMEs is account for 60 % of the gross domestic product. The goods produced by the SMEs accounts for the 60 % of the community's total sales. The tax revenue by SMEs turned over more than half of the total. The SMEs also supply more than 80 % of the total job positions. We can get the conclusion that the SMEs are playing an increasingly important role for the economic development in China. The development status of SMEs becomes an important indicator of economic vitality for a country or region all around the world.

However, it should be noted that the development of SME faced with unprecedented difficulties due to a variety of factors. There are serious problems for their ideas, technologies and equipment, management structure and other aspects. Particularly in its strategic management, the majority of SMEs lack of clear strategic positioning, and their strategic management are in chaos. With China's accession to WTO and economic globalization, information technology conditions, the SMEs exposure to a dynamic ultra-competitive environment the same as the large enterprises (Hennart 2001). This environment is unpredictable, treacherous, and for the self-limited conditions, often in competition for SMEs at a disadvantage. This environment is unpredictable, treacherous, and for the self-limited conditions, SMEs are often at a disadvantage in the competition. This determines the depth of the environment for SMEs to capture the opportunities, avoid threats, exceed and develop appropriate strategies to be possible to grasp the business destiny.

173.2 The Need for SMEs to Implement Strategic Management

The SMEs will face many strategic choices which can affect the fate of the corporations in their growth and development, just the same as the large businesses. In the course of business, there are strategic management issues. SME managers, especially senior management across the enterprise in the business planning process of development requires far-sighted to think, to make appropriate choices. These options relate to the long-term business interests and global interests, only to make the right strategic choices to be effective in guiding the development of enterprises.

173.2.1 The Implementation of the Strategic Management is the Need for SMEs to Survive

With the development of social productivity, market supply and demand has changed from past over-supply shortage. SMEs had a "small boat U-turn" advantage in the increasingly fierce competition in the market has gradually disappeared. The survival of SMEs should not only to consider the current pressure, but also to consider the future long-term environmental impact. Therefore, the strategic management of SMEs must be on the agenda, careful analysis of the external environment and internal business environment, accurate positioning and positioning the industry to continuously optimize the development strategy, otherwise the survival of SMEs will be increasingly difficult.

173.2.2 The Implementation of the Strategic Management is the Need for SMEs to Develop

The large enterprises usually developed on the basis of SMEs through the careful design their own development strategies, accurate self-positioning, the correct direction of investment, etc., only to the original to the continuous development of SMEs. Practice shows that the growth process in SMEs, strategic management is the management of the most important, only to seize the small and medium enterprise development strategies in the development of the road can make the right strategic choices.

173.2.3 The Implementation of Strategic Management is the Need for SMEs to Improve Core Competitiveness

Core competence is to win in a competitive market, the key to SMEs succeed in the attack of many large enterprises to survive, they must have the unique core competence, which can not be duplicated, and strategic management is to play small and medium enterprises effective way of core competence. SMEs under the guidance of strategic management thinking focus on human, financial and material resources form the core technology of its own intellectual property in order to enhance their core competitiveness.

173.2.4 The Implementation of Strategic Management is the Need for Innovative SMEs

With the rise of high-tech industries and knowledge economy, the world economy has entered a new era. In this economic situation that traditional industries are facing integration, the traditional mode of operation are facing challenges, and the new business areas and ways are emerging (Rugman and Verbeke 2001). Only the

SMEs with continuous innovation can be invincible. In the new economic situation, the SMEs should treat strategic management as the guiding ideology, and play their advantages as much as possible. The SMEs should continue their innovation in areas such as in the mode of operation, technology, product development, service production process.

173.3 The Step of the Implementation of Strategic Management for the SMEs

Taking into account the characteristics of SMEs, the steps of the implementation strategic management should include analysis of business environment, industry and market position, identify strategic objectives, business strategy formulation and selection, implementation and evaluation for strategy aspects.

173.3.1 Analysis of Business Environment

The business environment includes both the external environment and internal environment. The purpose of the external environmental analysis is to understand the enterprise's survival and development of a significant impact on the various factors including the macro environment, industry environment, and the competitive environment outside the enterprise (Williamson 1999). For SMEs, the external environment can not control, but can take corresponding measures with the different types of external influences. SMEs have to grasp the status and trends of macroeconomic environment and the industrial environment, which can enable their business strategy to have strong adaptability.

Internal environment analysis is the enterprise's own environment, including the operation of existing enterprises, business performance, product development and marketing, management ability, all kinds of resources to conduct in-depth analysis to understand they will have on future activities which affect the business. The analysis of the internal environment should have a clear understanding for the business advantages and disadvantages. The supporting impact is advantage, and the impeding inferior is disadvantage. We should know the advantage the companies have, and should clarify the disadvantages for the further development. In this way, we can get the right strategic direction on how to avoid weaknesses for the long-term development for SMEs.

