Lecture Notes in Electrical Engineering 242

Jiuping Xu
John A. Fry
Benjamin Lev
Asaf Hajiyev *Editors*

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Preface

Welcome to the proceedings of the Seventh International Conference on Management Science and Engineering Management (ICMSEM2013) held from November 7 to 9, 2013 at Drexel University, Philadelphia, Pennsylvania, USA.

International Conference on Management Science and Engineering Management is the annual conference organized by the International Society of Management Science and Engineering Management (ISMSEM). The goals of the Conference are to foster international research collaborations in Management Science and Engineering Management as well as to provide a forum to present current research results in the forms of technical sessions, round table discussions during the conference period in a relax and enjoyable atmosphere. 1420 papers from 35 countries were received and 130 papers from 12 countries were accepted for presentation or poster display at the conference after a serious review. These papers are from countries including USA, UK, Japan, Germany, Spain, Portugal, Turkey, China, Azerbaijan, Pakistan, Saudi Arabia and Australia. They are classified into 8 parts in the proceedings which are Computer and Networks, Information Technology, Decision Support System, Manufacturing, Supply Chain Management, Project Management, Ecological Engineering and Industrial Engineering. The key issues of the seventh ICMSEM cover various areas in MSEM, such as Decision Support System, Computational Mathematics, Information Systems, Logistics and Supply Chain Management, Relationship Management, Scheduling and Control, Data Warehousing and Data Mining, Electronic Commerce, Neural Networks, Stochastic models and Simulation, Heuristics Algorithms, Risk Control, and Carbon Credits. In order to further encourage the state-of-the-art research in the field of Management Science and Engineering Management, ISMSEM Advancement Prize for MSEM will be awarded at the conference for these researchers.

The conference also provides a suitable environment for discussions and exchanges of research ideas among participants during its well-organized post conference tours. Although we will present our research results in technical sessions, participate in round table discussions during the conference period, we will have extra and fruitful occasions to exchange research ideas with colleagues in this relaxed and enjoyable atmosphere of sightseeing.

We want to take this opportunity to thank all participants who have worked hard to make this conference a success. We appreciate the help from Drexel University and Sichuan University in conference organization. We also appreciate Springer-Verlag London for the wonderful publication of the proceedings. We are also grateful to all members of Organizing Committee, Local Arrangement Committee and Program Committee as well as all participants who have worked hard to make this conference a success. Finally we want to appreciate all authors for their excellent papers to this conference. Due to these excellent papers, ISMSEM Advancement Prize for MSEM will be awarded again at the conference for the papers which describe a practical application of Management Science and Engineering Management.

7-9 November 2013
Philadelphia, Pennsylvania, USA

ICMSEM General and Program Chairs

Contents

Organization

ICMSEM 2013 was organized by International Society of Management Science and Engineering Management, Sichuan University (Chengdu, China), Drexel University (Philadelphia, Pennsylvania, USA). It was held in cooperation with Lecture Notes in Electrical Engineering (LNEE) of Springer.

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Part V
Supply Chain Management

Chapter 66
On Effectivity of Delays in Queuing Systems

Asaf Hajiyev, Farah Ahmadzada and Irada Ibadova

Abstract For queuing systems with cyclic service for reducing of a customer average waiting time before service the delay of beginning service is introduced. The class of queuing systems for which it is advisable to introduce delay is described. The form of optimal function minimizing a customer average waiting time has found. Numerical examples demonstrating these results are given.

Keywords Customer average waiting time · Delay · Improvable service · Optimal function

66.1 Introduction

In this paper we consider queuing systems, for which $t_1, \cdots, t_n$ is the sequence of service starts instants. A stationary flow of customers with finite intensity arrives to service and this flow independent of t_i. At the instant t_i all customers that arrived over the interval $[t_{i-1}, t_i)$ are served instantaneously, i.e. it is assumed that server has infinite volume and service time equals zero. Such models are typical for applications and describe, for instance, behavior of transport systems. In the capacity of an efficiency index of a system we take a customer average time before service, which will be called w and σ is a variance of a customer waiting time before service. Our aim is by introducing of a control function to reduce a customer average waiting time before service. One of the simplest control policies is the introduction of service start delays that can be easily implemented in practice. The introduction of service start delays in systems with cyclic service has been studied in [1–3], where systems with service start delay preset as a constant were considered. In [4, 5], de-

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lays representing a certain class of control functions were studied in the case of systems with recurrent service.

66.2 Construction of Mathematical Models

Model 1. It is assumed that the sequence $t_1, t_2, \cdots, t_n$ is a simple renewal process. Define a customer waiting time before service as the time elapsed from the arrival of a customer into the system until the next service start. We will introduce control the service start instants; for this purpose we turn from the sequence $t_1, \cdots, t_n$ to the new sequence $t_1^*, \cdots, t_n^*$ using the following rule. Denote:

$$\eta_1 = t_1, \quad \eta_1 = t_i - t_{i-1}, \; i = 2, 3, \cdots,$$
$$\eta_1^* = t_1^*, \quad \eta_i^* = t_i^* - t_{i-1}^* = \eta_i + g(\eta_i), \; g \in G,$$

where G is a class of non-negative and measurable functions, i.e. $g(x) > 0$ and a random variable η_i, $i = 1, 2, \cdots$ has distribution function $F(x)$. As $t_1, \cdots, t_n$ is a renewal process, then $\eta_1, \eta_2, \cdots$ is a sequence of independent and identically distributed random variables with distribution function $F(x)$. Let $w(g)$ and $\sigma^2(g)$ be the expectation and the variance of the waiting time in a system with the control function $g \in G, c = E\eta^2/2E\eta$ and put $w(0) = 0$ and $\sigma^2(0) = \sigma^2$.

Definition 66.1. Service is improvable if there exists a function $g \in G$ such that $w(g) < w$, i.e. $\exists g(x) \in G$ such that $M_F(g) < 0$.

Statement 1. For service to be improvable it is necessary and sufficient holding of the following condition $x_0 < c$ such that $F(x_0) > 0$.

Definition 66.2. Function $g^*(x)$ is called an optimal if

$$\min_{g \in G} M_F(g) = M_F(g^*).$$

Statement 2. Under the conditions of the Statement 1 an optimal function has the following form:

$$g^*(x) = \max(0, c_1 - x) = (c_1 - x)^+ \text{ and } \sigma^2(g^*) \leq \sigma^2(g) \leq \sigma^2(0) = \sigma^2,$$

where $0 \leq c_2 \leq c_1$ and c_1 satisfies to the equation:

$$c_1^2 = \int_{c_1}^{\infty} (c_1 - x)^2 dF(x) \tag{66.1}$$

and moreover c_1 is a unique solution of the Equation (66.1).

Remark 66.1. In Fig. 66.1, the behavior of distribution function for initial system, and in Fig. 66.2, the distribution function for the optimal systems are shown.

$$F^*(x) = 0, \text{ if } x \leq c_1 \text{ and } F^*(x) = F(x), \text{ if } x > c_1.$$

Remark 66.2. The Statement 2 reminds paradox. Let us consider the large time interval $[0,T)$, and assume that there is k services for initial (without control) system and m services for controlled system. (see Fig. 66.3). It is clear that $k < l$. But according to the Statement 2, a customer average waiting time before service in system with greater number of services is greater than the same efficiency index in the system. It is alike to paradox.

At the time interval $[0,T)$ there is k number of services in the initial system and l $(k > l)$ services in the controlled system. According to the Remark 66.2, $w < w^*$.

Example 66.1. Let us put $F(x) = 1 - e^{-x}$, $x \geq 0$. Numerical computations yield:

$$w = 1;\ \sigma^2 = 1;\ w^* = 0.90;\ \sigma^{2^*} = 0.67;\ g*(x) = (0.90 - x)^+ = \max(0, 0.90 - x).$$

Therefore, the gain in customer average waiting time equals 10%, and in variance 33%.

Model 2. Let $t_1, t_2, \cdots, t_n, \cdots$ be times when service starts in some system. We assume $t_i = id + x_i, i = 1, 2, \cdots$, where d a constant is and $x_1, x_2, \cdots, x_n$ is a sequence of independent and identically distributed random variables $(i.i.d.r.v.)$ with

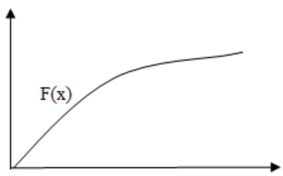


Fig. 66.1 The distribution function for initial system

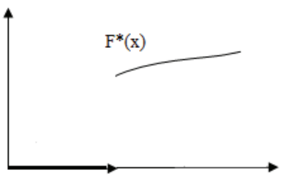


Fig. 66.2 The distribution function for the optimal systems

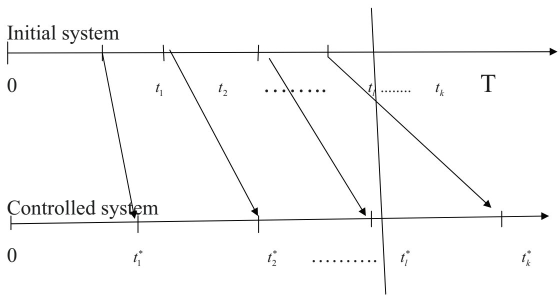


Fig. 66.3 k services for initial system and m services for controlled system

probability distribution function (d.f.) $G(x), |x| \leq d/2$ for all i. Such a scheme describes, for example, a behavior of public transport system where id $(i = 1,2,\cdots)$ is the ideal timetable for the arriving transport and $id + x_i$ $(i = 1,2,\cdots)$ is the real timetable. We denote $\eta_i = t_i - t_{i-1} = id + x_i - (i-1)d - x_{i-1} = d + x_i - x_{i-1}$. Then $\eta_1, \eta_2, \cdots, \eta_n, \cdots$ are identically distributed random variables with d.f.

$$F(x) = \int_{-d/2}^{d/2} G(x+y-d)dG(y),$$

but η_i, η_{i+1} are dependent. The flow of service customers is stationary with intensity $\mu < \infty$ and independent of $t_1, t_2, \cdots, t_n$. At the instant t_i, all customers, which arrived during the time interval $[t_{i-1}, t_i)$ are served immediately, in particular we assume that service time equals zero. If $t_1, t_2, \cdots, t_n, \cdots$ a stationary renewal process, $t_n = \eta_1 + \eta_2 + \cdots + \eta_n$ then according to Cox [6], we have:

$$w = \frac{E\eta^2}{2E\eta}, \ \sigma^2 = \frac{E\eta^3}{3E\eta} - \left(\frac{E\eta^2}{2E\eta}\right)^2, \tag{66.2}$$

where η is a random variable with d.f. $F(x)$. Next we shall show Equation (66.2) is true also or our model. Generally formula (66.2) is true for any identically distributed random (even dependent) variables η_i for which $\eta_i \geq 0, E\eta_i^2 < \infty$ for all i. (Proof see, Hajiyev [5]). Now we shall take delays into account, i.e. from the random variables $\eta_1, \eta_2, \cdots, \eta_n, \cdots$. we pass to random variables $\eta_1^*, \eta_2^*, \cdots, \eta_n^*, \cdots$ where $\eta_i^* = \eta_i + g(\eta_i), i = 1,2,\cdots, g \in G$. Here G is a class of measurable and non-negative functions. Let W^*, σ^{2*} be the expectations and variance of the delayed waiting times until service. Our interest concerns the following problem. For which systems can the introduction of delays diminish W. (i.e. give better service). Similarly Equation (66.2), we have:

$$w^* = \frac{E\eta^{2*}}{2E\eta^*}, \ \sigma^{2*} = \frac{E\eta^{3*}}{3E\eta^*} - \left(\frac{E\eta^{2*}}{2E\eta^*}\right)^2.$$

Statement 3. Service in the model 2 can be improved by delays if and only if there exists an $x_0 < c$ such that $F(x_0) > 0$, where $c = \frac{E\eta^2}{2E\eta}$.

Definition 66.3. We call $\tilde{g}(x)$ an optimal function if

$$\min_{g \in G} M_F(g) = M_F(\tilde{g}).$$

Statement 4. Under the conditions of the Statement 3 the optimal function has the form:

$$\tilde{g}(x) = (c_1 - x)^+ = \max(0, \ (c_1 - x)),$$

where c_1 is the unique solution of the equation:

$$c_1^2 = \int_{c_1}^{2d} (x - c_1)^2 dF(x).$$

Example 66.2. Let $d = 1$ and x_i has a uniform distribution on $\left[-\frac{1}{2}, \frac{1}{2}\right]$. Simple calculations yield $W = 0.583, \sigma^2 = 0.160$ and $W_* = 0.577, \sigma_*^2 = 0.156$ and $\tilde{g}(x) = (0.577 - x)^+$.

66.3 Queues with Complicated Structure

Model 3. Consider a model in which delay of one service start affects the next service, i.e., the sequence of controlled service start instants has the form:

$$
\begin{aligned}
&\xi_1^* = t_1^* = \xi_1^* + g_1(\xi_1^*),\\
&\xi_2^* = t_2^* - t_1^* = (\xi_1 + \xi_2 - \xi_1^*)^+ + g_2(\xi_1 + \xi_2 - \xi_1^*)^+\\
&\vdots\\
&\xi_n^* = t_n^* - t_{n-1}^* = (\xi_1 + \xi_2 + \cdots + \xi_n - \xi_1^* - \xi_2^* - \cdots - \xi_{n-1}^*)^+ +\\
&\qquad g_n(\xi_1 + \xi_2 - \xi_1^* - \xi_2^* - \cdots - \xi_{n-1}^*)^+,
\end{aligned}
$$

where $g_i(x) \in G$ is the class of non-negative measurable functions. Such models are typical for applications, because increasing an interval between two neighbor services we reduce next interval between services. Denote:

$$
\begin{aligned}
\eta_j &= (\xi_1 + \xi_2 + \cdots + \xi_j - \xi_1^* - \xi_2^* - \cdots - \xi_{j-1}^*)^+\\
&= \left(\sum_{i=1}^{j} \xi_i - \sum_{i=1}^{j-1} \xi_i^*\right)^+, \ \eta_j \geq 0, i = 1, 2, \cdots.
\end{aligned}
$$

Assume $\xi_1, \xi_2, \cdots, \xi_n$ are independent and identically distributed random variables with $E\xi_1 = d$ and $Var(\xi_i) = \sigma^2$.
Statement 5. For model 3 is true

$$
w = \lim_{n\to\infty} \left\{ \frac{(1/N)\sum_i^n E\eta_i}{(1/n)\sum_{i=`1}^n 2E\eta_i} \right\}, \quad w^* = \lim_{n\to\infty} \left\{ \frac{(1/N)\sum_i^n E\eta_i^*}{(1/n)\sum_{i=`1}^n 2E\eta_i^*} \right\}.
$$

Statement 6. If for the model 3 an optimal function exists then it has the following form

$$\tilde{g}(x) = (d - x)^+ = \max(0,\ d - x), \ \ d = \mathrm{E}\xi.$$

Corollary 66.1.

$$\tilde{w} = E\xi_1/2.$$

Statement 7. Service is improvable if and only if Var $\xi_i > 0$.

Corollary 66.2. *For the optimal function $\tilde{g}$, the following expression is true:*

$$W(\tilde{g}) = \mathrm{E}\xi/2, \quad \sigma^2(\tilde{g}) = \mathrm{E}\xi/12.$$

Example 66.3. Let $F(x) = 1 - e^{-x}$, $x \geq 0$, then $\tilde{g}(x) = (1-x)^+$, $W(\tilde{g}) = 1/2$, $\sigma^2(\tilde{g}) = 0.083$, i.e., the gain in mean waiting time is 50%.

66.4 Queues with Cyclic Services

Consider N terminals and one server, which serves customers at the each terminal (from i-th terminal to $(i+1)$-th terminal). At the each terminal Poisson flow of customers with finite intensity λ_i, $i = 1,2,\cdots,n$ arrives to service. Denote $t_1^i, t_2^i, \cdots, t_n^i$ the instants when service starts at the i-th terminal. At the t_j^i instant all customers, which arrived at the time interval $[t_{j-1}^i, t_j^i)$ immediately will get service, i.e. we consider server with infinite volume and assume that service time equals zero (see Fig. 66.4). Denote $X_j^i = t_{j+1}^i - t_j^i$ $(i = 1,2,\cdots,n;\ j = 1,2,\cdots)$, i.e. the time interval between $(j+1)$-th and j-th service at the i-th terminal. In the capacity of efficiency index (w) we take a customer average waiting time before service. Similarly as above, we will introduce delay of beginning service to reduce an average waiting time before service.

Assume that for any fixed i the random variables X_j^i $(j = 1,2,\cdots)$ independent and identically distributed random variables $(E|X_j^i| < \infty, E(X_j^i)^2 < \infty)$ and at the i-th terminal each customer pays penalty c_i $(i = 1,2,\cdots,n)$ for any unit time of waiting. Suppose $t_1^1 = 0$. Then for first terminal we have:

$$\mathrm{t}_1^1 = 0, \mathrm{t}_2^1 = \mathrm{t}_1^1 + X_1^1 + X_1^2 + \cdots + X_1^n, \cdots, \mathrm{t}_{\mathrm{m}+1}^1 = \mathrm{t}_{\mathrm{m}}^1 + X_m^1 + X_m^2 + \cdots + X_m^n.$$

For second $\mathrm{t}_1^2 = \mathrm{t}_1^1 + X_1^1, \mathrm{t}_2^2 = \mathrm{t}_2^1 + X_2^1, \cdots, \mathrm{t}_{\mathrm{m}+1}^2 = \mathrm{t}_{\mathrm{m}+1}^1 + X_{m+1}^1$ and so on. For n-th $\mathrm{t}_1^{\mathrm{n}} = \mathrm{t}_1^{\mathrm{n}-1} + X_1^{n-1}, \mathrm{t}_2^{\mathrm{n}} = \mathrm{t}_2^{\mathrm{n}-1} + X_2^{n-1}, \cdots, \mathrm{t}_{\mathrm{m}+1}^{\mathrm{n}} = \mathrm{t}_{\mathrm{m}+1}^{\mathrm{n}-1} + X_{m+1}^{n-1}$.

Consider the random variables $\eta_j^1 = \mathrm{t}_{\mathrm{j}+1}^1 - \mathrm{t}_{\mathrm{j}}^1 = X_j^1 + X_j^2 + \cdots + X_j^n$, $\eta_j^2 = \mathrm{t}_{\mathrm{j}+1}^2 - \mathrm{t}_{\mathrm{j}}^2 = X_{j+1}^1 + X_j^2 + \cdots + X_j^n, \cdots, \eta_j^n = \mathrm{t}_{\mathrm{j}+1}^{\mathrm{n}} - \mathrm{t}_{\mathrm{j}}^{\mathrm{n}} = X_{j+1}^1 + \cdots + X_{j+1}^{n-1} + X_j^n$. It is clear

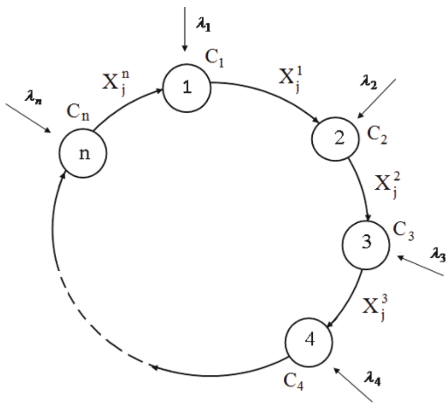


Fig. 66.4 N terminals and one server queues with cyclic services

that for fixed i the random variables η_j^i $(j=1,2,\cdots)$ are independent and identically distributed. Then according to Hajiyev [5], we have $W_i = \frac{E(\eta_j^i)^2}{2E\eta_j^j}$, $i=1,2,\cdots,n$. It follows:

$$W_i = \frac{E(\sum_{k=1}^n X_1^k)^2}{2E(\sum_{k=1}^n X_1^k)},\ i=1,2,\cdots,n$$

and for any customer its average penalty is:

$$C_0 = \frac{\sum_{k=1}^n \lambda_k c_k W_k}{\sum_{k=1}^n \lambda_k} = \frac{\sum_{k=1}^n \lambda_k c_k}{\sum_{k=1}^n \lambda_k} W_1$$

and $W_1 = W_2 = \cdots = W_n$.

66.4.1 Delay at the One Terminal

Let us introduce delays at the first terminal. Introduce the delay function g$(X^1, X^2, \cdots, X^n)$, which depends on previous intervals between services, where $g(\cdot)$ is measurable and non-negative function. Then

$$\xi_j^1 = \eta_j^1 + g(X_j), \xi_j^2 = \eta_j^2 + g(X_j), \cdots, \xi_j^n = \eta_j^n + g(X_j),$$

where $X_j = (X_j^1, X_j^2, \cdots, X_j^n),\ j=1,2,\cdots$ and we have:

$$W_1(g) = \frac{E(\xi_1^1)^2}{2E\xi_1^1} = \frac{E(X_1^1 + X_1^2 + \cdots + X_1^n + g(X_1))^2}{2E(X_1^1 + X_1^2 + \cdots + X_1^n + g(X_1))} = \frac{E(\sum\limits_{i=1}^n X_1^i + g(X_1))^2}{2E(\sum\limits_{i=1}^n X_1^i + g(X_1))},$$

$$W_2(g) = \frac{E(\xi_1^2)^2}{2E\xi_1^2} = \frac{E(X_2^1 + X_1^2 + \cdots + X_1^n + g(X_1))^2}{2E(X_2^1 + X_1^2 + \cdots + X_1^n + g(X_1))} = \frac{E(X_2^1 + \sum\limits_{i=2}^n X_1^i + g(X_1))^2}{2E(X_2^1 + \sum\limits_{i=2}^n X_1^i + g(X_1))},$$

$$\vdots$$

$$W_n(g) = \frac{E(\xi_1^n)^2}{2E\xi_1^n} = \frac{E(X_2^1 + X_2^2 + \cdots + X_2^{n-1} + X_1^n + g(X_1))^2}{2E(X_2^1 + X_2^2 + \cdots + X_2^{n-1} + X_1^n + g(X_1))}$$
$$= \frac{E(\sum\limits_{i=1}^{n-1} X_2^i + X_1^n + g(X_1))^2}{2E(\sum\limits_{i=1}^{n-1} X_2^i + X_1^n + g(X_1))}.$$

For penalties we have:

$$C(g) = \frac{\lambda_1 c_1 W_1(g) + \lambda_2 c_2 W_2(g) + \cdots + \lambda_n c_n W_n(g)}{\lambda_1 + \lambda_2 + \cdots + \lambda_n} G$$

is the class of all measurable and non-negative functions which are defined on:

$$R_+^n = \{\bar{x} : \bar{x} = (x_1, x_2, \cdots, x_n), x_1 \geq 0, x_2 \geq 0, \cdots, x_n \geq 0\}.$$

Our aim to minimize the value of penalties on the class G.

$$\mathrm{C(g) \to min, g \in G.}$$

Definition 66.4. Function $g^*(\cdot)$ is called an optimal if:

$$\min C(g) = C(g^*), \quad g \in G.$$

Introduce the following notations:

$$a = \frac{E(X_1^1 + X_1^2 + \cdots + X_1^n)^2}{2E(X_1^1 + X_1^2 + \cdots + X_1^n)} = \frac{E\left(\sum\limits_{i=1}^{n} X_1^i\right)^2}{2E\left(\sum\limits_{i=1}^{n} X_1^i\right)},$$

$$g_b(\bar{x}) = \left(b - \frac{\sum\limits_{i=1}^{n} \left(\sum\limits_{k=1}^{n-i} \lambda_k c_k E X_1^k + \sum\limits_{k=n-i+1}^{n} \lambda_k c_k x_k \right)}{\sum\limits_{i=1}^{n} \lambda_i c_i} \right),$$

where $\bar{x} = (x_1, x_2, \cdots, x_n)$. It is clear that,

$$C_0 = C(0) = \frac{\sum\limits_{k=1}^{n} \lambda_k c_k}{\sum\limits_{k=1}^{n} \lambda_k} a,$$

where c_0 means payment in the system without control. Denote $F(\bar{x})$ the joint probability distribution function of the random variables $X_1^1, X_1^2, \cdots, X_1^n$. Then

$$F(\bar{x}) = F_1(x_1) F_2(x_2) \cdots F_n(x_n),$$

where $F_1(x_1), F_2(x_2), \cdots, F_n(x_n)$ corresponding probability distribution function of the random variables $X_1^1, X_1^2, \cdots, X_1^n$. As for fixed i $(i = 1, 2, \cdots, n)$ the random variables X_j^i $(j = 1, 2, \cdots)$ have identically distribution and X_j^i $(i = 1, 2, 3;\ j = 1, 2, \cdots)$ are independent then:

$$\mathrm{C(g)} = \frac{\sum\limits_{k=1}^{n}\lambda_k c_k}{\sum\limits_{k=1}^{n}\lambda_k} \times \frac{\int\limits_{R_+^n} g(\bar{x})(\frac{g(\bar{x})}{2} - g_a(\bar{x}))dF(\bar{x})}{\sum\limits_{k=1}^{n} EX_1^k + \int\limits_{R_+^n} g(\bar{x})dF(\bar{x})} + \mathrm{C}_0.$$

Statement 8. Service is improvable if

$$\mathrm{g_a}(\bar{x}_0) > 0,\ F(\bar{x}_0) > 0.$$

Statement 9. Under the conditions of the Statement 5 the following expression is true:

$$\tilde{g}(\bar{x}) = \max(g_d(\bar{x}), 0).$$

Remark 66.3. We can show that d satisfies to the following condition:

$$2dE\left(\sum_{i=1}^{n} X_1^i\right) + E(\max(0, g_d(X_1)))^2 = E\left(\sum_{i=1}^{n} X_1^i\right)^2. \tag{66.3}$$

At the interval $(0,a)$, Equation (66.2) has a unique solution.

Remark 66.4. An average expenses for optimal function equals:

$$C(g^*) = \frac{\lambda_1 c_1 + \lambda_2 c_2 + \cdots + \lambda_n c_n}{\lambda_1 + \lambda_2 + \cdots + \lambda_n} d,$$

where d is defined in Equation (66.3).

Remark 66.5. If $\lambda_1 c_1 = \lambda_2 c_2 = \cdots = \lambda_n c_n$, then:

$$\begin{aligned} g^*(\bar{x}) &= \left(d - \frac{\sum\limits_{i=1}^{n}\big((n-i)EX_1^i + ix_i\big)}{n}\right)^+ \\ &= \left(d - \left(\frac{\big((n-1)EX_1^1 + x_1\big)}{n} + \frac{\big((n-2)EX_1^2 + 2x_2\big)}{n} + \cdots + x_n\right)\right)^+. \end{aligned}$$

If $n = 3$ then:

$$g^*(\bar{x}) = \left(d - \left(\frac{2EX_1^1 + x_1}{3} + \frac{EX_1^2 + 2x_2}{3} + x_3\right)\right)^+.$$

66.4.2 Two Terminals Delays at the Both Terminals

Consider two terminals system (Fig. 66.5). Introduce the following function:

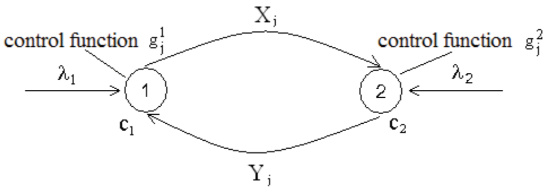


Fig. 66.5 Two terminals system

$$g^1 = (g_1^1, g_2^1, \cdots) = (g_j^1)_{j=1,\infty}, g^2 = (g_1^2, g_2^2, \cdots) = (g_j^2)_{j=1,\infty}.$$

g_j^i is delay function at the i-th terminal on j-th service, $X_j, Y_j (j = 1, \cdots, n)$.

$$X_1 \to g_1^2 \to Y_1 \to g_1^1 \to X_2 \to \cdots \to X_j \to g_j^2 \to Y_j \to g_j^1 \to X_{j+1} \to g_{j+1}^2 \to \cdots.$$

Then we have for first terminal:

$$\mathrm{t}_1^1 = 0, \mathrm{t}_2^1 = \mathrm{t}_1^1 + X_1 + \mathrm{g}_1^2 + Y_1 + \mathrm{g}_1^1, \cdots, \mathrm{t}_{\mathrm{m}+1}^1 = \mathrm{t}_{\mathrm{m}}^1 + X_m + \mathrm{g}_{\mathrm{m}}^2 + Y_{\mathrm{m}} + \mathrm{g}_{\mathrm{m}}^1,$$

for second:

$$\mathrm{t}_1^2 = X_1 + g_1^2, \mathrm{t}_2^2 = \mathrm{t}_1^2 + Y_1 + \mathrm{g}_1^1 + X_2 + \mathrm{g}_2^2, \cdots, \mathrm{t}_{\mathrm{m}+1}^2 = \mathrm{t}_{\mathrm{m}}^2 + Y_{\mathrm{m}} + \mathrm{g}_{\mathrm{m}}^1 + X_{m+1} + \mathrm{g}_{\mathrm{m}+1}^2$$

and

$$\xi_j = \mathrm{t}_{\mathrm{j}}^1 - \mathrm{t}_{\mathrm{j}}^1 = X_j + \mathrm{g}_{\mathrm{j}}^2 + Y_j + \mathrm{g}_{\mathrm{j}}^1,$$
$$\eta_{\mathrm{j}} = \mathrm{t}_{\mathrm{j}}^2 - \mathrm{t}_{\mathrm{j}}^2 = Y_j + \mathrm{g}_{\mathrm{j}}^1 + X_{j+1} + \mathrm{g}_{\mathrm{j}+1}^2.$$

According to Hajiyev [5], we have:

$$W_1(g^1, g^2) = \frac{\lim\limits_{N\to\infty} \frac{1}{N} \sum\limits_{j=1}^{N} E\xi_j{}^2}{2 \lim\limits_{N\to\infty} \frac{1}{N} \sum\limits_{j=1}^{N} E\xi_j} = \frac{\lim\limits_{N\to\infty} \frac{1}{N} \sum\limits_{j=1}^{N} E(X_j + \mathrm{g}_{\mathrm{j}}^2 + Y_j + \mathrm{g}_{\mathrm{j}}^1)^2}{2 \lim\limits_{N\to\infty} \frac{1}{N} \sum\limits_{j=1}^{N} E(X_j + \mathrm{g}_{\mathrm{j}}^2 + Y_j + \mathrm{g}_{\mathrm{j}}^1)},$$

$$W_2(g^1, g^2) = \frac{\lim\limits_{N\to\infty} \frac{1}{N} \sum\limits_{j=1}^{N} E\eta_j{}^2}{2 \lim\limits_{N\to\infty} \frac{1}{N} \sum\limits_{j=1}^{N} E\eta_j} = \frac{\lim\limits_{N\to\infty} \frac{1}{N} \sum\limits_{j=1}^{N} E(Y_j + \mathrm{g}_{\mathrm{j}}^1 + X_{j+1} + \mathrm{g}_{\mathrm{j}+1}^2)^2}{2 \lim\limits_{N\to\infty} \frac{1}{N} \sum\limits_{j=1}^{N} E(Y_j + \mathrm{g}_{\mathrm{j}}^1 + X_{j+1} + \mathrm{g}_{\mathrm{j}+1}^2)},$$

$$C(g^1, g^2) = \frac{\lambda_1 c_1 W_1(g^1, g^2) + \lambda_2 c_2 W_2(g^1, g^2)}{\lambda_1 + \lambda_2}.$$

Denote:

$$d = \frac{\lambda_1 + \lambda_2}{\lambda_1 c_1 + \lambda_2 c_2} \inf_{(g_1, g_2) \in G} C(g_1, g_2)$$

and consider the functional:

$$\begin{aligned} I(g^1,g^2) = \ & \alpha_1 \lim_{N\to\infty} \frac{1}{N} \sum_{j=1}^{N} E(X_j + \mathrm{g}_\mathrm{j}^2 + Y_j + \mathrm{g}_\mathrm{j}^1 - d)^2 \\ & + \alpha_2 \lim_{N\to\infty} \frac{1}{N} \sum_{j=1}^{N} E(Y_j + \mathrm{g}_\mathrm{j}^1 + X_{j+1} + \mathrm{g}_{\mathrm{j+1}}^2 - d)^2 - d^2, \end{aligned}$$

where

$$\alpha_1 = \frac{\lambda_1 c_1}{\lambda_1 c_1 + \lambda_2 c_2}, \ \ \alpha_2 = \frac{\lambda_2 c_2}{\lambda_1 c_1 + \lambda_2 c_2}, \alpha_1 + \alpha_2 = 1.$$

Introduce:

$$\begin{aligned} & \mathrm{g}_{\mathrm{j,d}}^1 = d - (\alpha_1 X_j + \alpha_2 EX + Y_j), j = 1,2,\cdots, \\ & \mathrm{g}_{\mathrm{j+1,d}}^2 = d - (X_{j+1} + \alpha_2 Y_j + \alpha_1 EY). \end{aligned}$$

It follows that $(\bar{g}^1, \bar{g}^2)$ is an optimal function for $(g^1, g^2) \in G_1$ if the following expression:

$$\begin{aligned} \lim_{N\to\infty} \frac{1}{N} \sum_{j=1}^{N} \Big(\ & E(\bar{\mathrm{g}}_\mathrm{j}^1 + \alpha_1 \bar{\mathrm{g}}_\mathrm{j}^2 + \alpha_2 \bar{\mathrm{g}}_{\mathrm{j+1}}^2 - \mathrm{g}_{\mathrm{j,d}}^1)(g_j^1 - \bar{g}_j^1) \\ & + E(\bar{\mathrm{g}}_{\mathrm{j+1}}^2 + \alpha_1 \bar{\mathrm{g}}_{\mathrm{j+1}}^1 + \alpha_2 \bar{\mathrm{g}}_\mathrm{j}^1 - \mathrm{g}_{\mathrm{j+1,d}}^2)(g_{j+1}^2 - \bar{g}_{j+1}^2) \Big) \geq 0 \end{aligned}$$

is true. Hence,

$$\hat{g}_{m_k}^2 = \left(g_{m_k,d}^2 - \alpha_2 \hat{g}_{m_k-1}^1 \right)^+,$$

$$\hat{g}_{m_k-1}^1 = \left(g_{m_k-1,d}^1 - \alpha_1 \hat{g}_{m_k-1}^2 - \alpha_2 E(\hat{g}_{m_k}^2 | K) \right)^+,$$

$$\hat{g}_{m_k-1}^2 = \left(g_{m_k-1,d}^2 - \alpha_1 (\hat{g}_{m_k-1}^1 | K) - \alpha_2 \hat{g}_{m_k-2}^1 \right)^+, \tag{66.4}$$

$$\hat{g}_j^1 = \left(g_{j,d}^1 - \alpha_1 \hat{g}_j^2 - \alpha_2 E(\hat{g}_{j+1}^2 | K) \right)^+. \tag{66.5}$$

From the Equations (66.4) and (66.5), we can find $\hat{g}_{m_k-1}^1$:

$$\hat{g}_{m_k-1}^1 = f_1 \left(X_{m_k-1}, Y_{m_k-1}, \hat{g}_{m_k-1}^2 \right) \tag{66.6}$$

and from the Equations (66.5) and (66.6), we can find $\hat{g}_{m_k-1}^2$:

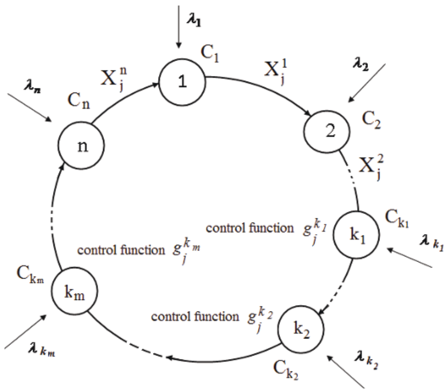
$$\hat{g}_{m_k-1}^2 = f_2 \left(Y_{m_k-2}, X_{m_k-1}, \hat{g}_{m_k-2}^1 \right). \tag{66.7}$$

Finally we can find $\hat{g}^i_j$. Thus, starting from the control function $\hat{g}^1_{m_k} = 0$ moving back we sequatially can find $\hat{g}^i_j$. Then we can find a minimum of expenses function $C_{\min} = C(g^1, g^2)$.

Remark 66.6. d is a solution of the non-linear equation:

$$2dE(X+Y) + \lim_{N\to\infty} \frac{1}{N} \sum_{j=1}^{N} \left(\alpha_1 E(\mathrm{g}^2_\mathrm{j} + \mathrm{g}^1_\mathrm{j})^2 + \alpha_2 E(\mathrm{g}^1_\mathrm{j} + \mathrm{g}^2_{\mathrm{j}+1})^2 \right) = E(X+Y)^2.$$

Fig. 66.6 Queueing system with *n* terminals



66.4.3 *Queues with n Terminals. Control at the Several Terminals*

Consider queueing system with n terminals. Control function is introduced at the m terminals $(m \le n)$, see Fig. 66.6. It is supposed that control function is introduced at the terminals with numbers $k_1, k_2, \cdots, k_m$, where $1 \le k_1 < k_2 < \cdots < k_m \le n$. Below is giving order of realizations $\cdots \to X^1_j \to \cdots \to X^{k_1-1}_j \to g^{k_1}_j \to X^{k_1}_j \to \cdots \to X^{k_m-1}_j \to g^{k_m}_j \to X^{k_m}_j \to \cdots \to X^n_j \to X^1_{j+1} \to \cdots$. We get the following integral equations:

$$\begin{aligned} \bar{\mathrm{g}}^{\mathrm{k_h}}_{\mathrm{j+1}} = & \left(\mathrm{g}^{\mathrm{k_h}}_{\mathrm{j+1,d}} - \sum_{i=1}^{h-1} \left[\left(1 - \sum_{l=k_i}^{k_h-1} \alpha_l \right) \bar{\mathrm{g}}^{\mathrm{k_i}}_{\mathrm{j+1}} + \sum_{l=k_i}^{k_h-1} \alpha_l E\left(\bar{\mathrm{g}}^{\mathrm{k_i}}_{\mathrm{j+2}} | K \right) \right] \right. \\ & \left. - \sum_{i=h+1}^{m} \left[\sum_{l=k_h}^{k_i-1} \alpha_l \bar{\mathrm{g}}^{\mathrm{k_i}}_{\mathrm{j}} + \left(1 - \sum_{l=k_h}^{k_i-1} \alpha_l \right) E\left(\bar{\mathrm{g}}^{\mathrm{k_i}}_{\mathrm{j+1}} | K \right) \right] \right)^+, \quad h = 1, 2, \cdots, m, \end{aligned}$$

where

$$g_{j+1,d}^{k} = \left(d - \sum_{i=1}^{k-1}\left(\sum_{l=i+1}^{k-1} \alpha_l EX_1^i + \left(1 - \sum_{l=i+1}^{k-1} \alpha_l\right) X_{j+1}^i\right)\right.$$
$$\left. - \sum_{i=k}^{n}\left(\left(1 - \sum_{l=k}^{i} \alpha_l\right) EX_1^i + \sum_{l=k}^{i} \alpha_l X_j^i\right)\right).$$

66.4.4 Numerical Examples

It was prepared a special program on a computer for numerical calculation. Moving time between terminals corresponds to the exponential distribution with parameters α_i $(i = 1, 2, \cdots, n)$.

Table 66.1 System with 2 terminals, $n = 2$

N	λ_1	λ_2	c_1	c_2	α_1	α_2	d	C_0	$C_{\min} = C(\tilde{g})$	Gain (%)
1.	2	3	1	2	1/5	1/6	6.82	13.24	10.9	17.6
2.	4	3	2	3	1/6	1/4	6.48	18.46	15.75	14.7
3.	3	5	4	2	1/3	2/7	4.40	13.43	12.11	9.9

Table 66.2 System with 3 terminals, $n = 3$

N	λ_1	λ_2	λ_3	c_1	c_2	c_3	α_1	α_2	α_3	d	C_0	$C_{\min}$	Gain (%)
1.	2	3	4	3	5	2	0.3	0.25	1/6	8.27	29.11	26.64	8.5
2.	3	1	2	2	5	4	0.4	0.6	0.7	3.22	11.99	10.18	15.1
3.	5	4	3	3	2	6	0.8	0.7	0.9	2.3	8.65	7.85	9.3

Table 66.3 System with 2 terminals, $n = 2$

N	λ_1	λ_2	c_1	c_2	I_1	I_2	d	C_0	$C_{\min} = C(\tilde{g})$	Gain (%)
1.	2	3	2	1	[2,3]	[4,5]	3.51	4.92	4.92	0
2.	4	3	2	3	[7,11]	[5,7]	6.86	18.35	16.66	9.2
3.	3	5	4	2	[8,12]	[6,8]	8.34	23.51	22.94	2.4

Table 66.4 System with 5 terminals, $n = 5$, (1)

N	λ_1	λ_2	λ_3	λ_4	λ_5	c_1	c_2	c_3	c_4	c_5
1.	2	4	5	3	2	3	2	1	3	5
2.	4	6	5	4	3	3	2	3	4	5
3.	6	4	2	5	4	4	5	5	3	7

Table 66.5 System with 5 terminals, $n = 5$, (2)

N	α_1	α_2	α_3	α_4	α_5	C_0	d	$C_{\min}$	Gain (%)
1.	0.9	0.75	0.9	0.95	0.8	133.7	2.06	78.4	41
2.	0.8	0.85	1.2	1	0.95	223.8	1.92	135.1	39
3.	1.5	1.7	1.1	1.3	0.9	233.6	1.64	159.5	31

(a) Moving time between terminals corresponds to the uniform distribution at the intervals I_1 and I_2.
(b) System with 5 terminals. Moving time between terminals corresponds to the exponential distribution with parameters α_i $(i = 1,2,3,4,5)$. Delays are introduced at the 1, 2 and 4 terminals.

Tables 66.1 $\sim$ 66.5 show, that for some systems gain in the average expenses can be reduced to 40%.