173.3.2 Positioning of Industry and Market

We should make comprehensive consideration of their internal and external environment when the SMEs conduct industry and market positioning. We should start from the situation of the enterprises themselves, and select the proper industries and markets for the survival and development of small and medium enterprises. For SMEs in general should choose the less trade monopoly or near perfectly competitive market. In addition, the business scope should not be too broad, should concentrate their limited resources and human well specialization (Ghemawat 2003). When the development of SMEs to a certain scale, in order to expand, you can try to diversification, but must carefully consider their own abilities, or they might have disastrous consequences.

173.3.3 Identify the Strategic Objectives

The strategic goal means the expected results to be achieved in the scope of their business during certain period of time under the enterprises' operation thought. The division of the contents of strategic objectives will be different with different categories standards. It can be divided into departmental goals, and job goals according to target level. It can also be divided into long-term goals, medium-term objectives and short-term goals according to the length of time. The SMEs should be according to their capabilities, and can not be too high or too low, it should be through the efforts of the enterprise can achieve In determining the strategic objectives.

173.3.4 Formulate and Choose the Business Strategy

Business strategy is means of channels and concrete action plans adopted to achieve the strategic goals. Management strategy to be addressed include business how to allocate and use enterprise resources, how to coordinate actions among various departments, how to improve overall competitiveness of enterprises to achieve the desired strategic effects (Almeida 1996). SMEs in the development and selection of management strategy must be combined with the characteristics of the enterprises themselves, according to the enterprise, outside the specific environment to develop viable business strategy, the choice of the number of options to select the best of its ability to pay attention not to go to the pursuit of satisfaction strategy difficult to achieve the optimal strategy.

173.3.5 Implementation and Evaluation of the Strategy

The Implementation and evaluation of the strategy is the key link to achieve strategic objectives. The SMEs are different from large enterprises, so we should pay more attention for the strategy control in the implementation of the strategy. That means we should control the speed, direction, deviation of the implementation of the strategy. At the same time, we should clarify the scope of responsibility of all organizations, so that every department, every employee behavior and corporate coherent overall strategy. In the strategy implementation process, we also constantly checking the implementation, correct the problem in time. We should make accurate evaluation for the implementation of the strategic objectives, and make certain adjustment according to strategic objectives and strategic programs. The implementation of the strategy process is a continuous improvement process. The SMEs should be on implementation of the strategy process and results of lessons learned in a timely manner, so as to achieve satisfactory results.

173.4 The Problems of Implementation of Strategic Management for the SMEs

173.4.1 The Lack of Strategic Development and Implementation Skills

Some of our SMEs lack strategic thinking, and don't have adequate understanding of what is the strategy, the value of strategic for enterprise. They treat strategy intangible thing, and the short-term behaviors are very common without long-term goals. However, more and more enterprises realize the importance of strategic with the deep of reform and opening up, the frequency of economic activities, the promotion of their own understanding (Hedlund 2007). But many of the managers of SMEs lack enough awareness of what kind of strategy on the development, how to develop strategies and how effective implementation of the strategic and other issues. Some SMEs treat corporate profits as a strategic objective, but lack of depth thought on where's the money earned, earn whose money and so on. The company is in machine industry today, may enter the health care products, real estate and other industries tomorrow, which significantly increase business risk.

173.4.2 SMEs Strategy is Not with the State's Political and Economic Environment

A considerable part of the SME leaders think macro-economic and political environment has little to do with production and operations (Chang and Singh 2000). Some of them even don't have time to take account of these issues. China's SME owners like to deal with urgent business personally, and are difficult to find time for strategic thinking. Their efforts are how to survive their enterprises and how to solve the employees' food problem. Thus changes in domestic and international political and economic situation and little is known about the general direction of existing problems. The scanty information, shallow understanding and they are not good at closely linking the macro political and economic environment and production and operations. Their grasp of policy and the economy is relatively slow, which missed the best opportunity of development. Some enterprises even as the direction and policy guidance is inconsistent, leading to bankruptcy and insolvency risk.

173.4.3 The Speculative Mentality is Serious and Like Opportunism

During China's 30 years of market economic reforms, many speculators have gotten great interest in short time due to policy loopholes and laws are not perfect. In this way, many small business owners develop a quick success, ignoring the rules of the bad habits (Scott 2006). They believe that success relies on speculation and luck, and don't take a strategic perspective on the development of enterprises. There are lots of meteor type business because of the lack of speculative opportunities and intense competition in the market. Such kinds of enterprises have created a brilliant closing down of many small and medium enterprises.