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Chapter 67
Rough Approximation Based Decentralized Bi-level Model for the Supply Chain Distribution Problem

Zhimiao Tao, Yuan Wang, Zhibin Wu and Jinwei Hu

Abstract This paper considers a core enterprise-dominant supply chain distribution modeling problem under a fuzzy environment. In particular, the common benefit and mutual interact of the upstream and downstream enterprise in the supply chain is considered. Thus, a decentralized bi-level programming model is constructed. To deal with the fuzzy parameters in the objective functions, an expected value operation based on Me is employed. As to the feasible region with fuzzy coefficient, a similarity relation based on the fuzzy measure Pos is defined, based on which, the rough approximation method is adopted. Then, two rough approximation models (UAM and LAM) is developed. To solve the two models, a rough simulation is developed, after which the fuzzy interactive programming and genetic algorithm can be adopted to find the solutions.

Keywords Rough approximation · Decentralized bi-level programming · Supply chain · Rough simulation · Fuzzy environment

67.1 Introduction

With the increasing competition, the effectiveness of supply chain management is more and more important. A well organized supply chain distribution system can simplify the sales section, decrease the selling cost, increase the satisfactory degree of the supply chain members, maximize the corporate profit and improve the final performance [8]. According to former reaches, the core enterprise in a supply chain is the key role in leading function and promoting performance. Hence, how the

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core enterprise organize the resource effectively, handle the information rapidly and consider the interaction of upstream and downstream enterprise is vital to increase the member satisfactory degree and improve the supply chain stability and virtuous circle.

In the former researches about distribution system, some scholars from the qualitative point of view, such as Ji [4] and Guo [2]. Some scholars also from quantitative point of view. Hamedi [3] constructed a mixed integer non-linear programming model for a single-objective, multi-period, and single-product problem. Moreover, Bilge Bilgen [1] constructed a fuzzy model taking into account the fuzziness. Also, Selim [7] constructed a multi-objective linear programming mode into which decision makersimprecise aspiration levels for the goals are incorporated using fuzzy goal programming approach. However, these researches neglected the interaction of upstream and downstream enterprise. So, a bi-level programming model is constructed in this paper. Meanwhile, as the consumer demand is influenced by many factors, such as product price, quality, consumer preference, even season, it is with a high level of uncertainty. Considering lacking of data, the uncertainty is regarded as fuzzyness as the uncertain parameters can be estimated by some experts. The usual method to handle the fuzzyness is the expected value. When the constraints also contain fuzzy parameters, the expected operator may lose some information even a optimal solution. Rough set theory, which was introduced by Pawlak [5] gives us an other direction to handle this problem. Rough approximation method has been applied to some models successfully [9, 10]. In this paper, it is adopted to handle the constraints featured by fuzzy parameter to make relatively a expanding and a shrinking feasible region.

Above all, the aim of this paper is to develop a decentralized bi-level model considering the interaction of upstream and downstream enterprise and common benefit. Meanwhile, considering the uncertain phenomenon, fuzzy variables are recommended. To handle the fuzzy variables, expected value based on Me and rough approximation are adopted, through which the model is transformed into two approximation models, i.e. the upper approximation model (UAM) and the lower approximation model (LAM). Finally, to solve the models, rough simulation is developed. After the simulation, the models can be solved by fuzzy interactive programming and genetic algorithm.

67.2 Key Problem Statement

This paper considers a supply chain consisting of a manufacturer, which is the core enterprise, and N distributors. The N distributors have different retail prices and quality levels because of their different wholesale prices and sale costs. The quality level here includes the service level and business reputation which the customs perceive. They competed with each other. As the manufacturer is the core enterprise, the objective of optimizing the supply chain is maximizing its total income, to which is leaded by a high sales volume. To stimulate the distributors to order more products, the manufacturer makes a buy back contract with each distributor, which allows the distributors sell the remaining products back to the manufacturer at a fixed price. In this supply chain, all the distributors and the manufacturer want the maximizing income. For the manufacturer, he/she should set appropriate wholesale prices, buy back prices and order quantities of each distributor to maximize its total income. For the distributors, they should make appropriate price and quality level according to the decisions of the manufacturer to make the income maximized. In the process of making a contract, there exist negotiations between them. However, as the manufacturer is the core enterprise, he/she is in a strong standing throughout the negotiation, which results in the distributors' signing contracts meeting the manufacturer's demand. Hence, the relationship between them can be regarded as hierarchical. The manufacturer is the leader, while the distributors are the followers. The manufacturer makes decisions first. Then, the distributors make their decisions accordingly. So, the problem considered in this paper can be regarded as a decentralized bi-level programming problem.

67.3 Modelling

67.3.1 Assumptions

To construct a model for the problem mentioned above, the following assumptions are adopted.

- N distributors are in the same market, they compete with each other based on retail price and quality level (business reputation and service level, etc.).
- The product in this supply chain is perishable, which can't be stored.
- The remaining products have residual value.
- The manufacturer is the upper-level DM, while the distributors are the lower-level DMs.

67.3.2 Objective Functions

(1) Objective function of the upper-level model

In this bi-level programming problem, the manufacturer is the leader. The objective of he/she is maximizing the total income through deciding the appropriate wholesale prices, buy back prices and the order quantities of each distributor. The function of it can be formulated as:

$$
\begin{aligned}
\widetilde{I} = & \sum_{n=1}^{N}(f_n - c)d_n - \sum_{n=1}^{N}(h_n - v)(d_n - \tilde{q}_n) \\
= & \sum_{n=1}^{N}(f_n - c)d_n - \sum_{n=1}^{N}(h_n - v)\left(d_n - \left(\tilde{a} - \sum_{j\neq n}\tilde{a}_j\right) + \tilde{b}_n p_n\right. \\
& \left. - \sum_{j\neq n}\tilde{c}_j p_j - \tilde{\alpha}_n m_n + \sum_{j\neq n}\tilde{\beta}_j m_j\right),
\end{aligned} \tag{67.1}
$$

where f_n, d_n, h_n represent the wholesale price, buy back price and order quantity of the n-th distributor, respectively. c represents the unit cost of product. v represents the unit residual value of the remaining product.
(2) Objective function of the lower-level model

According to the decisions that manufacturer makes, i.e. the wholesale price, buy back price and order quantity of each distributor, the distributors decide the retail price and service level to maximize their income. The function can be formulated as:

$$
\begin{aligned}
\tilde{i}_n = & (p_n - c_n)\tilde{q}_n - f_n d_n + h_2(d_n - \tilde{q}_n) - \tfrac{l_n m_n^2}{2} \\
= & (p_n - c_n)\left(\left(\tilde{a} - \sum_{j\neq n}\tilde{a}_j\right) - \tilde{b}_n p_n + \sum_{j\neq n}\tilde{c}_j p_j + \tilde{\alpha}_n m_n - \sum_{j\neq n}\tilde{\beta}_j m_j\right) - f_n d_n \\
& + h_2\left(d_n - \left(\left(\tilde{a} - \sum_{j\neq n}\tilde{a}_j\right) - \tilde{b}_n p_n + \sum_{j\neq n}\tilde{c}_j p_j + \tilde{\alpha}_n m_n - \sum_{j\neq n}\tilde{\beta}_j m_j\right)\right) - \tfrac{l_n m_n^2}{2},
\end{aligned} \tag{67.2}
$$

where p_n, m_n are decision variables, representing the retail price and quality level of the n-th distributor. c_n represents the selling cost of the n-th distributor. $\frac{l_n m_n^2}{2}$ represents the cost of quality level m_n. l_n represents the cost coefficient of quality level.

67.3.3 Constraints

According to the problem, it is easy to know that the constraints of the upper-level model is:

$$
\begin{cases}
d_n > 0, & n = 1, 2, \cdots, N, \\
f_n > c, & n = 1, 2, \cdots, N, \\
h_n > v, & n = 1, 2, \cdots, N.
\end{cases} \tag{67.3}
$$

Then consider the lower-level model. In the real world, government or the industry association may set limitation values of price and service level in some industry. Hence, the retail price should be less than the limitation value and the quality level should be more than the limitation value. Moreover, From a long-term point of view, the distributor should increase their sales volume gradually to get attention of the manufacturer, which will lead to lower wholesale price resulting in more profit. So, there should be a lower limit for the sales volume. Whole the constraints can be represented as:

$$\begin{cases} \left(\tilde{a} - \sum_{j \neq n} \tilde{a}_j\right) - \tilde{b}_n p_n + \tilde{\alpha}_n m_n \geq S_{\min}, \\ p_n \leq p_{\max}, \\ m_n \geq m_{\min}. \end{cases} \tag{67.4}$$

The first formula represents the lower limit of sales volume, which is the minimal sales volume without considering the other competitors.

67.3.4 Global Model

From the discuss above, the global model can be represented as:

$$\begin{cases} \max \widetilde{I} = \sum_{n=1}^{N} (f_n - c) d_n - \sum_{n=1}^{N} (h_n - v) \Bigg(d_n - \left(\tilde{a} - \sum_{j \neq n} \tilde{a}_j\right) + \tilde{b}_n p_n \\ \qquad - \sum_{j \neq n} \tilde{c}_j p_j - \tilde{\alpha}_n m_n + \sum_{j \neq n} \tilde{\beta}_j m_j \Bigg), \\ \text{s.t.} \begin{cases} d_n > 0,\ n = 1, 2, \cdots, N, \\ f_n > c,\ n = 1, 2, \cdots, N, \\ h_n > v,\ n = 1, 2, \cdots, N, \end{cases} \\ \text{where } \ p_n, m_n (n = 1, 2, \cdots, N) \text{ solve} \\ \max \tilde{i}_n = (p_n - c_n) \Bigg(\left(\tilde{a} - \sum_{j \neq n} \tilde{a}_j\right) - \tilde{b}_n p_n + \sum_{j \neq n} \tilde{c}_j p_j + \tilde{\alpha}_n m_n \\ \qquad - \sum_{j \neq n} \tilde{\beta}_j m_j \Bigg) - f_n d_n + h_2 \Bigg(d_n - \Bigg(\left(\tilde{a} - \sum_{j \neq n} \tilde{a}_j\right) - \tilde{b}_n p_n \\ \qquad + \sum_{j \neq n} \tilde{c}_j p_j + \tilde{\alpha}_n m_n - \sum_{j \neq n} \tilde{\beta}_j m_j \Bigg) \Bigg) - \frac{l_n m_n^2}{2}, \\ \text{s.t.} \begin{cases} \left(\tilde{a} - \sum_{j \neq n} \tilde{a}_j\right) - \tilde{b}_n p_n + \tilde{\alpha}_n m_n \geq S_{\min}, \\ p_n \leq p_{\max}, \\ m_n \geq m_{\min}, \end{cases} \\ n = 1, 2, \cdots, N. \end{cases} \tag{67.5}$$

67.4 Model Analysis

Noticing that both the objectives and constraints of model (67.5) contains fuzzy parameters. The objective functions with fuzzy parameters represent a vague goal, which can't be maximized. Moreover, the constraints with fuzzy parameters define a uncertain feasible region. Hence, it should be converted into a crisp model before solving it.

67.4.1 Expected Value Based on Me

To convert the model (67.5) to be a crisp one, the expected value based on *Me* is adopted. There are many definitions for expected value in fuzzy theory. There are definitions based on *Pos*, Nec and Cr. The measure Pos represents an absolutely optimistic attitude while Nec represents an absolutely pessimistic attitude. The measure Cr represents a composite attitude which combines half optimistic and half pessimistic. In a realistic decision problem, however, the attitudes of the different decision makers are different and therefore may be not absolutely optimistic or pessimistic, or half optimistic and half pessimistic, so, the expected value based on Me is adopted, which is defined as: $\mathrm{Me} = \lambda \mathrm{Pos} + (1-\lambda)\mathrm{Nec}$, where λ is the optimistic-pessimistic parameter to determine the combined attitude of the decision makers. The expected value based on Me [11] of a fuzzy variable ξ is defined as:

$$E[\xi] = \int_0^{+\infty} Me\{\xi \geq r\}dr - \int_{-\infty}^{0} Me\{\xi \leq r\}dr. \tag{67.6}$$

Using the definition of expected value based on Me, the objectives can be clearly formulated. The objective of the upper-level model is:

$$\begin{aligned} \max E(\widetilde{I}) = \ & E\Bigg(\sum_{n=1}^{N}(f_n - c)d_n - \sum_{n=1}^{N}(h_n - v)\Bigg(d_n - \Bigg(\tilde{a} - \sum_{j\neq n}\tilde{a}_j\Bigg) + \tilde{b}_n p_n, \\ & -\sum_{j\neq n}\tilde{c}_j p_j - \tilde{\alpha}_n m_n + \sum_{j\neq n}\tilde{\beta}_j m_j\Bigg)\Bigg), \end{aligned} \tag{67.7}$$

$$\begin{aligned} \max E(\tilde{i}_n) = \ & E\Bigg((p_n - c_n)\Bigg(\Bigg(\tilde{a} - \sum_{j\neq n}\tilde{a}_j\Bigg) - \tilde{b}_n p_n + \sum_{j\neq n}\tilde{c}_j p_j + \tilde{\alpha}_n m_n - \sum_{j\neq n}\tilde{\beta}_j m_j\Bigg) \\ & - f_n d_n + h_2\Bigg(d_n - \Bigg(\Bigg(\tilde{a} - \sum_{j\neq n}\tilde{a}_j\Bigg) - \tilde{b}_n p_n \\ & + \sum_{j\neq n}\tilde{c}_j p_j + \tilde{\alpha}_n m_n - \sum_{j\neq n}\tilde{\beta}_j m_j\Bigg)\Bigg) - \frac{l_n m_n^2}{2}\Bigg). \end{aligned} \tag{67.8}$$

As the upper and lower boundary and the value with the most possibility of the fuzzy parameters in Equations (67.7) and (67.8) can be estimated by the experts with specialized knowledge and experience, they can be regarded as triangle fuzzy numbers. If $\tilde{a} = (a_1, a_2, a_3)$ (assume that other fuzzy numbers also have the similar form), the expected value of it can be represented as below:

$$E^{Me}[\tilde{a}] = \frac{(1-\lambda)a_1 + a_2 + \lambda a_3}{2}, \tag{67.9}$$

where λ is the optimistic-pessimistic index to determine the combined attitude of a decision maker. The expected value of other fuzzy numbers can also be represented as similar form. Then, the expected value of the consumer demand function can be formulated as:

$$\begin{aligned} E(\tilde{q}) = & \frac{(1-\lambda)a_1 + a_2 + \lambda a_3}{2} - \sum_{j \neq n} \frac{(1-\lambda)a_{j1} + a_{j2} + \lambda a_j 3}{2} \\ & - \frac{(1-\lambda)b_{n1} + b_{n2} + \lambda b_{n3}}{2} p_n + \sum_{j \neq n} \frac{(1-\lambda)\alpha_{n1} + \alpha_{n2} + \lambda \alpha_{n3}}{2} m_n \\ & - \sum_{j \neq n} \frac{(1-\lambda)\beta_{j1} + \beta_{j2} + \lambda \beta_{j3}}{2} m_j. \end{aligned} \tag{67.10}$$

Then, Equations (67.7), (67.8) can be transformed into:

$$\max E(\widetilde{I}) = \sum_{n=1}^{N} (f_n - c)d_n - \sum_{n=1}^{N} (h_n - v)(d_n - E(\tilde{q})), \tag{67.11}$$

$$\max E(\tilde{i}_n) = (p_n - c_n)E(\tilde{q}) - f_n d_n + h_n(d_n - E(\tilde{q})) - \frac{l_n m_n^2}{2}, \tag{67.12}$$

where $E(\tilde{q})$ represents the value of Equation (67.10).

67.4.2 Rough Approximation

As mentioned above, the feasible region of model (67.5) is uncertain, the feasibility of a solution can't be judged. Using the expected value or fuzzy measure to handle it may lose many useful information. In this paper, rough approximation is adopted.

Assume $x_1 = (f_1^1, h_1^1, d_1^1, \cdots, f_n^1, h_n^1, d_n^1, p_1^1, m_1^1, \cdots, p_n^1, m_n^1)$ and $x_2 = (f_1^2, h_1^2, d_1^2, \cdots, f_n^2, h_n^2, d_n^2, p_1^2, m_1^2, \cdots, p_n^2, m_n^2)$ are two solutions of the model. Based on the definition of the *Pos* measure, the following similarity relationship R_h^δ can be defined for the constraints:

$$\begin{aligned} & R_h^\delta(x^1, x^2) : Pos\left\{\left(\tilde{a} - \sum_{j \neq n} \tilde{a}_j\right) - \tilde{b}_n(p_n^1 - p_n^2) + \tilde{\alpha}_n(m_n^1 - m_n^2) \leq h\right\} \geq \delta, \\ & \quad (n = 1, 2, \cdots, N), \end{aligned} \tag{67.13}$$

where δ is the confidence level, and h is the deviation which the DM permits. Here, the measure Pos is used as it determines a relatively expanding feasible region where more information and a possible solution may be combined.

For the relationship, there are:

$$\begin{aligned} & Pos\left\{\left(\tilde{a} - \sum_{j \neq n} \tilde{a}_j\right) - \tilde{b}_n(p_n^1 - p_n^1) + \tilde{\alpha}_n(m_n^1 - m_n^1) \leq h\right\} \\ & = Pos\left\{\left(\tilde{a} - \sum_{j \neq n} \tilde{a}_j\right)\right\} > 1 \geq \delta \end{aligned} \tag{67.14}$$

and

$$Pos\{(\tilde{a}-\sum_{j\neq n}\tilde{a}_j)-\tilde{b}_n(p_n^1-p_n^2)+\tilde{\alpha}_n(m_n^1-m_n^2)\leq h\}\geq\delta$$
$$\Longleftrightarrow Pos\left\{\left(\tilde{a}-\sum_{j\neq n}\tilde{a}_j\right)-\tilde{b}_n(p_n^2-p_n^1)+\tilde{\alpha}_n(m_n^2-m_n^1)\leq h\right\}\geq\delta, \quad (67.15)$$

That is, the relationship has reflexivity and symmetry. Then R_h^δ is a similarity relationship.

With the similarity relationship, the constraints of the contractor-level model can be formulated as:

$$\begin{cases} Pos\left\{\left(\tilde{a}-\sum_{j\neq n}\tilde{a}_j\right)-\tilde{b}_n p_n+\tilde{\alpha}_n m_n\geq S_{\min}-h^*\right\}\geq\delta, \\ h^*=\max\left\{h|\frac{|\underline{X_h}|}{|\overline{X_h}|}\geq\rho\right\}, \\ |\underline{X_h}|=\int\int_{\underline{X_h}}1dp_ndm_n, \\ |\overline{X_h}|=\int\int_{\overline{X_h}}1dp_ndm_n, \\ p_n\leq p_{\max}, \\ m_n\geq M_{\min} \end{cases} \quad (67.16)$$

or

$$\begin{cases} Pos\left\{\left(\tilde{a}-\sum_{j\neq n}\tilde{a}_j\right)-\tilde{b}_n p_n+\tilde{\alpha}_n m_n\geq S_{\min}+h^*\right\}\geq\delta, \\ h^*=\max\left\{h|\frac{|\underline{X_h}|}{|\overline{X_h}|}\geq\rho\right\}, \\ |\underline{X_h}|=\int\int_{\underline{X_h}}1dp_ndm_n, \\ |\overline{X_h}|=\int\int_{\overline{X_h}}1dp_ndm_n, \\ p_n\leq p_{\max}, \\ m_n\geq M_{\min}, \end{cases} \quad (67.17)$$

where the region represented by Equation (67.16) is the R-upper approximation of the feasible region for the contractor. While the one at Equation (67.17) is the R-lower approximation. Here, the second equation guarantees the required accuracy is achieved. The third and the fourth equations express the cardinal numbers of $\underline{X_h}$ and $\overline{X_h}$, respectively as they are a finite and discrete set. $\underline{x_{ij}}$ and $\overline{x_{ij}}$ represent the following regions, respectively.

$$\begin{cases} Pos\left\{\left(\tilde{a}-\sum_{j\neq n}\tilde{a}_j\right)-\tilde{b}_n p_n+\tilde{\alpha}_n m_n\geq S_{\min}-h\right\}\geq\delta, \\ h^*=\max\left\{h|\frac{|\underline{X_h}|}{|\overline{X_h}|}\geq\rho\right\}, \\ p_n\leq p_{\max}, \\ m_n\geq M_{\min} \end{cases} \quad (67.18)$$

and

$$\begin{cases} Pos\left\{\left(\tilde{a} - \sum\limits_{j\neq n} \tilde{a}_j\right) - \tilde{b}_n p_n + \tilde{\alpha}_n m_n \geq S_{\min} + h\right\} \geq \delta, \\ h^* = \max\left\{h | \frac{|\underline{X_h}|}{|\overline{X_h}|} \geq \rho\right\}, \\ p_n \leq p_{\max}, \\ m_n \geq M_{\min}. \end{cases} \tag{67.19}$$

Also, from the relevant theorems [11], the following conclusions can be derived:

$$\begin{aligned} &Pos\{(\tilde{a} - \sum_{j\neq n} \tilde{a}_j) - \tilde{b}_n p_n + \tilde{\alpha}_n m_n \geq S_{min} - h^*\} \geq \delta \\ &\Longleftrightarrow (a_2 - \sum_{j\neq n} a_{j2}) - b_{n2} p_n + \tilde{\alpha}_{n2} m_n + (1 - \delta(((a_3 - a_2) - \sum_{j\neq n} (a_{j3} - a_{j2}) \\ &\quad -(b_{n3} - b_{n2}) p_n + (\alpha_{n3} - \alpha_{n2}) m_n) \geq S_{min} - h^*, \end{aligned} \tag{67.20}$$

$$\begin{aligned} &Pos\{(\tilde{a} - \sum_{j\neq n} \tilde{a}_j) - \tilde{b}_n p_n + \tilde{\alpha}_n m_n \geq S_{min} + h^*\} \geq \delta \\ &\Longleftrightarrow (a_2 - \sum_{j\neq n} a_{j2}) - b_{n2} p_n + \tilde{\alpha}_{n2} m_n + (1 - \delta(((a_3 - a_2) - \sum_{j\neq n} (a_{j3} - a_{j2}) \\ &\quad -(b_{n3} - b_{n2}) p_n + (\alpha_{n3} - \alpha_{n2}) m_n) \geq S_{min} + h^*. \end{aligned} \tag{67.21}$$

67.4.3 Equivalent Crisp Global Model

After the handling above, model (67.5) can be transformed into two crisp models (67.22) and (67.23), which are the upper-approximation model (UAM) and the lower-approximation model (LAM). These two models, which are with a relative expanding and shrinking feasible region, respectively, provide the DMs different solutions. For the completely optimistic DMs, they can choose the solution of the UAM, while the DMs with completely pessimistic attitude can choose the solution of the LAM. Other DMs can choose the linear combination of the two solutions to find a solution that fits the attitude of them.

$$
(\text{UAM})\begin{cases}
\max E(\widetilde{I}) = \sum_{n=1}^{N}(f_n - c)d_n - \sum_{n=1}^{N}(h_n - v)(d_n - E(\tilde{q})),\\
\text{s.t.}\begin{cases} d_n > 0,\ n = 1,2,\cdots,N,\\ f_n > c,\ n = 1,2,\cdots,N,\\ h_n > v,\ n = 1,2,\cdots,N,\end{cases}\\
\text{where }\ p_n, m_n (n = 1,2,\cdots,N) \text{ solve}\\
\max E(\tilde{i}_n) = (p_n - c_n)E(\tilde{q}) - f_n d_n + h_n(d_n - E(\tilde{q})) - \frac{l_n m_n^2}{2},\\
\text{s.t.}\begin{cases}
\left(a_2 - \sum_{j\neq n} a_{j2}\right) - b_{n2}p_n + \tilde{\alpha}_{n2}m_n + (1 - \delta(((a_3 - a_2)\\
\qquad - \sum_{j\neq n}(a_{j3} - a_{j2}) - (b_{n3} - b_{n2})p_n\\
\qquad + (\alpha_{n3} - \alpha_{n2})m_n) \geq S_{\min} - h^*,\\
h^* = \max\left\{h | \frac{|\underline{X_h}|}{|\overline{X_h}|} \geq \rho\right\},\\
|\underline{X_h}| = \int\int_{\underline{X_h}} 1 dp_n dm_n,\\
|\overline{X_h}| = \int\int_{\overline{X_h}} 1 dp_n dm_n,\\
p_n \leq p_{\max},\ m_n \geq M_{\min}, n = 1,2,\cdots,N
\end{cases}
\end{cases}
\tag{67.22}
$$

and

$$
(\text{LAM})\begin{cases}
\max E(\widetilde{I}) = \sum_{n=1}^{N}(f_n - c)d_n - \sum_{n=1}^{N}(h_n - v)(d_n - E(\tilde{q})),\\
\text{s.t.}\begin{cases} d_n > 0,\ n = 1,2,\cdots,N,\\ f_n > c,\ n = 1,2,\cdots,N,\\ h_n > v,\ n = 1,2,\cdots,N,\end{cases}\\
\text{where }\ p_n, m_n (n = 1,2,\cdots,N) \text{ solves}\\
\max E(\tilde{i}_n) = (p_n - c_n)E(\tilde{q}) - f_n d_n + h_n(d_n - E(\tilde{q})) - \frac{l_n m_n^2}{2},\\
\text{s.t.}\begin{cases}
\left(a_2 - \sum_{j\neq n} a_{j2}\right) - b_{n2}p_n + \tilde{\alpha}_{n2}m_n + (1 - \delta(((a_3 - a_2)\\
\qquad - \sum_{j\neq n}(a_{j3} - a_{j2}) - (b_{n3} - b_{n2})p_n\\
\qquad + (\alpha_{n3} - \alpha_{n2})m_n) \geq S_{\min} + h^*,\\
h^* = \max\left\{h | \frac{|\underline{X_h}|}{|\overline{X_h}|} \geq \rho\right\},\\
|\underline{X_h}| = \int\int_{\underline{X_h}} 1 dp_n dm_n,\\
|\overline{X_h}| = \int\int_{\overline{X_h}} 1 dp_n dm_n,\\
p_n \leq p_{\max},\ m_n \geq M_{\min},\ n = 1,2,\cdots,N.
\end{cases}
\end{cases}
\tag{67.23}
$$

67.5 Solution Approach

To solve models (67.22) and (67.23), we design a so-called rough simulation-based hybrid genetic algorithm (RS-based hGA), which is a combination of rough simulation, fuzzy interactive programming [6] and genetic algorithm.

67.5.1 Rough Simulation

Consider the following constraint:

$$h^* = \max\left\{h|\frac{|\underline{X}_{h_1}|}{|\overline{X}_{h_1}|} \geq \rho\right\}. \tag{67.24}$$

Step 1. Randomly generate two numbers $h_1$and h_2 such that according to the relationship $R^\delta_{h_1}$ and $R^\delta_{h_2}$,

$$\frac{|\underline{X}_{h_1}|}{|\overline{X}_{h_1}|} \geq \rho, \ \frac{|\underline{X}_{h_2}|}{|\overline{X}_{h_2}|} < \rho. \tag{67.25}$$

Step 2. Let $h = (h_1 + h_2)/2$.
Step 3. If $\frac{|\underline{X}_h|}{|\overline{X}_h|} \geq \rho$, let $h_1 = h$; Otherwise, let $h_2 = h$.
Step 4. If $|h_1 - h_2| \geq \varepsilon$(a given small positive number), go to the step 2; otherwise, let $h^* = h_1$. Then, h^* is the maximal h.

67.5.2 Hybrid Genetic Algorithm

Since bilevel model has special structure, simple genetic algorithm can not balance the relationship between the UAM and LAM. We embed the fuzzy interactive programming method in to genetic algorithm. The key part is the setting of fitness function. Consider the satisfaction levels of the upper DM and lower DM in fuzzy interactive algorithm, let X be the feasible regions and

$$\begin{aligned}
I_{\min} &= I(x_1^0) = \min_{x\in X} I(x), \ i^n_{\min} = i^n(x_n) = \min_{x\in X} i^n(x) \ (n = 1,2,\cdots,N),\\
I_m &= \max\{I(x_1^0), I(x_1), \cdots, I(x_N)\}, \ i^n_m = \max\{i_n(x_1^0), i_n(x_1), \cdots, i_n(x_N)\}\\
&\quad (n = 1,2,\cdots,N).
\end{aligned}$$

Then, the membership function of each objective is formulated as:

$$\mu(I(x)) = \begin{cases} 1, & \text{if } C(x) \geq C_m,\\ \frac{C(x)-C_m}{C_{min}-C_m}, & \text{if } C_{\min} \leq C(x) \leq C_m,\\ 0, & \text{if } C(x) \leq C_{\min},\end{cases}$$

$$\mu_n(i_n(x)) = \begin{cases} 1, & \text{if } i_n(x) \geq i^n_m,\\ \frac{i_n(x)-i^n_m}{i^n_{\min}-i^n_m}, & \text{if } i^n_{\min} \leq i_n(x) \leq i^n_m,\\ 0, & \text{if } i_n(x) \leq i^n_m.\end{cases}$$

To guarantee the equity between the upper DM and the lower DM, the following ratios of satisfactory degrees is introduced to balance the satisfactory degrees between the two levels:

$$\Delta = \frac{\min\{\mu_1(i_1(x)), \mu_2(i_2(x)), \cdots, \mu_N(i_N(x))\}}{\mu(I(x))}, \tag{67.26}$$

$$\Delta_n = \frac{\mu_n(i_n(x))}{\mu(I(x))}, \tag{67.27}$$

where Equation (67.26) balances the satisfactory degrees between the upper level and lower level; Equation (67.26) balances the satisfactory degrees among the lower level DMs. The upper DM can set satisfactory ration of maximal satisfactory degree and minimal satisfactory degree such that $\Delta \in [\Delta_{\min}, \Delta_{\max}]$ and $\Delta_n \in [\Delta^0_{\min}, \Delta^0_{\max}]$.

From the formulation of satisfactory degrees, denote a chromosome and its corresponding solution by s and x. Then adopt the following satisfactory degree:

$$f_s = \max\{\mu(I(x)), \zeta(x)\}, \tag{67.28}$$

where

$$\zeta(x) = \begin{cases} 1, & \text{if } i_n(x) \geq i^n_m, \\ \frac{i_n(x) - i^n_m}{i^n_{\min} - i^n_m}, & \text{if } i^n_{\min} \leq i_n(x) \leq i^n_m, \\ 0, & \text{if } i_n(x) \leq i^n_m. \end{cases} \tag{67.29}$$

As the above fitness function is adopted, the solution is not only balance the the satisfactory degrees between upper level and lower level but also balance the the satisfactory degrees among lower level DMs. The lower level DM can adjust satisfactory ratio of maximum and minimum until he/she obtain satisfactory solutions.

We state the rough simulation-based genetic algorithm procedure as follows:

Step 1. Input the parameters $N_{pop-size}, P_c$ and P_m.

Step 2. Initialize $N_{pop-size}$ chromosomes whose feasibility may be checked by rough simulation.

Step 3. Update the chromosomes by crossover and mutation operations and rough simulation is used to check the feasibility of offspring.

Step 4. Compute the fitness of each chromosome.

Step 5. Select the chromosomes by spinning the roulette wheel.

Step 6. Repeat Step 3 to Step 5 for a given number of cycles.

Step 7. Return the best chromosome as the optimal solution.

67.6 Numerical Example

To demonstrate the feasibility of the proposed decentralized bi-level programming model and RS-based hGA, consider the following supply chain distribution decision-making problem.

Assume that there are only two supplier. The parameters values are $\tilde{a} = (9, 10, 11)$, $\tilde{a}_1 = (1,2,3), \tilde{a}_2 = (2,3,4), \tilde{b}_1 = (1,2,3), \tilde{b}_2 = (1,2,3), \tilde{c}_1 = (2,3,4), \tilde{c}_2 = (1,2,3)$, $\tilde{\alpha}_1 = (2,3,4), \tilde{\alpha}_2 = (3,4,5), \tilde{\beta}_1 = (0.8, 1, 0.2), \tilde{\beta}_1 = (0.9, 1.1, 1.2), c = 20, v = 8, c_1 =$

$10, c_2 = 9, l_1 = 7, l_2 = 5, S_{\min} = 9, p_{\max} = 6, m_{\min} = 2$. Take these value into model (67.5), we obtain the global model for this supply chain distribution decision-making problem. For solving model, fuzzy parameters are tackled firstly. By substituting values into Equations (67.11), (67.12), (67.16) and (67.17), and it follows from Equations (67.20) and (67.21), we obtain UAM and LAM as Equations (67.21) and (67.22), respectively. These two models are RS-based hGA and ran on MATLAB. Let $\rho = 0.8$ and obtain $h* = 4.8172$ by rough simulation. Let $\lambda = 0.7$ and use hGA to solve the two models. Essential parameters are: $N_p = 50$, $P_c = 0.5$, $P_m = 0.05$, $N_g = 200$, $[\Delta_{\min}, \Delta_{\max}] = [0.75, 1]$, $[\delta^0_{\min}, \delta^0_{\max}] = [0.65, 1]$. The results of UAM are: $d_1 = 11.3812$, $d_2 = 14.5173$, $f_1 = 24.2269$, $f_2 = 23.5671$, $h_1 = 9.0173$, $h_2 = 8.8524$, $p_1 = 38.5024$, $p_2 = 37.6083$, $m_1 = 2.0244$, $m_2 = 2.1208$. The results of LAM are: $d_1 = 10.5876$, $d_2 = 13.2731$, $f_1 = 23.5824$, $f_2 = 22.6723$, $h_1 = 8.2347$, $h_2 = 8.7236$, $p_1 = 37.6238$, $p_2 = 36.8234$, $m_1 = 2.0239$, $m_2 = 2.0989$. The difference between the results of UAM and LAM reflects the DM's different risk attitudes. The results can provide flexible choices for DM. If the core enterprise are not satisfied for the results, he/she can adjust the values of $\Delta_{\min}$, $\Delta_{\max}$, $\Delta^0_{\min}$, $\Delta^0_{\max}$.

By running the above algorithm to solve UAM, we find the variance is small (0.5824), which shows the stability of the algorithm.

67.7 Conclusions

In this paper, a distribution system modelling problem in which the manufacturer is the core enterprise is considered. After the problem analysis, a decentralized bi-level programming model with fuzzy parameters is constructed.

Through the model proposed in this paper, the benefit of each enterprise in the supply chain distribution system is well balanced, and the uncertain phenomenon is well handled. Future reach may focus on the different uncertain environment (e.g. random) in the supply chain distribution system.

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Chapter 68
The Selection of Supply Chain Strategic Partners

Hongchun Wang and Yimiao Lv

Abstract Enterprises were set in competition through the supply chain against each other, and the first issue is to choose partners to construct the supply chain. According several principles, an evaluation index system, which contains product competitiveness, the enterprise internal competitiveness, and cooperation competitiveness, was established; indexes weight were calculated by AHP; and a new method to select supply chain strategic partners is put forward in this paper.

Keywords Supply chain · Partners · AHP

68.1 Introduction

Worldwide interest in supply chain management has increased steadily since the 1990s when organizations began to see benefits of collaborative relationships in an era filled with rapid development in economic, technology, management and market. As the concepts of horizontal got more and more attention [1], there was a cooperation among enterprises, named as "combination of giants", which was reflected in the change of business environment. Thus they can increase the competitive advantage and reduce the enterprise cost by keeping each enterprise's core strengths and outsourcing uncompetitive services to other companies [2]. However, anticipated advantages of supply chain did not get a high level [3] and not every enterprise in the supply chain achieved success in the end [4]. Actually the preceding selection of strategic partners provides a basis to the formation of supply chain, modeling of organization structure and processing of operation. And the efficiency of supply chain was influenced by business type, financial condition, technical efficiency,

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strategic target, the consistency of the culture, credit worthiness, etc. In the development of business relationship, the published material mainly consists of traditional enterprise relationship stage characterized by technology and management innovation, logistics relationship stage represented as manufacturing industry innovation and technological development and strategic partnership stage aimed at strategic assistance. As strategic partnership was viewed as the highest cooperation level [5], a higher level of cooperation and integration was pursued, low cost and high quality was called for, profits and customer satisfaction was required among enterprises, which is the formation reasons of strategic partner pattern. The preceding selection and evaluation made a premise to ensure supply chain operate smoothly and efficiently.An efficient supply chain strategic partner evaluation system was established in this paper based on AHP.

68.2 The Principles to Establish Strategic Partners Evaluation System

(1) The principle of comprehensive and systematic

Various aspects must be considered as much as possible when indexes were selected. Partners must provide the supply chain with their own core competence [6] which mainly involves in contribution of product development, advantages of the leading enterprises [7] and technical capacity.

(2) The principle of scientific and conciseness

Good indexes should be clear and tightly focused [8], and the evaluation process should be simplified.

(3) The principle of stability and comparability

Indexes of investment consciousness [9] such as the time, manpower and material resources and the rate of special assets which determines exit risks must be comparable among enterprises.

(4) The principle of operability

The data for evaluation was operability-required.

(5) The principle of qualitative and quantitative analysis

The index system is designed for giving quantitative description such as financial and quality as well as qualitative analysis.

(6) The principle of dynamic adaptability

The development process of companies must be taken in to consideration while innovation capability and development prospect be reflected. A major goal of supply chain strategy is be flexible in reallocating resources to new opportunities [10]. For this reason, fast responses to customer demand, core enterprises and partners were eagerly pursued in alternative companies.

(7) The principle of flexibility

Index system should be improved and expanded with the market conditions, adjustment of enterprise target and can be updated according to the specific situation of market.

68.3 The Strategic Partner Index System

Research result shows that the establishment of index system can be defined from three aspects: product competence, cooperation and internal competence in companies.

68.3.1 Product Competence

The section proposed a framework of product competence, and three indexes that determined the ability were presented. The indexes are: product quality, product cost and product flexibility. A company can not be survived without good product quality, and cost directly influenced product competitiveness as well as flexibility played a great effect on demand response.
(1) Product quality

The index quality can reflect the product quality and customer demand, and it can be measured with function performance, safety, usability and reliability.

- Product qualification rate
  The concept of product qualification rate is the ratio of qualified products number in to total product number.
- Rate of rework
  In practical terms, we can define the rate of rework as the ratio of the repaired products number in to the total product number in a period of time. The formula can be expressed as follows:
  Repair return rate=reprocessed product number/total product $*100\%$,
  Repair return rate=return product number/total sales product $*100\%$.
  The reprocessed product due to equipment accuracy or operation mistake, and the return product caused by transport damage or products are unconformable to the customer requirements.
- Quality system authentication
  Quality system authentication can strengthen internal management, improve product quality increase enterprise efficiency, expand market share, be beneficial to the economic cooperation and technological exchange between enterprises.

(2) Product cost

- Manufacturing cost
  Both direct cost such as direct material and direct labor costs in products manufacturing, and indirect cost like delivery service cost were concluded. material consumption level and equipment utilization rate can be reflected in manufacturing cost. The formula is:
  manufacturing materials=indirect materials cost+indirect labor cost+indirect cost in single product.

- Distribution cost
  Distribution cost is the total expanse in delivery process, named many links payment. The formula is:
  distribution cost=distribution transportation cost+sorting cost+assembling cost +processing cost.
  Distribution cost can indicate the level of enterprise's system.
- Inventory cost
  Inventory cost refers to the storage cost in warehouse, which mainly involved in inventory holding cost, obtain cost, shortage cost, ordering cost, acquisition cost, storage cost. The formula is:
  inventory cost=inventory holding cost+obtain cost+shortage cost+ordering cost +acquisition cost+storage cost.
- Recovering cost
  Recovering cost contains edge recycling cost in manufacturing process and defective goods and trash recycling cost in transport, storage, disassemble process.

(3) Product flexibility

- Substitutability
  The indicate was used to show the enterprise capability of changing suppliers and the enterprise influence,
- Batch flexibility
  Batch flexibility reflected the ability of bulk-production and viability in dynamic demand.
- Varieties flexibility
  Varieties flexibility means various materials with high quality can be produced quickly and economically in the scenio of product update or production shifts.
- Emerging needs flexibility
  Emerging needs flexibility refers to manufacturing system or process change or adjust its system, add module so as to adapt to product/materials changes

68.3.2 The Enterprise Internal Competitiveness

In addition to enterprise external competitiveness indicators, internal indexes conclude production capacity, management level, capacity development and delivery ability also need to be focused on.
(1) Production capacity

- Fixed assets investment rate
  Fixed assets investment rate reflect the competitiveness of enterprises, and it can be evaluated in production equipment, transportation tools, instruments, building and the fixed asset investment which indicate scale of production capacity. The formula is:
  Fixed assets investment rate=fixed asset investment/total assets $*100\%$.

- Manufacturing process optimization
  The concept of manufacturing process optimization refers to analyze the general flow chart of system, find out core factor in every department,try to eliminate rework and parts round handling, reduce work-in-process between adjacent processes within reasonable process steps.
- Labor productivity
  The labor productivity is the number of product made by the same labor in a certain period of time. The more the product produced in unit time, the higher labor productivity reached. It reflected the ratio of the fruits of labor in labor consumption. The formula is:
  labor productivity=product quantity/production time$*$100%.
- Idealness ratio of plant
  Idealness ratio of plant is the ratio of unused equipment sets in all equipment sets. The formula is:
  idealness ratio of plant=unused equipment sets/all equipment sets$*$100%.

(2) Management level

- Strategic goal setting
  Strategic goal setting is the reifiable enterprise mission and a larger target pursuited and concerned by companies, which also provides the evaluation criterion and the basis for evaluation and decision on strategic programmes.
- Experience of top-managers
  The indicator allow us to evaluate manager ability to make the right decisions in academic level and working ambit.
- Organization structure
  Organization structure is arrangement sequence of every department, contact information and framework of management system, which needs to vary to respond the change of corporation's strategic goal so as to achieve the strategic target.
- Human resources training and testing
  Human resources training and testing concludes human resources training time, investment and appraisal way, which refers to realize the management goal by improving job skills and enthusiasm.