173.5 The Recommendations to Promote the Strategic Management of SMEs

Whether to implement the strategic management of the enterprise is ultimately determined by enterprises. Can be expected, with the SME owners and entrepreneurs on the environment is complex and dynamic nature of awareness-raising, our newly revised state constitution to protect private property on the terms of the deeply rooted among the growing number of SMEs will abandon the short-term behavior, lofty ideals, in order to implement and strengthen the strategic management as an inherent requirement of enterprise development. We put forward the following recommendations, in order to make strategic management been widely used to enable the small and medium enterprises.

173.5.1 Strong Leadership Training and Enhance Their Own Capacity

Corporate strategy is often the values of a company's top leader. So, First of all, business leaders must be trained to improve their strategy awareness and skills. Now business leaders are increasingly aware of the importance of training. However, most of them think that only the subordinates need training to improve strategy execution. They do themselves or as busy no time to participate in specific training or simply think they don't need training. As everyone knows most need training in business strategy is to business leaders themselves. Training method can be flexible. For example, enterprises have plans to allow the operator to "go out" to the advanced business study tour or through target training. We can send them out to supplement the theoretical knowledge management systematically. We can also ask some related experts and scholars come to update their management philosophy and knowledge. We have to develop their thinking, enhance their management, strengthen the political and economic policy studies and enhance their ability to grasp the political and economic direction.

173.5.2 Encourage the Staff Involved in Developing Corporate Strategies

The staff participation is the key for whether the corporate strategy can be carried out perfectly. When employees do not agree with the strategic decisions, there will be resistance, decreased satisfaction, which will impact on productivity directly. If a company's employees do not understand how to be different with companies, do not understand what business value created, they will be difficult to understand face multiple choices (Brandenburger and Nalebuff 1995). If the sales staff does not know strategy, they will not know who to sell. If engineers do not know strategy, they will not know what outputs. If the employee participate in strategic management, understand business strategy development through, it is easy to recognize strategy, understand strategic in their daily work.

173.5.3 Strengthen Human Resource Management

Modern enterprise competition is the talent competition. Any effective strategy is to develop and implement by people. Therefore, the level of capacity of enterprises will directly determine the effect of the strategy. There are certain problems for the human resources management of China's SMEs such as the lack of scientific and effective introduction of talents, training and use of mechanisms; personnel appointments and irrational allocation of human resources; human resource performance evaluation and incentives imperfect. There are two main reasons for the low efficiency of productivity in SMEs: the lack of staff capability in itself; the second is the lack of system and means to full use the human capacity. We can rely on new concepts, establish the right talent, strengthen staff training, individual talent among staff. We can establish scientific personnel selection system and equal competition, and establish a scientific distribution system. We should improve the incentive mechanism, so as to improve the level of human resource management of SMEs.

173.5.4 We Should Make Use of Outer Brain and Establish Thinking Tanks

There are more and more factors to consider for enterprises' business development strategy. Enterprise business development strategy more and more factors to consider. Strategies must also change according to market changes more and more frequently. We should grasp the changing situation, develop appropriate strategies and countermeasures. It is not enough to make decision with individual mind, and should focus as much as possible of social intelligence (Glimstedt et al. 2006). The thinking tank has the following functions:

Innovate business thinking. We can break the company's own mindset through the introduction of foreign brains Resources. We can eliminate blind spots in production, management, sales, service, research and other areas to provide new ideas, new knowledge, new information, new ideas, new methods, and new strategies.

Enhance enterprise intelligence. Leadership and employees are fixed constants, but the outer brain resources are infinite variables. The establishment of think tanks outside the brain will result in enhanced business intelligence advantage. Mechanism in the enterprise has created a unique highlight of the new intelligence, which will effectively improve the business identify problems and solve problems (Mulcaster 2009). Competition in the market committed fewer errors, and create more opportunities.

Develop the interface of enterprise. The introduction of outer brains can not only enhance business intelligence with external intelligence, but also can integrating the human, material and social relations owned by outer brains. We can expand the interface through the project or joint system of enterprise management platform. This flexible operation mode can maximize the company's virtual resources and make up the short board for business (Markides 1999).

173.6 Conclusion

Some SME managers believe that only the large enterprises need strategic management, while SMEs do not need. Such kind of idea is completely wrong. The Viability of the SMEs is tough, because the SMEs can not to compete with larger enterprises in terms of technology, personnel, capital and other aspects. SMEs without clear strategic management thinking will easily get lost in the market and defeated with the increasingly fierce international and domestic market competition. Therefore, how to implement the strategic management of small and medium enterprises, how to analyze their strengths and weaknesses, how to correctly select the management strategy have become the key for the healthy and rapid development of SMEs in the future.

Acknowledgment This research is supported by the Foundation of Guangxi Educational Committee (Grant No: 201012MS121).

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