(3) Development capacity

- Research input rate
  Research input is related to corporate further development. The more the investment input, the greater the development potential is. The formula is:
  research input rate=scientific research funds/total profit $*$100%.
- Innovation product development cycle
  Innovation product development cycle refers to propose originality, chose technology and equipment, brand packaging, experiment, sales and service training, etc.
- Success rate of new product development
  The formula is:

new product development success rate=successful new product quantity/total product quantity∗100%.
The index shows that the efficiency of the new product development, the higher the index appears, the stronger research and development ability is.

- Knowledge renewal
Staff's learning ability and knowledge renewal refers to a total duration employees accept internal and external training in a certain period of time, this index signal the emphasis on staff training, and whether promoting a new product new policy measures succeed or not eventually.

(4) Delivery performance

- On time delivery rate
The formula is:
On time delivery rate=on time delivery times/total delivery times∗100%.
- Correct delivery ratio
The formula is:
correct delivery ratio=the correct delivery times/delivery total number∗100%.
- Bulk delivery delivery ratio
Bulk delivery delivery ratio is the ratio of bulk delivery times to total delivery times. The formula is:
bulk delivery delivery ratio=mass delivery times/delivery total number∗100%.

68.3.3 Collaborate Capability

Collaborate capability can be analysed in enterprise reputation, compatibility, communication ability and development environment.
(1) Enterprise credit
As credit is an important factor in choosing a parter, companies with cooperation experience can obtain the chance easier. In addition to this indicator, contractual capacity and repaid credit are also essential indexes.

- Cooperation experience
Previous cooperation experience can be appraised from three dimensions: the number of cooperation, the scope of cooperation, cooperation time.
- Contractual capacity
Contractual capacity include two aspects: one is rigorous performance of contract, and the other is effective and full implementation of the contracts.
- Repaid credit
Repaid credit is the ratio of repayment amount in all loans. The formula is:
repayment rate=payment-in-time/loan amount∗100%.
- Environmental measures
Environmental measures contains using green materials in manufacturing process, green technology, waste liquid discharge and harnessing environment input.

(2) Compatibility

Here concludes four indicators: culture, strategy compatibility degree, environmental consciousness similarity and information system compatibility.

- Culture compatibility
  The enterprise culture compatibility reflects unique enterprise characteristic of value orientation, management style, which was used to direct employees' activities.
- Strategic target compatibility
  Strategic target points out the future development in along period, which needs fit strategy compatibility.
- Environmental consciousness similarity
  Several aspects of cooperation such as price negotiation of green materials and selection of packaging materials might be affected without an agreement on environmental protection.
- Information system compatibility
  Department information has been realized such as financial, market and other units information, how to address information integration in the whole enterprise and among them matters the success of supply chain.

(3) Communication capability

Communication skills is not just not only a basic quality to speak clearly but also the share in information and warning timely.

- Communication degree
  Communication degree can be evaluated in three dimensions: willing to communicate, communication frequency and agreements reached.
- Information sharing
  The contents of information includes market demand, stock information, the information of substitute.
- Crisis warning
  The indicator refers to the capability of finding out the risks in cooperation and notifying timely.

(4) Development environment

- Political and legal environment
  Political and legal environment can be evaluated in different national policy, economic system, trade agreement, etc.
- Technical and economic environment
  Technical and economic environment can be measured in technology and economic development conditions such as the ability to develop new products, per capita income level, the market capacity, etc.
  • Geographic location
  Take enterprise own position and cooperation enterprise distance into consideration, geographic location can reflected transportation cost directly.

Table 68.1 AB layer judgment matrix, corresponding weight and consistency inspection results

A	B1	B2	B3	λ_{max}	Weight column matrix	C.I.	C.R.
B1	1	1/3	1/5	3.0385	0.1506	0.0190	0.0330
B2	3	1	1/3		0.3715		
B3	5	3	1		0.9161		

Notes: B1—product internal competitiveness, B2—enterprise internal competitiveness, B3—cooperation ability.

Table 68.2 B1C layer judgment matrix, corresponding weight and consistency inspection results

B1	C1	C2	C3	λ_{max}	Feature vector	Single weight	C.I.	C.R.
C1	1	3	4	3.0735	0.9027	0.6144	0.0367	0.0633
C2	1/3	1	3		0.3943	0.2683		
C3	1/4	1/3	1		0.1722	0.1172		

Notes: B1—product internal competitiveness, C1—product quality, C2-product cost, C3—product flexibility.

Table 68.3 B2C layer judgment matrix, corresponding weight and consistency inspection results

B2	C4	C5	C6	C7	λ_{max}	Feature vector	Single weight	C.I.	C.R.
C4	1	3	4	5	4.111	0.8836	0.5408	0.5408	0.2297
C5	1/3	1	2	3		0.3754	0.2297		
C6	1/4	1/2	1	3		0.2508	0.1535		
C7	1/5	1/3	1/3	1		0.1239	00.07		

Notes: B2—enterprise internal competitiveness, C4—production capacity, C5—management level, C6—development capacity, C7—delivery capacity.

Table 68.4 B3C layer judgment matrix, corresponding weight and consistency inspection results

B3	C8	C9	C10	C11	λ_{max}	Feature vector	Single weight	C.I.	C.R.
C8	1	4	5	6	4.1279	0.9232	0.599	0.0426	0.0474
C9	1/4	1	2	3		0.3063	0.1987		
C10	1/5	1/2	1	3		0.2077	0.1347		
C11	1/6	1/3	1/3	1		0.104	0.0675		

Notes: B3—collaborate capability, C8—enterprise credit, C9—compatibility, C10—Communication skill, C11—development environment.

68.4 AHP in Strategic partner selection and evaluation

L. Saaty, an American operations researcher, proposed Analytic Hierarchy Process (AHP) in 1970s, which refers to a hierarchical and structured decision-making method that make the decision-making process modelized and quantified. Basic steps include: establishing the hierarchical structure model, structuring a judge ma-

Table 68.5 C1D layer judgment matrix, corresponding weight and consistency inspection results

C1	D11	D12	D13	λ_{max}	Feature vector	Single weight	C.I.	C.R.
D11	1	5	7	3.0649	0.914	0.6491	0.0320	0.0559
D12	1/5	1	5		0.3928	0.2789		
D13	1/7	1/5	1		0.1013	0.0719		

Notes: C1—product quality, D11—product pass rate, D12—repair and return ratio, D13—quality certification system.

Table 68.6 C2Dlayer judgment matrix, corresponding weight and consistency inspection results

C2	D21	D22	D23	D24	λ_{max}	Feature vector	Single weight	C.I.	C.R.
D21	1	1/5	1/4	3	4.1323	0.1879	0.1149	0.0441	0.0490
D22	5	1	2	6		0.8231	0.5033		
D23	4	1/2	1	5		0.5269	0.3222		
D24	1/3	1/6	1/5	1		0.0974	0.0595		

Notes: C2—product cost, D21—production cost, D22—delivery costs, D23—inventory cost, D24—recovery cost.

Table 68.7 C3D layer judgment matrix, corresponding weight and consistency inspection results

C3	D31	D32	D33	D34	λ_{max}	Feature vector	Single weight	C.I.	C.R.
D31	1	6	4	3	4.0813	0.8859	0.5494	0.0271	0.0301
D32	1/6	1	1/3	1/4		0.1047	0.0649		
D33	1/4	3	1	1/2		0.2364	0.1466		
D34	1/3	4	2	1		0.3852	0.2389		

Notes: C3—product flexibility, D31—substitutability, D32—batch flexibility, D33—varieties flexibility, D34—emerging needs flexibility.

Table 68.8 C4D layer judgment matrix, corresponding weight and consistency inspection results

C4	D41	D42	D43	D44	λ_{max}	Feature vector	Single weight	C.I.	C.R.
D41	1	9	3	7	4.2058	0.9045	0.5942	0.0600	0.0762
D42	1/9	1	1/7	1/5		0.0593	0.03		
D43	1/3	7	1	3		0.3853	0.2531		
D44	1/7	5	1/3	1		0.1729	0.1136		

Notes: C4—production capacity, D41—Fixed assets investment rate, D42—manufacturing process optimization, D43—labor productivity.

trix and assignment, order in hierarchical single sort, hierarchy total sequencing and inspection. Table 68.1 is the results of the judgment matrix, corresponding calculated weight, and consistency check.

Table 68.9 C5D layer judgment matrix, corresponding weight and consistency inspection results

C5	D51	D52	D53	D54	λ_{max}	Feature vector	Single weight	C.I.	C.R.
D51	1	3	5	7	4.2281	0.8553	0.5437	0.0760	0.0840
D52	1/3	1	5	7		0.4891	0.3109		
D53	1/5	1/5	1	3		0.1533	0.0974		
D54	1/7	1/7	1/3	1		0.0753	0.0478		

Notes: C5—management level, D51—strategic goal setting, D52—experience of top managers, D53—organization structure, D54—human resources training and testing.

Table 68.10 C6D layer judgment matrix, corresponding weight and consistency inspection results

C6	D61	D62	D63	D64	λ_{max}	Feature vector	Single weight	C.I.	C.R.
D61	1	3	1/5	1/6	4.0925	0.1446	0.0916	0.0300	0.0531
D62	1/3	1	1/8	1/9		0.0671	0.0425		
D63	5	8	1	1/2		0.541	0.342		
D64	6	9	2	1		0.8258	0.5231		

Notes: C6—development capacity, D61—research input rate, D62—innovation product development cycle, D63—success rate of new product development, D64—knowledge renewal.

Table 68.11 C7Dlayer judgment matrix, corresponding weight and consistency inspection results

C7	D71	D72	D73	λ_{max}	Feature vector	Single weight	C.I.	C.R.
D71	1	4	3	3.0183	0.9154	0.625	0.0091	0.0101
D72	1/4	1	1/2		0.1999	0.1364		
D73	1/3	2	1		0.3493	0.2384		

Notes: C7—delivery performance, D71—on time delivery rate, D72—correct delivery ratio, D73—bulk delivery delivery ratio.

Table 68.12 C8D layer judgment matrix, corresponding weight and consistency inspection results

C8	D81	D82	D83	D84	λ_{max}	Feature vector	Single weight	C.I.	C.R.
D81	1	3	5	6	4.0788	0.8903	0.5636	0.0262	0.0452
D82	1/3	1	3	4		0.4069	0.2576		
D83	1/5	1/3	1	2		0.1729	0.1094		
D84	1/6	1/4	1/2	1		0.1093	0.0692		

Notes: C8—enterprise credit, D81—cooperation experience, D82—contractual capacity, D83—repaid credit, D84—environmental measures.

68.4.1 Suppose

We take object layer as A, criteria layer as B, and index layer was settled as C and sub-index layer *D*. According to the number of graphic design, the judgment matrixes of the index system are shown in Tables 68.1 $\sim$ 68.16.

Table 68.13 C9D layer judgment matrix, corresponding weight and consistency inspection results

C9	D91	D92	D93	D94	λ_{max}	Feature vector	Single weight	C.I.	C.R.
D91	1	4	5	3	4.2538	0.869	0.5327	0.0846	0.094
D92	1/4	1	1/3	1/4		0.1214	0.0744		
D93	1/5	3	1	1/3		0.2095	0.1284		
D94	1/3	4	3	1		0.4315	0.2645		

Notes: C9−compatibility, D91−culture compatibility, D92-strategic target compatibility, D93−environmental consciousness similarity, D94−information system compatibility.

Table 68.14 C10D layer judgment matrix, corresponding weight and consistency inspection results

C10	D101	D102	D103	λ_{max}	Feature vector	Single weight	C.I.	C.R.
D101	1	3	5	3.1851	0.8846	0.6093	0.0925	0.159
D102	1/3	1	6		0.4519	0.3112		
D103	1/5	1/6	1		0.1154	0.0795		

Notes: C10−communication capability, D101−communication degree, D102−information sharing, D103−crisis warning.

Table 68.15 C11D layer judgment matrix, corresponding weight and consistency inspection results

C11	D111	D112	D113	λ_{max}	Feature vector	Single weight	C.I.	C.R.
D111	1	3	4	3.1973	0.8791	0.5956	0.0986	0.17
D112	1/3	1	5		0.4552	0.3083		
D113	1/4	1/5	1		0.1415	0.0958		

Notes: C11−development environment, D111−political and legal environment, D112−technical and economic environment, D113−geographic location.

68.4.2 the results of index weight were calculated based on MATLAB7.1 [12]

The matrix eigenvalue and characteristic vector are shown in Table 68.17.

$\lambda_{max} = 4.2058$, the corresponding feature vector for $w = (0.9045, 0.0593, 0.3853, 0.1729)^T$, the normalizing result is $\bar{w} = (0.5943, 0.0389, 0.2531, 0.1136)$, each element is processed with $\bar{b}_{ij} = b_{ij}/\sum_{k=1}^{n} b_{kj}\ (i = 1, 2.\cdots, n)$.

68.4.3 Consistency of Judgments

While multiple pairwise comparisons improve accuracy, decisions makers' judgments still cannot be measured with absolute certainty and therefore can be inconsistent with their valuations. For example, if a decision maker prefers A to B, and

Table 68.16 The fundamental scale for pairwise comparisons [11]

Intensity	Definition	Explanation
1	Equal importance	Two activities contribute equally to the objective
3	Moderate importance	Experience and judgment slightly favor one activity over another
5	Strong importance	Experience and judgment strongly favor one activity over another
7	Very strong importance	One activity is favored very strongly over another; its dominance demonstrated in practice
9	Extreme importance	Evidence favoring one activity over another is of the highest possible order of affirmation
2,4,6,8	For compromise between above values	

Table 68.17 The matrix eigenvalue and characteristic vector

C4	D41	D42	D43
D41	1	9	3
D42	1/9	1	1/7
D43	1/3	7	1
D44	1/7	5	1/3

Table 68.18 Consistency ratio calculations

Multiplicity	1	2	3	4	5	6	7	8	9	10
R.I.	0	0	0.58	0.9	1.12	1.24	1.32	1.41	1.45	1.49

C.R. = C.I./R.I. = 0.06/0.9 = 0.0762.

then B to C, we can expect A to be preferred to C. However, inconsistency arises when the decision maker prefers C to A. Inconsistency is measured by the consistency ratio (C.R.) and it is generally acceptable if C.R. < 0.10. When CR becomes relatively large (> 0.10), then its reasons should be explored. The consistency index is given by C.I. $= \lambda_{\max} - n/n - 1$, C.R. = C.I./R.I., where n are number of criteria, and max is the maximum eigenvalue which was provided by the eigen function in *R*. Details of consistency ratio calculations are provided in Table 68.18.

Like before, we can get the criteria priority weights from the aggregated comparison matrix in Table 68.19.

68.5 Conclusions

In this brief issue we showed how to use the analytic hierarchy process (AHP) for making decisions combined objective judgments with expert opinions, decisions can be explained, rationalized, and reviewed to assess which factors had the biggest influence on the final decision or ranking (also called sensitivity analysis). While

Table 68.19 Weights table

	Weight	Serial no.	Criteria	Weight	Serial no.	Alternative	Weight
B1 Product internal competitiveness	0.1047	C1	Product quality	0.0643	D11	Product pass rate	0.0417
					D12	Repair and return ratio	0.0179
					D13	Quality certification system	0.00462
		C2	Product cost	0.0281	D21	Production cost	0.00323
					D22	Delivery cost	0.0141
					D23	Inventory cost	0.00905
					D24	Recovery cost	0.00167
		C3	Product flexibility	0.0123	D31	Substitutability	0.006
					D32	Batch flexibility	0.007
					D33	Varieties flexibility	0.001
					D34	Emerging needs flexibility	0.002
B2 Enterprise internal competiteness	0.2583	C4	Production capacity	0.1397	D41	Fixed assets investment rate	0.5943
					D42	Manufacturing process optimization	0.0389
					D43	Labor productivity	0.2531
					D44	Idealness ratio of plant	0.1136
		C5	Management level	0.0593	D51	Strategic goal setting	0.0322
					D52	Top managers experience	0.0184
					D53	Organization structure	0.0057
					D54	Resources training and testing	0.0028
		C6	Development capacity	0.0396	D61	Research input rate	0.0037
					D62	Innovation product development cycle	0.0016
					D63	Success rate of new product development	0.013
					D64	Knowledge renewal	0.6207
		C7	Delivery performance	0.0196	D71	On time delivery rate	0.0122
					D72	Bulk delivery delivery ratio	0.0026
					D73	Correct delivery ratio	0.0046
B3 Collaborate capability	0.6369	C8	Enterprise credit	0.3815	D81	Cooperation experience	0.215
					D82	Contractual capacity	0.0982
					D83	Repaid credit	0.0417
					D84	Environmental measures	0.0263
		C9	Compatibility	0.1266	D91	Culture compatibility	0.0674
					D92	Strategic target compatibility	0.0094
					D93	Environmental consciousness similarity	0.0163
					D94	Information system compatibility	0.0335
		C10	Communication capability	0.0858	D101	Communication degree	0.0523
					D102	Information sharing	0.0267
					D103	Crisis warning	0.0068
		C11	Development environment	0.0423	D111	Political and legal environment	0.0251
					D112	Technical and economic environment	0.013
					D113	Geographic location	0.0041

the AHP does require some matrix algebra, this can easily be handled using a freely available software MATLAB.

The paper set up a index system for the selection of supply chain parters and calculated the corresponding weight of product, enterprise and cooperation ability aspects, which form the basis for next research.

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Chapter 69
A Coordination-based Two-stage Algorithm for Pickup and Delivery of Customers to Airport

Zhengzheng Xu and Jiafu Tang

Abstract This paper studies the vehicle routing and scheduling problem of pickup and delivery of customers to airport. Different from previous method, we propose a new model and algorithm to solve it. Firstly, we employ the vehicle coordination to improve the practical vehicle scheduling. And the customer satisfaction degree and vehicles circumvention is considered to build our model. Secondly, the vehicles are divided into both basic vehicles and coordination vehicles. Furthermore, a multi-objective model with constraints is proposed. Thirdly, the isolated customer point is defined to decide which vehicles will take part in coordination. According to the vehicle coordination in the pickup and delivery of customers to airport, we propose a two-stage heuristic algorithm, which is based on the coordination in the driving route, to overcome quickly the problem. Finally, we conduct a series of test to validate our algorithm. Simulation results show that the algorithm proposed in this paper is feasible and promising.

Keywords Vehicle coordination · Satisfaction degree · Isolated customer point · Heuristic algorithm · Pickup and delivery service

69.1 Introduction

The vehicle routing and scheduling, which is significantly important for the modern logistics engineering and transportation, has received the extensive attention and

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studied well. The Vehicle Routing and Scheduling Problem of pickup and delivery of customers to airport (VRSP) is an extended application of the Vehicle Routing Problem with Time Windows (VRPTW) [1]. VRSP pay an important role in the travel by plane, especially in China. It can enhance the competitive power of flight ticket sales companies and provide customers with the better service. As an addition service, the cost of VRSP is a primary problem of flight ticket sales companies to take in account. However, the existing VRSP methods hardly consider the vehicle coordination [2]. As a result, this is lead to increase the additional cost of flight ticket sales companies. And thus the coordination-based VRSP is currently paid more attention to [1–4].

Generally, if flight ticket sales companies do not consider the vehicle coordination when they arrange vehicles for each customer or customer point, the more vehicles and more number of trips of pickup and delivery are needed to meet the requirement of VRSP. In fact, some vehicles and number of trips are unnecessary for the whole pickup and delivery service [3, 4]. Therefore, in such a case, companies are to support considerable expenses and in turn affect their market competitiveness [4–6]. In this paper, we take into consideration the vehicle coordination to reduce the cost of companies and raise the utilization ratio of vehicles. Some vehicle coordination methods are proposed to solve the Vehicle Routing problem (VRP). Baldacci et al [1] studied the capacitated vehicle routing problem and the vehicle routing problem with time windows. Najera and Bullinaria [2] presented a multi-objective evolutionary algorithm to the vehicle routing problem with time windows. Szeto et al [5] exploited an artificial bee colony heuristic to study the capacitated vehicle routing problem. Yu and Yang [6] used an ant colony algorithm to solve period vehicle routing problem with time windows. Hong [7] investigated the dynamic vehicle routing problem with hard time windows. Vidal et al [8] studied the multi-depot VRP, the periodic VRP, and the multidepot periodic VRP with capacitated vehicles and constrained route duration. Drexl [9] reviewed the vehicle routing problems with multiple synchronization constraints. Dong et al [10] studied the VRSP with set-partitioning model. Lin [11] proposed a cooperative strategy to solve VRPTW for goods transportation.

Different from previous method in VRP, for VRSP, we can in advance get the customer point information such as customer point position, boarding time information, number of customers and so forth. The vehicle coordination of VRSP refers to the case that the customers at the customer point are taken to the airport in the vehicle coordination way. Due to the different constraints, some customers at the customer point are to be sent to the airport respectively. How to deal with these customer points effectively, improve vehicle utilization rate and reduce the cost of transportation is a very important problem to be solved in the current VRSP. In this paper, we propose the concept of isolated customer point in the vehicle coordination. By considering the customer satisfaction level and vehicles circumvention, we model the vehicle routing and scheduling problem of pickup and delivery of customers to airport as a multi-objective optimal problem. And then according to the isolated points, we can decide which vehicles are to take part in the coordination. According to our model and the vehicle coordination in the airport pickup and delivery service, we propose a two-stage heuristic algorithm based on the coordination in the driving route. Simulation results show that our algorithm can obtain the promising results for VRSP.

69.2 Problem Statement

For a planning cycle (such as one day) of the flight ticket sales company, we exploit the customer information to perform the vehicle routing and scheduling in VRSP. In other word, the considered information of customer to travel by plane in a planning cycle is including flight number, pickup location, and pickup time requirement. And in order to attain the minimal cost and the largest satisfaction degree of customers, we model our VRSP in the vehicle coordination way by taking in account the number of trips and the time of each vehicle trip to set out. At the same time, we are also to consider the customers to pick up, pickup order of customers, and pickup time in the same vehicle trip.

Now, to describe and model the above problem, we make the following assumptions:

- There is only one depot and one airport.
- Regard the customers with the same boarding time requirements and in the same location as a whole indivisible [5], namely as a customer point. Otherwise, customers are regarded as the different customer point.
- The number of customers for each customer point is less than or equal to the carrying capacity of the vehicle.
- Each vehicle serves a loop, starting from the depot and eventually returning to the depot.
- The vehicle is the same type with a capacity of 4 people; the number of vehicles is unlimited.
- The vehicles are all at a constant speed, meet just-in-time service, ignore the on and off time, and we do not consider the delay and waiting.
- The required customer transfer time is ignored in the process of vehicle coordination.
- The basic vehicles and coordination vehicles are met in an ideal state, without waiting time. Here, the coordination vehicle is the one which starts from the depot to pick up customers but does not reach the destination, only assisting the basic vehicle to finish the pickup and delivery task.The basic vehicle refers to the one which sets out from the depot to pick up customers and carry the customers to the destination. One trip of the basic vehicle, which is regarded as one vehicle, is a process that the basic vehicle sets out from the depot to pick up the customers and send them to the destination and then go back to the depot. One trip of the coordination vehicle, which is also named as one vehicle, is a process that the coordination vehicle starts from depot to pick up customers and transfers them to the basic vehicle and then goes back to depot.

Here, we give the below notation for our problem statement. U denotes the planning cycle which is generally one day, $C = \{1, 2, \cdots, n\}$ represents the set of customer points, 0 stand for the depot position, the set N is satisfied with $N = C \bigcup \{0\}$, the $n+1th$ point expresses the airport location, $N' = C \bigcup \{0\} \bigcup \{n+1\}$ denotes the set of all locations, ω_i represents the number of customers of customer point i, α is the satisfaction level which is acceptable by customers, $K = \{1, 2, \cdots, m\}$ is the set of vehicles, $k \in K$ denotes the kth vehicle, δ_{ik} is an arrival time of vehicle k to customer point i, Q represents the capacity of each vehicle, T_{ij} is the traveling time from customer point i to customer point j, d_{ij} denotes the distance between customer point i and customer point j, t_i represents the arrival time of the customer point i to the airport, β delivery service to the traveling time that the customer directly move from its position to airport. Additionally, z_k, y_{ik}, x_{ijk} and v_{ijk} are 0-1 variables which are the decision variables for vehicle k. If vehicle k is used, $z_k = 1$, or otherwise $z_k = 0$. If the customers at customer point i is transferred by vehicle k, $y_{ik} = 1$, or otherwise $y_{ik} = 0$. If the basic vehicle k go from i to j, $x_{ijk} = 1$, or otherwise $x_{ijk} = 0$. If the coordination vehicle k travels from i to j, $v_{ijk} = 1$, or otherwise $v_{ijk} = 0$.

In the pickup and delivery service, the satisfaction level of customers is a parameter to consider. We let $[e_i, l_i]$ denote the soft time windows [6] of the customers at customer point i, which the customers expects to reach the airport within. If the customer arrived at the airport during this time windows, the customer would feel very satisfied and the satisfaction level is 100%. As the airlines generally have the restrictions on the check time of each customer, the customers should not reach the airport too early or too late. As mentioned in Hong [7], we define $[e_i^t, l_i^t]$ as the hard time windows. If the time of reaching the airport is smaller than e_i^t or larger than l_i^t, the pickup and delivery service is unacceptable to customers and the satisfaction level becomes 0. If the time of reaching the airport is larger than e_i^t but smaller than e_i, or larger than l_i but smaller than l_i^t, the pickup and delivery service would accept with a satisfaction level. According to the above discussion, the time t_i for customers at customer point to arrive at airport should belong to one of the following time intervals:

$$\begin{cases} \infty < t_i < e'_i, \\ e'_i \leq t_i < e_i, \\ e_i \leq t_i < sl_i, \\ l_i \leq t_i < l'_i, \\ l'_i \leq t_i < \infty. \end{cases} \tag{69.1}$$

Equation (69.1) shows that if the time t_i falls into the different time interval, customers are to obtain the different satisfaction level. To characterizer accurately the satisfaction level of customers, we can define the satisfaction function $S(t_i)$ as follows:

$$S(t_i) = \begin{cases} 1 - p_i, & t_i \in [e_i, l_i], \\ \frac{e'_i - t_i}{e'_j - e_i}(1 - p_i), & t_i \in [e'_i, e_i], \\ \frac{l'_i - t_i}{l'_i - l_i}(1 - p_i), & t_i \in [l_i, l'_i], \\ 0, & t_i \in [e'_i, l'_i], \end{cases} \tag{69.2}$$

where p_i is constant, and $0 \le P_i \le 1$. When the customers at customer point i do not need to be transferred, $p_i = 0$, or $p_i > 0$.

To describe the VSRP with the vehicle coordination, we choose the objective function as follows:

$$\min \left(\sum_{k\in K} \sum_{i\in N'} \sum_{j\in N'} d_{ij} x_{ijk} + \sum_{k\in K} \sum_{i\in N} \sum_{j\in N} d_{ij} v_{ijk} \right), \tag{69.3}$$

where the first term represents the traveling distance of non-cooperative vehicles and the second term represents the traveling distance of the coordination vehicles. Equation (69.3) formulates that we can get the optimal result of VSRP with the vehicle coordination by minimizing the traveling distance.

However, Equation (69.3) only tell us the optimal objective that we can perform VSRP. In fact, to solve Equation (69.3), some constraints should be taken into account. For example, we need to consider the satisfaction level of customers, the limitation of vehicle capacity, constraints of traveling time and so on. According to the above discussion, we model VSRP with the vehicle coordination as follows:

$$\min \left(\sum_{k\in K} \sum_{i\in N'} \sum_{j\in N'} d_{ij} x_{ijk} + \sum_{k\in K} \sum_{i\in N} \sum_{j\in N} d_{ij} v_{ijk} \right), \tag{69.4}$$

subject to

$$S(t_i) \ge \alpha, \quad \forall i \in C, \tag{69.5}$$

$$\sum_{k\in K} \omega_i \gamma_{ik} \le Q, \quad \forall k \in K, \tag{69.6}$$

$$\sum_{j\in N'} (t_i - \delta_{ik}) \gamma_{ik} \le \beta T_{i(n+1)}, \quad \forall i \in C, \tag{69.7}$$

$$\sum_{j\in N'} x_{0jk} = z_k, \quad \forall k \in K, i \ne j, \tag{69.8}$$

$$x_{0(n+1)k} = 1, \quad \forall k \in K, \tag{69.9}$$

$$\sum_{j\in C} v_{0jk} = 1, \quad \forall k \in K, \tag{69.10}$$

$$\sum_{i\in N} v_{ihk} - \sum_{j\in N} v_{hjk} = 0, \quad \forall h \in C, \forall k \in K, \tag{69.11}$$

where Equation (69.4) denotes the objective function, Equations (69.5) $\sim$ (69.11) represent the constraints satisfied with by Equation (69.4). Equation (69.5) ensures that every customer satisfaction degree is not less than α. Equation (69.6) illuminates the vehicle capacity limit is not exceeded. Equation (69.7) describes the vehicle arrives at the airport on condition that the bypass time is acceptable. Equations (69.8) and (69.9) state that each basic vehicle starts from the depot and pass the customer points, go back from the airport to the depot lastly. Equations (69.10) and (69.11) show that each coordination vehicle starts from the depot, pass the customer points, and do not achieve the airport but go back to the depot directly.

Now, we have built our model for the above discussed problem. What it follows is that we discuss and propose our algorithm for this model.

69.3 Heuristic Algorithm

From the above discussion, we know that Equations (69.4) $\sim$ (69.11) describe a multi-object problem with constraints. It is significantly difficult to solve it. Therefore, we propose a two-stage heuristic algorithm based on the vehicle coordination on the driving route in order to obtain the optimal solution.

To decide which vehicles are to take part in coordination, here we give the definition of the isolated (customer) point. If the customers at a customer point have to be sent to the airport separately without coordination, according to some constraints after generating the feasible route and the vehicle clusters, then such a customer point is regarded as the isolated point. Without loss of generality, we take as an example a pickup and delivery service for four customer points shown in Fig. 69.1. In Fig. 69.1, the solid line is the traveling route of a basic vehicle, the dotted line denotes the traveling route of a coordination vehicle, solid circles A, B, C and D represent customer points, solid circle O is the depot, solid circle P stands for the destination (airport), and solid circle E represents the coordination point. Assume customer point A is the isolated point, and thus the vehicle coordination on the driving route is shown in Fig. 69.1.

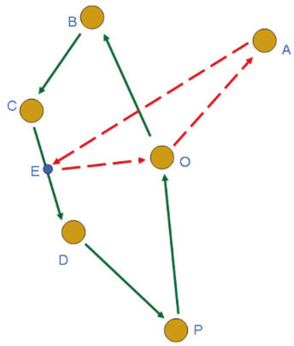

Fig. 69.1 Vehicle coordination on the driving route

Here, we define the mirror point as follows: The mirror point is the symmetric point of a point to a line. To meet the constraints shown in Equations (69.5) $\sim$ (69.11) and build our two-stage heuristic algorithm,we propose the choice regulations for the cooperative transfer point on the driving route as follows:

Regulation 1: When the mirror point of an isolated point exists, we seek the smallest sum of the distance of two points outside a line to a point on the line according to mathematic theory. In terms of the smallest sum of the distance, the transfer point is decided.

Regulation 2: When the mirror point of an isolated point does not exist, we are to choose the transfer point by seeking all points on the line linking two customer points. The point on the line including two customer points, corresponding to the smallest sum of distance to two points outside the line, is regarded as the transfer point.
Regulation 3: If the capacity of the basic vehicle is satisfied with the constraint in Equation (69.7), it, in one trip, can cooperate with several coordination vehicles.

To avoid the difficulty in solving directly the constraint in Equations (69.4) $\sim$ (69.11), we deal with the problem through a two-stage algorithm. In stage 1, we do not take in account the coordination. And we employ the clustering priority heuristic based on time order to generate the initial vehicle trips and access sequence of customers in each vehicle trip. And then the set of isolate points is produced according to the bypass constraints. The detail steps at stage 1 of the proposed heuristic are as follows:
Step 1. Input the information of all customer points, and calculate the latest time of arriving airport. Initialize the basic vehicle set K and isolated point set S.
Step 2. Arrange the customer points from the earliest to the latest in terms of the lower limit of the time windows of arrival, and get the customer point set Ψ.
Step 3. Check whether the set Ψ is empty. If Ψ is empty, then output the basic vehicle set K and isolated point set S and exit.
Step 4. Select the first customer point from Ψ as a set Φ. And cluster Φ and the other customer point ϕ in Ψ which have the same time window with Φ. If the constraints in Equations (69.6) and (69.7), then add ϕ into Φ. Repeat the above operation until all the customers in Φ are checked. And then a cluster set Φ is built.
Step 5. If there is only one customer point in Φ, then add it as a isolated point into set S. Build the full arrangement P of set Φ. Choose the arrangement P with the shortest driving route from . Add P as a vehicle trip into set K.
Step 6. Delete all the customer points in Φ from Ψ and get a new customer point set Ψ'. Let $\Psi = \Psi'$, go back to Step 3.

On the basis of stage 1, stage 2 considers the satisfaction level of customers and coordination regulations proposed above. According to the basic vehicle set K and isolated point set S obtained in stage 1, we here exploit the coordination on the driving route to delivery the customers in S with K. Now we present our detailed steps in stage 2 as follows:
Step 1. Change the satisfaction level of customers in S. And recalculate their time windows of reaching the destination. Consider the constraints in Equation (69.6), and build the subset Z with the same time window in S and K.
Step 2. According to the constraints in Equations (69.4) $\sim$ (69.11) and coordination regulations proposed above, insert the customers in Z and S into the vehicles in Z and K.
Step 3. Delete the inserted isolated point from S. Then get the new sets S' and K.
Step 4. If S is empty, save the results and exit. Or update $S = S'$ and $K = K'$, and go back to Step 1.

So far, we have proposed our two-stage heuristic algorithm based on the coordination on the driving route. Our algorithm can obtain the optimal solution satisfied with our model shown in Equations (69.4) $\sim$ (69.11). What it follows is to further discuss performance of our algorithm.

69.4 Simulation Results and Analysis

In this section, we are to conduct a series of test to validate our algorithm. Simulation scenarios include the 20 customer points with a random distribution, which need to be served within a certain period of flight times (AM 8:00 12:00). Here the customer point instances are generated randomly, and they randomly distribute in a rectangular region by 55 km $\times$ 55 km. The desired soft time window of each customer point is 20 min while the hard time window is 40 min. The maximum customer capacity of each vehicle is $Q = 4$. The depot coordinates are (35, 37) and the airport coordinates are (50, 50). The speed of each vehicle is 0 km/h and the lower bound of the satisfaction level of customers is $\alpha = 0.8$. And let parameters $\beta = 1.5$ and $p_i = 0.1$.

To facilitate our statements, we give the following notation:

CP : Lower bound of Hard time Windows;
LSW : Lower bound of Soft time Windows;
USW : Upper bound of Soft time Windows;
UHW : Upper bound of Hard time Windows;
NC : Number of Customers.

Table 69.1 denotes the information of customer points in our simulation

Table 69.1 Information of customer points

CP	1	2	3	4	5	6	7	8	9	10
LCP	(42,34)	(33,37)	(43,45)	(35,44)	(44,40)	(42,41)	(35,44)	(40,33)	(39,36)	(30,47)
LHW	7:25	7:45	7:35	7:55	7:40	7:50	8:10	8:00	8:05	8:25
LSW	7:35	7:55	7:45	8:05	7:50	8:00	8:20	8:10	8:15	8:35
USW	7:55	8:15	8:05	8:25	8:10	8:20	8:40	8:30	8:35	8:55
UHW	8:05	8:25	8:15	8:35	8:20	8:30	8:50	8:40	8:45	9:05
NC	2	1	1	2	3	1	1	1	2	1
CP	11	12	13	14	15	16	17	18	19	20
LCP	(23,27)	(31,50)	(34,30)	(40,51)	(44,16)	(38,22)	(45,21)	(29,51)	(45,52)	(40,20)
LHW	8:35	9:05	8:30	9:10	8:45	9:15	8:40	8:50	8:55	9:25
LSW	8:45	9:15	8:40	9:20	8:55	9:25	8:50	9:00	9:05	9:35
USW	9:05	9:35	9:00	9:40	9:15	9:45	9:10	9:20	9:25	9:55
UHW	9:15	9:45	9:10	9:50	9:25	9:55	9:20	9:30	9:35	10:05
NC	1	1	3	1	1	1	1	1	1	1

According to Table 69.1, we perform the algorithm steps of stage 1. The initial number of trips and the order of access to customer points in each trip are attained.

The results after running the algorithm steps of stage 1 are shown in Table 69.2. In terms of Table 69.2, we can get the minimum mileage without the vehicle coordination on the driving route.

Table 69.2 Results of our algorithm in stage 1

Vehicle	Departure time	Route	Comments
1	7.15	depot → cp1 → cp3 → airport → depot	-
2	7:36	depot → cp4 → cp6 → airport → depot	-
3	7:27	depot → cp2 → cp5 → airport → depot	-
4	7:50	depot → cp11 → cp13 → airport → depot	-
5	8:03	depot → cp10 → cp7 → airport → depot	-
6	8:26	depot → cp18 → cp19 → airport → depot	-
7	8:45	depot → cp12 → cp14 → airport → depot	-
8	7:41	depot → cp8 → airport → depot	Isolated point
9	7:51	depot → cp9 → airport → depot	Isolated point
10	7:55	depot → cp15 → airport → depot	Isolated point
11	8:37	depot → cp16 → airport → depot	Isolated point
12	7:59	depot → cp17 → airport → depot	Isolated point
13	8:43	depot → cp20 → airport → depot	Isolated point

The route without the vehicle coordination on the driving route is represents in Fig. 69.2, where the isolated points are customer points 8, 9, 15, 16, 17 and 20.

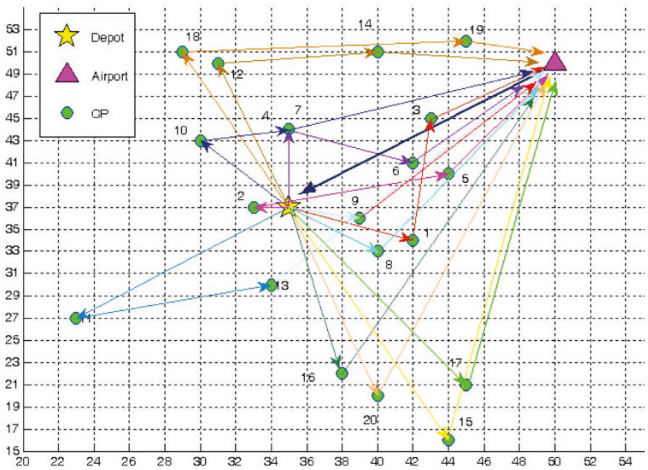

Fig. 69.2 Route of our algorithm in stage 1 without the vehicle coordination on the driving route

According to Table 69.2 and Fig. 69.2, the total vehicle mileage without the vehicle coordination on the driving route can be denoted as:

$$\min \sum_{k\in K}\sum_{i\in N'}\sum_{j\in N'} d_{ij}x_{ijk} = 737 \text{ km}.$$

Base on the results of stage 1, we proceed with performing the algorithm steps in stage 2. And the results of the algorithm steps in stage 2 are shown in Table 69.3.

Table 69.3 Results of our algorithm in stage 2

Vehicle	Departure time	Route	Comments
1	7.15	depot → cp1 → cp3 → airport → depot	-
2	7:42	depot → cp4 → point22(40,42) → cp6 → airport → depot	coordinated
3	7:27	depot → cp2 → cp5 → airport → depot	-
4	7:50	depot → cp11 → cp13 → airport → depot	-
5	8:03	depot → cp10 → point24(35,44) → cp7 → airport → depot	coordinated
6	8:26	depot → cp18 → point23(36,51) → cp19 → point25(47,51) → airport → depot	coordinated
7	9:01	depot → cp12 → point 26(33,50) → point27(34,50) → cp14 → airport → depot	coordinated
8	7:39	depot → cp8 → point22(40,42) → airport → depot	coordinated
9	8:03	depot → cp9 → point24(35,44) → airport → depot	coordinated
10	7:51	depot → cp15 → point25(47,51) → airport → depot	coordinated
11	7:55	depot → cp16 → point27(34,50) → airport → depot	coordinated
12	8.37	depot → cp17 → point23(36,51) → airport → depot	coordinated
13	7:59	depot → cp20 → point26(33,50) → airport → depot	coordinated

Table 69.3 shows that by performing the vehicle coordination on the driving route, the customers of isolated point 8 can be transferred from coordination vehicle 8 to basic vehicle 2 at location (40, 42) on the driving route of basic vehicle 2. The customers of isolated point 9 can be turned from coordination vehicle 9 to basic vehicle 5 at location (35, 44) on the driving route of basic vehicle 5. The customers of isolated points 15 and 17 can be transferred from two coordination vehicles 10 and 12 to basic vehicle 6 at point (47, 51) and point (36, 51) on the driving route of basic vehicle 6, respectively. The customers of isolated points 16 and 20 can also be passed from two coordination vehicles 11 and 13 to basic vehicle 7 at point (34, 50) and point (33, 50) on the driving route of basic vehicle 7, respectively.

Fig. 69.3 denotes the route with the vehicle coordination on the driving route. According to Table 69.3 and Fig. 69.3, the total vehicle mileage can be obtain as follows:

$$\min \left(\sum_{k\in K}\sum_{i\in N'}\sum_{j\in N'} d_{ij}x_{ijk} + \sum_{k\in K}\sum_{i\in N}\sum_{j\in N} d_{ij}v_{ijk}\right) = 672 \text{ km}.$$

From the above simulation, we can find that in contrast to the route without the vehicle coordination on the driving route, our algorithm can drive the mileage less by 65 km. This is because we can effectively consider the coordination among the vehicles and customer points. As a result, we can further decrease the cost of

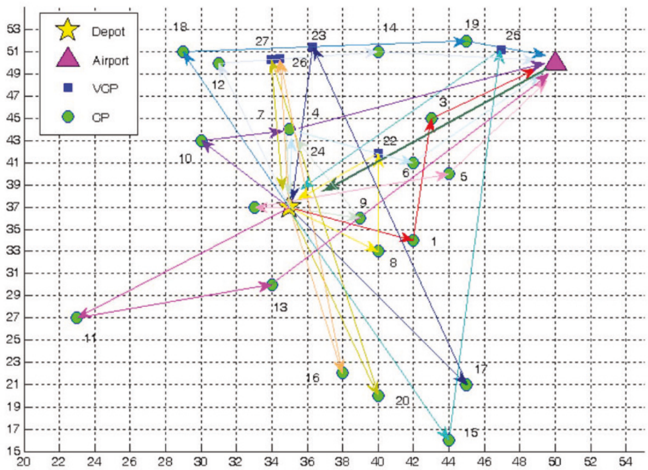

Fig. 69.3 Route of our algorithm in stage 2 with the vehicle coordination on the driving route, where points 22-27 are the transfer

VRSP and improve the utilization of vehicles but not reduce the satisfaction level of customers. This shows that our algorithm in this paper is effective and promising.

69.5 Conclusions

This paper investigated the vehicle routing and scheduling problem of pickup and delivery of customers to airport, based on the vehicle coordination on the driving route. By considering the customer satisfaction degree and vehicles circumvention, we proposed our model for this problem, which fully takes into account the vehicle coordination on the driving route. The isolated (customer) point is used to make sure which vehicles are to perform the coordination process. By the vehicle coordination in the pickup and delivery of customers to airport, a two-stage heuristic algorithm, which is based on the coordination in the driving route, is presented to solve this problem. Simulation results indicates that the algorithm proposed in this paper is promising.

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Chapter 70
Research on the Supply Chain Coordination of the Buyback Contract Based on Sales Effort

Guorui Jiang and Juanyu Liu

Abstract Under demand uncertainty, the issue of how to use buyback contract to achieve supply chain coordination has been a hot topic in supply chain management. In a two-echelon supply chain, consists of a single supplier and a single retailer, we used Stackelberg game method to study the buyback contract model under such conditions that whether the retailer made sales effort or not. The result shows that: (1) the buyback contract model in which the retailer does not make sales effort can achieve supply chain coordination when the shortage cost exists and the supplier does not provide sales incentives; (2) the buyback contract model in which the retailer makes all or part sales effort cannot achieve supply chain coordination but can improve the profits of the supply chain when the shortage cost exists and the supplier does not provide sales incentives; (3) the buyback contract model in which the retailer makes all sales effort can achieve supply chain coordination when the supplier provides sales incentives to the retailer. And in this condition, if the supplier adjusts the wholesale price, when the wholesale price increases, the retailer's profits will decrease and the supplier's profits will increase, by using the buyback reward contract, the model can achieve the supply chain coordination.

Keywords Sales effort · Stackelberg game · Buyback contract · Coordination

70.1 Introduction

It is an important element to use reasonable contract mechanisms to achieve the coordination of supply chain in the study of supply chain coordination. There are some contracts which can achieve the coordination of supply chain: buyback contract; quantity discount contract; quantity flexibility contract; wholesale price contract;

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revenue sharing contract. Cachon [1] has given a good overview about supply chain contract. At present, domestic and foreign experts also have achieved certain results about the supply chain coordination. Shin and Benton [2] have studied a quantity discount problem between a single supplier and a single retailer. They set up a Buyer's Risk Adjustment model under uncertain demand. In this model, the supplier offers quantity discount and shares the retailer's product backlog. The result shows that the model is very effective. Scottwebster [3] constructed a model between a single supplier and a single retailer to study the stochastic demand under the price sensitivity of short-cycle product. Li [4] studied a supply chain coordination model, which contains a single supplier and a single retailer. In the model, the short-cycle products are sold in the retail market, the members of the supply chain use revenue sharing contract to bargain. The result shows that the centralized supply chain can achieve coordination, both the supplier and the retailer can make profits. Qiu and Huang [5] have studied the revenue sharing contract in supply chain contract coordination. They have developed the random expected value model of revenue sharing contract coordination in supply chain with underage cost and analyzed the effect of revenue sharing mechanism for improving the operational performance of entire supply chain. The result shows the random expected value model of revenue sharing contract coordination developed in this paper is practical and coordinates the operation of supply chain with random demand. Suo and Jin [6] developed and analyzed two kinds of Stackelberg game models. One kind of model is that the supplier plays the dominant part; the other is that the retailer plays the dominant part. In these two kinds of models, they developed the Nash equilibrium solution, and also studied the changes of trade price, order quantity and retail price. Zhang and Liu [7] considered a two-stage supply chain consisting of a single supplier and a single retailer and established Stackelberg games of profit division. They used the revenue sharing contract in the games as a profit division approach. And the parameters made by the dominant firm can coordinate the supply chain to the optimal level. Song and Wang [8] considered a two-stage supply chain consisting of a supplier and a retailer. They analyzed the changes of trade price and order quantity when the retailer is dominant. The result shows that asymmetric information will lead to offset the supply chain under uncertain demand information. The supplier and the retailer should seek effective coordination mechanism to overcome this offset.

Using the buyback contract to achieve coordination of the supply chain has also obtained some results. Yao et al [9] analysis the impact of the buyback contract on price sensitivity. They pointed out that by using the buyback contract can improve the total profits of the supply chain, but the increased profits are different among the supply chain members. Xu and Zhu [10] used a constrained buyback contract to achieve the coordination of supply chain. The result shows that the higher the buyback price, the higher profits of the supplier's and the lower profits of the retailer's. Wang and Sang [11] have found that using different trade price and different buyback price can achieve the coordination of supply chain.

At this stage, the market demand of products is influenced not only by retail price but also by the retailer's promotional effort, the retailer's sales effort may stimulate the market demand of products. Huang and Li [12] have explored the role of cooperative advertising in the supply chain by analyzing the advertising makement of the supplier and the retailer, and have developed a shared mechanism to share the cost of advertising. Li and Huang [13] have studied three different game models in a supply chain consisting of a single supplier and a single retailer. The result shows that the total profits of the system in cooperation case are always greater than the non-cooperation's. He and Prasad [14] have constructed an active model, where the supplier decides the wholesale price and advertising share, the retailer decides the advertising makement and retail price. They have found a suitable method which the supplier and the retailer can both make maximum profits. Zhang and Liang [15] have studied how the supplier uses the optimal discount mechanism to improve the advertising cost and order quantity of the retailer. Khouja and Robbins [16] have studied the influence of advertising makement, but they have not studied how to achieve the coordination of supply chain.

The previous studies only consider one supply chain contract or only have made sales effort to determine the retailer's optimal order quantity, few scholars have studied both the two conditions. Considering the two conditions, the study of how to design an effective buyback contract model to achieve the coordination of supply chain is needed.

Considering the conditions of demand uncertainty, this paper will discuss three different conditions. In a single supplier and a single retailer composed of two levels of the supply chain, using two echelon Stackelberg game method to study the buyback contract model, whether the retailer makes sales efforts or not.

70.2 Problem Description and Parameter Defination

In this paper, considering a two-stage supply chain consisting of a single supplier and a single retailer, assuming both are risk neutral and fully rational, and the information is symmetrical. The market changes as the random demand distribution, and it is not allowed out of stock. The supplier provides a short-cycle commodity. When the retailer does not make sales effort, the retailer decides optimal order quantity according to the supplier's wholesale price, When the retailer has made sales effort, the retailer decides optimal order quantity and optimal sales effort according to the supplier's wholesale price.

Related parameters are defined as follows:

p : retailer's retail price of unit product;
w : supplier's wholesale price of unit product;
c : supplier's cost of unit product;
s : shortage cost of unit product;
v : retailer's salvage value of unit product, $s > p > w > c > v$;
b : buyback price of unit product, $p > w > c > b > v$;
T : incentive target (the supplier sets up incentive target to incentive the retailer);

t : it means if the retailer completes the incentive target the supplier will give the excess part per unit product award;
x : the market demand when the sales effort is not input;
$f(x)$: probability density function;
$F(x)$: distribution function;
μ : expect;
σ^2 : vatiance;
e : the degree of sales effort;
$c(e)$: the cost of sales effort;
a : the proportion of the sales effort of the retailerthe proportion of the supplier: $1-a, 0<a<1$;
x_e : the market demand when the degree of sales effort is e;
$f(x_e)$: probability density function when the degree of sales effort is e;
$F(x_e)$: distribution function when the degree of sales effort is e;
π : the total profits of the supply chain;
π_r : the profits of the retailer;
π_s : the profits of the supplier;
$E(Q_sc)$: the total profits function where the sales effort is not input;
$E(Q_sce)$: the total profits function where the sales effort is input;
$E(Q_r)$: the retailer's profits function where the sales effort is not input;
$E(Q_re)$: the retailer's profits function where the sales effort is input;
$E(Q_s)$: the supplier's profits function where the sales effort is not input;
$E(Q_se)$: the supplier's profits function where the sales effort is input;
$E(Q_rte)$: the retailer's profits function where the supplier gives the incentive to the retailer.

70.3 The Buyback Contract Model Where the Sales Effort Is not Input

In a two-stage supply chain consisting of a single supplier and a single retailer, when the retailer does not make sales efforts and the supplier does not provide sales incentives to the retailer, the retailer decides optimal order quantity according to the supplier's wholesale price.

70.3.1 Centralized Decision

The total profits function:

$$E(Q_{sc}) = p\left[\int_0^{Q_{sc}} xf(x)dx + \int_{Q_{sc}}^{\infty} Q_{sc}f(x)dx\right] + v\int_0^{Q_{sc}} (Q_{sc}-x)f(x)dx$$

$$-s\int_{Q_{sc}}^{\infty}(x-Q_{sc})f(x)dx-cQ_{sc}. \tag{70.1}$$

Then

$$\frac{dE(Q_{sc})}{dQ_{sc}}=(p+s-c)-(p+s-v)\int_{0}^{Q_{sc}}f(x)dx. \tag{70.2}$$

When the supply chain profits are maximization, it needs:

$$(p+s-c)-(p+s-v)\int_{0}^{Q_{sc}}f(x)dx=0. \tag{70.3}$$

So $Q_{sc}^{*}=F^{-1}\frac{(p+s-c)}{(p+s-v)}$. The total profits:

$$E(Q_{sc}^{*})=(p+s-v)\int_{0}^{Q_{sc}^{*}}xf(x)-\mu s. \tag{70.4}$$

70.3.2 Dispersion Decision

The supplier's profits function:

$$E(Q_{sc}^{*})=(p+s-v)\int_{0}^{Q_{sc}^{*}}xf(x)-\mu s. \tag{70.5}$$

The retailer's profits function:

$$\begin{aligned}E(Q_r)=\ & p\left[\int_{0}^{Q_r}xf(x)dx+\int_{Q_r}^{\infty}Q_rf(x)dx\right]+(v+b)\int_{0}^{Q_r}(Q_r-x)f(x)dx\\ & -s\int_{(}Q_r)^{\infty}(x-Q_r)f(x)dx-wQ_r. \end{aligned}\tag{70.6}$$

Then:

$$\frac{dE(Q_r)}{dQ_r}=(p+s-w)-(p+s-v-b)\int_{0}^{Q_r}f(x)dx. \tag{70.7}$$

When the retailer's profits are maximum, it needs:

$$(p+s-w)-(p+s-v-b)\int_{0}^{Q_r}f(x)dx=0. \tag{70.8}$$

So $Q_r^{*}=F^{-1}\frac{(p+s-w)}{(p+s-v-b)}$. The retailer's profits:

$$E(Q_r^{*})=(p+s-v-b)\int_{0}^{Q_r^{*}}xf(x)dx-\mu s. \tag{70.9}$$

In this condition, if the model can achieve coordination, it needs: $Q_sc^{*}=Q_r^{*}$. So $\frac{p+s-c}{p+s-v}=\frac{p+s-w}{p+s-v-b}$. Then,

$$b = \frac{(w-c)(p+s-v)}{p+s-c} = (p+s-v) - \frac{(p+s-w)(p+s-v)}{p+s-c} < p+s-v.$$

Now, we can see that when the retailer does not make sales effort and the supplier does not provide sales incentives to the retailer, if the wholesale price has been decided, we can use buyback price $b = \frac{(w-c)(p+s-v)}{p+s-c}$ to achieve the supply chain coordination.

70.4 The Buyback Contract Model When the Retailer Makes All Sales Effort

In this part, we consider the retailer makes all sales effort and the supplier still does not provide sales incentives to the retailer.

70.4.1 Centralized Decision

The total profits function:

$$\begin{aligned} E(Q_{sce}) = \; & p\left[\int_0^{Q_{sce}} x_e f(x_e)dx_e + \int_{Q_{sce}}^{\infty} Q_{sce} f(x_e)dx_e\right] + v\int_0^{Q_{sce}} (Q_{sce} - x_e)f(x_e)dx_e \\ & -s\int_{Q_{sce}}^{\infty} (x_e - Q_{sce})f(x_e)dx_e - cQ_{sce} - c(e) \\ = \; & (p+s-c)Q_{sce} - (p+s-v)\int_0^{Q_{sce}} (Q_{sce} - x_e)f(x_e)dx_e \\ & -\mu_e s - c(e). \end{aligned} \tag{70.10}$$

We assume that:

$$HQ_{sce}(e) = \int_0^{Q_{sce}} (Q_{sce} - x_e)f(x_e)dx_e. \tag{70.11}$$

When the supply chain profits are maximization, it needs:

$$\frac{\partial E(Q_{sce})}{\partial Q_{sce}} = (p+s-c) - (p+s-v)\frac{\partial HQ_{sce}(e)}{\partial Q_{sce}} = 0, \tag{70.12}$$

$$\frac{\partial E(Q_{sce})}{\partial e} = (p+s-v)\frac{\partial HQ_{sce}(e)}{\partial e} + (\partial \mu_e s)/\partial e + \partial c(e)\partial e = 0. \tag{70.13}$$

So $Q^*_{sce} = F_e^{-1}\frac{p+s-c}{p+s-v}$.

70.4.2 Dispersion Decision

The supplier's profits function:

$$E(Q_{se}) = (w-c)Q_{se} - b\int_0^{Q_{se}} (Q_{se}-x_e)f(x_e)dx_e. \tag{70.14}$$

The retailer's profits function:

$$\begin{aligned} E(Q_{re}) = {} & p\left[\int_0^{Q_{re}} x_e f(x_e)dx_e + \int_{Q_re}^{\infty} Q_{re} f(x_e)dx_e\right] + (v+b)\int_0^{Q_{re}} (Q_{re}-x_e) \\ & f(x_e)dx_e - s\int_{Q_{re}}^{\infty} (x_e - Q_{re})f(x_e)dx_e - wQ_{re} - c(e) \\ = {} & (p+s-w)Q_{re} - (p+s-v-b)\int_0^{(} Q_{re})(Q_{re}-x_e)f(x_e)dx_e \\ & -\mu_e s - c(e). \end{aligned} \tag{70.15}$$

We assume that:

$$HQ_{re}(e) = \int_0^{Q_{re}} (Q_{re}-x_e)f(x_e)dx_e.$$

When the retailer's profits are maximum, it needs:

$$\frac{\partial E(Q_{re})}{\partial Q_{re}} = (p+s-w) - (p+s-v-b)\frac{\partial HQ_{re}(e)}{\partial Q_{re}} = 0, \tag{70.16}$$

$$\frac{\partial E(Q_{re})}{\partial e} = (p+s-v-b)\frac{\partial HQ_{re}(e)}{\partial e} + \frac{\partial \mu_e s}{\partial e} + \frac{\partial c(e)}{\partial e} = 0. \tag{70.17}$$

Then,

$$Q_{re}^* = F_e^{-1}\frac{p+s-w}{p+s-v-b}.$$

In this condition, if the model can achieve the supply chain coordination, it needs:

$$Q_{sce}^* = Q_{re}^*\frac{p+s-v}{p+s-v-b} = 1. \tag{70.18}$$

So, it needs $b = 0$, $w = c$. It means that the buyback price of unit product is zero and the supplier's wholesale price of unit product equals to the supplier's cost of unit product. It is obviously impossible. We can see that when the retailer makes all sales effort and the supplier does not provide sales incentives to the retailer, the supply chain cannot achieve the coordination.

70.5 The Buyback Contract Model Where the Retailer Makes Part of Sales Effort

In the former part, we see that the model cannot achieve coordination, now we consider the retailer makes part of sales effort, in this condition, the supplier still does not provide sales incentives to the retailer.

70.5.1 Centralized Decision

Set a is the proportion of the sales effort of the retailer, so the proportion of the sales effort of the supplier is $1-a$, $0<a<1$.

$$\begin{aligned} E(Q_{sce}) = \; & p\left[\int_0^{Q_{sce}} x_e f(x_e)dx_e + \int_{Q_{sce}}^{\infty} Q_{sce} f(x_e)dx_e\right] + v\int_0^{Q_{sce}} (Q_{sce}-x_e) \\ & f(x_e)dx_e - s\int_{Q_{sce}}^{\infty} (x_e-Q_{sce})f(x_e)dx_e - cQ_{sce} - c(e) \\ = \; & (p+s-c)Q_{sce} - (p+s-v)\int_0^{Q_{sce}} (Q_{sce}-x_e)f(x_e)dx_e \\ & -\mu_e s - c(e). \end{aligned} \tag{70.19}$$

70.5.2 Dispersion Decision

The supplier's profits function:

$$E(Q_{se}) = (w-c)Q_{se} - b\int_0^{Q_{se}} (Q_{se}-x_e)f(x_e)dx_e - (1-a)c(e). \tag{70.20}$$

The retailer's profits function:

$$\begin{aligned} E(Q_{re}) = \; & p\left[\int_0^{(} Q_r e) x_e f(x_e)dx_e + \int_{(} Q_r e)^{\infty} Q_{re} f(x_e)dx_e\right] + (v+b)\int_0^{Q_{re}} (Q_{re}-x_e) \\ & f(x_e)dx_e - s\int_{Q_{re}}^{\infty} (x_e-Q_{re})f(x_e)dx_e - wQ_{re} - ac(e) \\ = \; & (p+s-w)Q_{re} - (p+s-v-b)\int_0^{Q_{re}} (Q_{re}-x_e)f(x_e)dx_e - \mu_e s - ac(e). \end{aligned}$$

When the retailer's profits are maximum, it needs:

$$\frac{\partial E(Q_{re})}{\partial Q_{re}} = (p+s-w) - (p+s-v-b)\frac{\partial HQ_{re}(e)}{\partial Q_{re}} = 0, \tag{70.21}$$

$$\frac{\partial E(Q_{re})}{\partial e} = (p+s-v-b)\frac{\partial HQ_{re}(e)}{\partial e} + \frac{\partial \mu_e s}{\partial e} + a\frac{\partial c(e)}{\partial e} = 0. \tag{70.22}$$

Then,

$$Q_{re}^* = F_e^{-1}\frac{p+s-w}{p+s-v-b}.$$

When the retailer makes parts of sales effort, if the model can achieve the coordination, it needs:

$$Q_{sce}^* = Q_{re}^*\frac{p+s-v}{p+s-v-b} = 1 = \frac{1}{a}. \tag{70.23}$$

So $a = 1, b = 0$.

We can see that when the retailer makes part of sales effort and the supplier does not provide sales incentives to the retailer, the supply chain cannot achieve coordination.

Above all, when the demand is influenced by sales effort, if the supplier does not provide sales incentives to the retailer, neither the retailer makes all sales effort nor part of sales effort can achieve the coordination.

70.6 The Dispersion Decision of Buyback Contract Based on Stackelberg Game

In the buyback contract model, the supplier first decides the buyback price, the retailer decides the optimal order quantity and sales effort according to the demand. Based on the previous hypothesis, we can assume the retailer and the supplier ordering procedure as a completing information of the two stage Stackelberg game, both the two sides pursue the maximization of their own expected profits.

In the previous parts, we can see that when the demand is influenced by sales effort, neither the retailer makes all sales effort nor part of sales effort can achieve the coordination. Now we study that when the retailer makes all sales efforts, the supplier provides sales incentives to the retailer, if the model can achieve supply chain coordination.

The retailer's profit function:

$$\begin{aligned} E(Q_{rte}) = {} & p\left[\int_0^{Q_{rte}} x_e f(x_e)dx_e + \int_{Q_{rte}}^{\infty} Q_{rte} f(x_e)dx_e\right] + (v+b)\int_0^{Q_{rte}} (Q_{rte}-x_e) \\ & f(x_e)dx_e - s\int_{Q_{rte}}^{\infty}(x_e - Q_{rte})f(x_e)dx_e - wQ_{rte} - c(e) \\ & + t\left[\int_T^{Q_{rte}}(x_e - T)f(x_e)dx_e + \int_{Q_{rte}}^{\infty}(Q_{rte}-T)f(x_e)dx_e\right] \\ = {} & (p+s+t-w) - (p+s+t-v-b)\int_0^{Q_{rte}}(Q_{rte}-x_e)f(x_e)dx_e - tT \end{aligned}$$

$$-t\int_{T}^{Q_{rte}} f(x_e)dx_e - \mu_e s - c(e). \tag{70.24}$$

We assume that:

$$HQ_{rte}(e) = \int_{0}^{Q_{rte}} (Q_{rte} - x_e)f(x_e)dx_e.$$

When the retailer's profits are maximum, it needs:

$$\frac{\partial E(Q_{rte})}{\partial Q_{rte}} = (p+t+s-w) - (p+s+t-v-b)\frac{\partial HQ_{rte}(e)}{\partial Q_{rte}} = 0, \tag{70.25}$$

$$\frac{\partial E(Q_{rte})}{\partial e} = (p+s+t-v-b)\frac{\partial HQ_{rte}(e)}{\partial e} + \frac{\partial \mu_e}{\partial e} + \frac{\partial c(e)}{\partial e} = 0. \tag{70.26}$$

Then,

$$Q_{rte}^{*} = F_e^{-1}\frac{p+s+t-w}{p+s+t-v-b}.$$

In this condition, if the model can achieve the coordination, it needs:

$$Q_{sce}^{*} = Q_{rte}^{*}(p+s-v)/(p+s+t-v-b) = 1. \tag{70.27}$$

So, $b = t = w - c$.

We can see that when the retailer makes all sales efforts, if the supplier provides sales incentives to the retailer, the model can achieve supply chain coordination. And it needs $b = t = w - c$.

70.7 Example Analysis

We assume $x = y(e) \times g$, $y(e)$ is an increasing function, g is a random variables. $\mu = 100$, $\sigma = 20$, $y(e) = e$, $c(e) = \frac{1}{2}ke^2$, $p = 90$, $w = 80$, $c = 50$, $s = 110$, $v = 20$, $T = 1000$, $k = 100$. Some data comes from literature [17].

In this paper, the model is solved by Matlab. Its results are shown in Tables 70.1 and 70.2. Results:

- I and II, when there are no sales effort input, the total profits and the optimal order quantity in centralized decision are greater than the dispersion decision. I and III, when there are no sales effort input, we can find a suitable buyback price to achieve the supply chain coordination.
- I and IV, II and V. We can see that when there is sales effort, the profits of supply chain members and the retailer's optimal order quantity have increased.
- IV and IV. We can see that when the retailer makes sales effort, if the supplier provides sales incentives to the retailer, the model can achieve the optimal order quantity and the best sales effort degree, which also can achieve supply chain coordination.
- VI. When w changes, if the w increases, the retailer's profits will decrease and the supplier's profits will increase.

Table 70.1 The optimal order quantity, the best sales effort degree, the profits of supply chain members under different buyback contract model

	w	t	b	Q	e	π	π_r	π_s
I				1367.05		34801.30		
II	80			1291.86		29067.68	8015.04	21052.64
III	80		36	1367.05		34801.30	9160.26	25641.04
IV				1758.63	14.15	40365.20		
V	80			1711.49	12.28	37401.75	9970.49	27431.26
VI	80	30	30	1758.63	14.15	40365.20	21519.89	18845.31

Table 70.2 The changes of the retailer's profits and the supplier's profits with the w's changes

	w	t	b	Q	e	π	π_r	π_s
VI	80	30	30	1758.63	14.15	40365.20	21519.89	18845.31
	85	35	35	1319.20	14.15	40365.20	17727.05	22638.15
	90	40	40	1319.20	14.15	40365.20	11897.12	28468.08
	92	42	42	1319.20	14.15	40365.20	10289.57	30075.63
	95	45	45	1319.20	14.15	40365.20	8716.64	31648.56

70.8 Conclusions

This paper considers stock-out cost, the demand is random and depends on sales effort. We find the optimal order quantity of the retailer and the best sales effort cost both in centralized decision and dispersion decision. At last, considering the retailer makes all sales effort cost, if the supplier gives sales incentives to the retailer, the model can achieve the supply chain coordination. The study also found the follow patterns: (1) If the retailer makes sales effort cost, whether centralized decision or dispersion decision, can improve the profits of supply chain members, so as to improve the supply chain system total profits; (2) When the retailer makes all sales effort cost, if the supplier provides sales incentives, the model can achieve the supply chain coordination; (3) if the supplier adjusts the wholesale price, by using the buyback reward contract, the model can achieve the supply chain coordination.

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Chapter 71
Supply Chain Contract: Informed Manufacturer (Principal) and Risk Undertake

Hongmei Guo, Pingping Wang and Xianyu Wang

Abstract We provide a simple incentive model with a privately informed manufacturer (principal) who provides goods to retailer (agent) in which the manufacturer has private information about the goods' type he offers to the retailer. The type affects the market demand. We show how the manufacturer's mechanism is designed if he holds private information. Our main finding is that the equilibrium that gives the highest profit to the manufacturer is a pooling equilibrium in which the payment is independent of the manufacturer's private information. This highlights that the contracting under private information on the manufacturers' side make the manufacturer undertake more risk than contracting under symmetric full information.

Keywords Informed principal · Principal-agent · Supply chain

71.1 Introduction

Information plays an important role in the formulation of corporate strategies in the competitive business environment of the twenty-first century. Since the entities in a supply chain usually belong to different firms who have conflicting objectives and possibly have private information, a system wide optimal solution is not implementable unless it can fully resolve any incentive problem caused by private information in the system.

The economics and supply chain management literatures analyze a variety of contract types to resolve these incentive problems. Corbett and Groote [1] derive the optimal quantity discount policy under asymmetric information and compare it to the situation where the supplier has full information. Albert [2] shows that it is no longer possible to achieve the single firm solution When the marginal cost of

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the buyer is private information. The optimal order quantity is always smaller while the optimal sale price of the finished product is higher than the single firm solution. Corbett et al [3] studies the value to a supplier of obtaining better information about a buyer's cost structure, and of being able to offer more general contracts. They use the bilateral monopoly setting to analyze six scenarios. They derive the supplier's optimal contracts and profits for all six scenarios and examine the value of information and of more general contracts. Liu et al [4–7] analyze the value of information under asymmetric information and come to different conclusions.

An increasing number of work studies how principal can use incentive schemes to influence agents' behavior, thus reducing the principal's (and the total supply chain's) costs or increasing his profit. Various functional forms for such incentive schemes have been proposed, but a few of them consider the informed principal. In fact, the informed side can signal his private information to demonstrate his favorable information.

There are some scholars studying the principal-agent problem about informed principal in other areas but few in supply chain management. Simon [8–10] studied the credit markets under incomplete information by signaling models and obtained some useful conclusions.

In this paper, we consider a manufacturer who is about to enter a new market, modifying an existing product to meet local needs. The manufacturer needs to find a local retailer through which to sell the product. A manufacturer and its retailer are independent decision makers. The principal objective of this paper is to study how a manufacturer (principal) with private information can design a contract to maximize his expected payoff.

The informed principal problem relates to the situation in which a principal has private information relevant to the agency relationship at the time of negotiating the contract. This informational asymmetry seems justified in many situations since, at the time of signing, the manufacturer often knows more about the product's type which is affected by quality, advertising, technology and so on than does the retailer. Because the manufacturer's information can affect the market demand and the agent's incentives, an optimal contract must trade off the advantages of revealing information and providing proper incentives. The retailer (agent) may try to infer the manufacturer's information from his contract. In this situation, the elements of the contract become signals of the principal's private information.

The main question addressed in this paper is how a principal's private information, the product's type, changes the characteristics of optimal incentive contracts. In particular, it is examined whether this informational asymmetry can lead the principal to undertake all demand's risk even when both principal and agent are risk neutral.

The remaining sections of the paper are structured as follows. The model and assumptions are presented in Sect. 71.2. In Sect. 71.3, we present a stylized principal-agent problem and the optimal contract for the case where the principal does not have informational advantage in product's type. Sect. 71.4 characterizes the principal's choice of contract for informed principal problem. The main results on the terms of this contract and on the undertaking of the demand's risk are derived in this section. Sect. 71.5 contains concluding comments.

71.2 The Model

A manufacturer with his product is about to search a retailer to sell his product that yields D in the best case and 0 in the worst case. Both parties are assumed to be risk neutral and the interest rate is normalized to 0. We assume that all the cash generated by the supply chain belongs to manufacturer and the manufacturer as a principal designs a contract consists of a transfer to the retailer (agent). In this relationship, the form of the contract needs only to specify two parameters ω and b, in which ω is a base payment that independent of the yield and b is a payment paid when the high state of yield is realized.

We consider a setting where the manufacturer is a principal and makes a take-it-or-leave-it contract to retailer. Importantly, the principal is considered to be experienced and, consequently, as having access to some private information about the probability of demand. To formalize such informational advantage, we assume that the probability of success (get the biggest demand) is θ, where $\theta \in [0,1]$ can be thought of as a market parameter. Importantly, θ is only observable by the manufacturer. Still, it is common knowledge that θ is distributed according to a cdf $F(\Box)$ with full support on $[0,1]$.

Typically, the retailer (agent) has an outside opportunity, giving her a reservation profit level-for instance, the profit she could obtain from allocating the shelf space to another manufacturer's product. If the manufacturer's contract is not sufficiently attractive, the buyer will refuse to trade. We assume that if the retailer (agent) does not work for the principal, the agent can obtain a reservation utility U_0. To summarize, we consider a game with the following timing (see Fig. 71.1).

- Nature draws the value of θ from the distribution $F(\Box)$ that is privately by the manufacturer.
- The manufacturer decides whether to search the retailer or not. If the supply chain fails to be formed, the game ends and both parties get 0 from this game. If the supply chain is formed, the manufacturer gets all supply chain's income and offers the transfer ω and b to agent.
- The retailer accepts or rejects the offer. If he rejects, the game ends and both parties get 0 from this game. If he accepts, contracts go on.
- Nature decides whether the supply chain succeeds or fails according to the probability of success θ.
- Contracts are enforced and payoffs are realized.

We do not consider the cost of the manufacturer or the cost has been assumed as sunk cost, so the supply chain's expected utility function is:

$$\Pi(\theta) = \theta D - U_0. \tag{71.1}$$

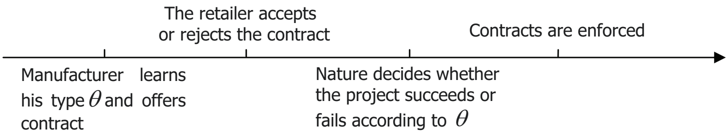


Fig. 71.1 Timeline of events

The prerequisites that manufacturer searches retailer is $\Pi(\theta) \geq 0$, that is:

$$\theta \geq \frac{U_0}{D} \triangleq \theta_0. \tag{71.2}$$

Note that the manufacturer offers the contract only his type satisfies the above inequality, that is:

$$\theta \in [\theta_0, 1]. \tag{71.3}$$

71.3 Contract with Complete Information

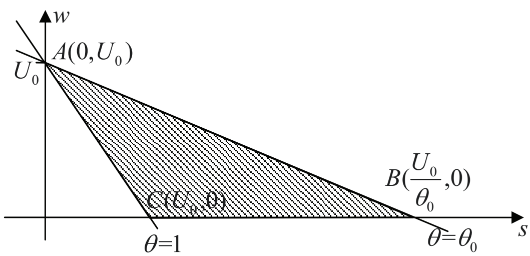
Suppose first that θ is common knowledge. For a realized type the manufacturer solves the following problem:

$$\max_{\omega,s} \theta(D-\omega-s)+(1-\theta)(-\omega), \tag{71.4}$$

$$\text{s.t.} \quad \omega+\theta s \geq U_0. \tag{71.5}$$

This is a problem of linear programming about ω and s. The retailer's individual rationality constraint (71.5) is binding. We can obtain that all the solutions which satisfy $\omega+\theta s = U_0$ are the optimal payments. That is, the problem has infinite number of solutions which have the same optimal value. In other words, the manufacturer can use different payments to achieve the same expected utility, but different payments derive different risk-sharing. The more ω the more risk the manufacturer must take. So we can get Proposition 71.1 as follow.

Fig. 71.2 Optimal payments



Proposition 71.1. *Suppose product type θ is observable. Then the optimal payment for any $\theta \in [\theta_0, 1]$ manufacturer, $\{\omega^c, s^c\}$, is specified by $\omega + \theta s = U_0$. The retailer can get expected utility U_0; the manufacturer with θ_0 type obtains 0 utility, while $\theta > \theta_0$ type obtains positive utility and the utility is increasing with type θ, that is $V(\theta) = \theta D - U_0$.*

We can know from the Fig. 71.2, at point A, retailer can get fixed base payment $\omega = U_0$, no risk, while the manufacturer undertakes all risk which is caused by market. Conversely, at point B or C, retailer obtains on fixed payment and undertakes all risk, while no risk for manufacturer. Every payment derives same expected utility but different risk undertaking.

71.4 Contract with Informed Principal

In this section, we assume that the only information that the retailer is aware of is that the probability of success of the market depends on product's type θ that is distributed according to the cumulative distribution function $F(\theta)$ over $\theta \in [0, 1]$.

If the product's type (manufacturer's type) is private information to the principal and principal with the better type offers the contract from the previous section, then he might be mimicked by a principal with the worse type. The reason for this is that worse principal can pay less expected transfer to agent if he mimics the better one because his probability of success is smaller than the better one. By the same argument mimicking in the opposed direction is never profitable. However, in some settings it might be too costly for a principal with the better type to separate from principals with the worse type. Less profit or more risk. This raises the issue of optimality (or existence) of separating equilibriums.

If the better principal wants to separate from the worse one, then he can increase the differences among the premiums of different contracts with different types by adjusting ω and s.

For any type $\theta \in [0, 1]$, we look for the following incentive problem:

$$\max_{\omega, s} V(\theta) = \theta\,(D - \omega(\theta) - s(\theta)) + (1 - \theta)\,(-\omega(\theta)), \tag{71.6}$$

$$\text{s.t.}\ \ \omega(\theta) + \theta s(\theta) \geq U_0, \tag{71.7}$$

$$\tilde{\theta}\left(D - s(\tilde{\theta})\right) - \omega(\tilde{\theta}) \geq \tilde{\theta}\,(D - s(\theta)) - \omega(\theta) \quad \forall \theta,\ \tilde{\theta} \in [0, 1]^2. \tag{71.8}$$

Formula (71.6) is the θ manufacturer's objective function; inequality (71.7) is retailer's individual rationality constraint; inequality (71.8) is manufacturer's incentive constraint. From inequality (71.8), we have:

$$\tilde{\theta} s(\tilde{\theta}) + \omega(\tilde{\theta}) \leq \tilde{\theta} s(\theta) + \omega(\theta), \tag{71.9}$$

$$\theta s(\theta) + \omega(\theta) \leq \theta s(\tilde{\theta}) + \omega(\tilde{\theta}). \tag{71.10}$$

By using Equations (71.9) and (71.10), we get:

$$(\theta - \tilde{\theta})\left(s(\theta) - s(\tilde{\theta})\right) \leq 0. \tag{71.11}$$

So, we can obtain $s(\theta)$ is not increasing with θ from manufacturer's incentive constraint. That is:

$$\dot{s}(\theta) \leq 0. \tag{71.12}$$

In order to prevent the manufacturer mimicking the other type, for any θ we must have:

$$\theta \dot{s} + \dot{w}(\theta) = 0. \tag{71.13}$$

Formulas (71.12) and (71.13) imply that:

$$\dot{\omega}(\theta) \leq 0, \tag{71.14}$$

which implies that base payment $\omega(\theta)$ is increasing with θ. We can make $\omega^* = U_0, s^* = 0$ which satisfies retailer's individual rationality constraint and obtain the following Proposition 71.2.

Proposition 71.2. *Suppose product type θ is unobservable. There is a pooling equilibrium $\{\omega^* = U_0, s^* = 0\}$ for all $\theta \in [\theta_0, 1]$. The pooling equilibrium prevents the mimic between different types of manufacturers and gives the highest profit to each type manufacturer.*

Proof. We first show that the manufacturers with $\theta \in [0, \theta_0]$ will not mimic the others. Then we can get that for any $\theta \in [\theta_0, 1]$, mimicking the better type is not profitable for the worse type principals, i.e. if the incentive constraint is satisfied and binding.

It is obvious that the manufacturers with $\theta \in [0, \theta_0]$ will get negative utility if he implements the contract $\{\omega^* = U_0, s^* = 0\}$.

Suppose $\forall \theta_H, \theta_L \in [\theta_0, 1]$ and $\theta_H > \theta_L$, if the θ_H type manufacturer offers contract $\{\omega_H, s_H\}$ in which $\omega_H < H_0$, then there exist $s_H > 0$ such that $\omega_H + \theta_H s_H = U_0$. The θ_L type manufacturer will mimic θ_H and offer contract $\{\omega_H, s_H\}$ since $\theta_H > \theta_L$ and $\omega_H + \theta_L s_H < U_0$. Thus he can pay less to retailer by mimicking the θ_H type than signal his true type and obtain more expected utility by undertaking less risk. If $\omega_H > U_0$, the manufacturer's expected utility will be reduced. Therefore, the pooling equilibrium $\{\omega^* = U_0, s^* = 0\}$ prevents the mimic between different types of manufacturers and gives the highest profit to each type manufacturer.

From Proposition 71.2, it follows that the means for the manufacturers to signal the information they have are through the payment transferred to the retailers by undertaking all market risk. That is to say, the principals must pay the cost to signal the information they have and make the agent receive their contracts when they know which type they are facing. The cost can be measured in form of undertaking risk.

71.5 Conclusion

In summary, we have analyzed a principal-agent model in supply chain where the manufacturer (principal) is privately informed about his goods' type, and have obtained result that do not arise under complete information. To signal type the manufacturer has to undertake all risk and the retailer obtain fixed transfer. To make the analysis tractable, we have restricted attention to a simple model with one side private information, two outcomes. Extending the results beyond this simple framework seems like an interesting exercise.

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Chapter 72
Evaluation on the Risk of Supply Chain Basing on the RS and the Principal Component in the Real Estate Enterprises

Rongsheng Lv and Yijie Liu

Abstract Evaluation on real estate enterprises supply chain risk factors can make the enterprises accurately grasp the main factors, targeted to take measures to reduce risk. This article firstly reduces the redundant indicators of supply chain risk in the real estate enterprises by using the rough set theory, analyses the supply chain risk factors of the real estate enterprises in some region making the use of principal component analysis to conclude the most important risk factor of the real estate enterprise supply chain, and order the analyzing results. It hopes to provide a scientific and feasible new method for the actual evaluation.

Keywords Supply chain of the real estate enterprise · Risk assessment · Rough set · Principal component analysis

72.1 Introduction

Risk produced in every industry, along with the widely application of the real estate enterprises in the competitive and supply chain, real estate enterprise supply chain risk has become a hot problem to both academic and business. Real estate enterprises is not allowed in to prevent risks due to grasp the main factors and minor factors, it is easy to "good steel to use on the blade" [1, 2], therefore, to determine which factor plays a main role of supply chain risk is the primary task of risk early warning. Evaluation of an area of real estate enterprise supply chain risk condition, will not only help enterprises adjust their position, also can promote the enterprise

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to grasp the main risk factors, adjust enterprise internal risk early warning mechanism. This article attempts to use the method of rough set and principal component analysis of selected risk factors are contracted, puts forward the main risk factors, and sorted, using principal component analysis dimensionality reduction in supply chain risk evaluation of real estate enterprises.

72.2 The Real Estate Enterprise Supply Chain Risk Classification

There are many factors that can affect the risk of real estate enterprise's supply chain, this article mainly from two aspects to carry on the analysis, from the real estate's supply chain, influence the real estate enterprise supply chain risk index I_1 mainly include [3]: (1) system structure I_{11}, huge risks existing in the exclusive provider policy; (2) cost sharing I_{12}, after the information sharing and envoys point enterprise reduce the risk of bargaining power; (3) information sharing I_{13}, mainly refers to the node enterprise from their own interests than the risk of information sharing; (4) partners I_{14}, partner choice and risk as a result of the financial condition; (5) the subjective behavior I_{15}, in decision-making by the risks of subjective consciousness; (6) demand fluctuations I_{16}, the risk due to fluctuations in customer satisfaction with the product; (7) environment Mutation I_{17}, social environment of the adverse impact of sudden accident, also including social unrest, war, and so on that accidents to the adverse impacts of a supply chain; (8) based conditions I_{18}, modern information technology security hidden danger caused by the risk; (9) natural disasters I_{19}, including floods, fires, earthquakes and other force majeure events such as the risk; (10) other factors I_{110}, including regulations and policies, the economic situation of the risk.

To consider from the Angle of real estate enterprise itself development main risk, financing risk and financial risk from three aspects, including secondary indexes including [4, 5]: Risk indicators I_2: (11) the ratio of land to be developed area and development area I_{21}; (12) housing construction area completion rate (%) I_{22}; (13) Assets Liabilities Ratio of the real estate development enterprise I_{23}; (14) real estate development enterprise land transfer income accounted for the proportion of total income I_{24}. Financing risk indicators I_3: (15) solvency I_{31}; (16) policy stability I_{32}; (17) economy stability I_{33}; (18) exchange rate changes I_{34}. Fiscal risk indicators I_4: (19) land transfer price I_{41}; (20) the ratio of construction land and farmland I_{42}; (21) construction tax accounted for the proportion of total income fiscal I_{43}; (22) the growth rate of population urbanization rate I_{44}.

72.3 Rough Set and Principal Component Analysis

72.3.1 The Rough Set Theory

Rough Set theory is a kind of describe incompleteness and uncertainty of mathematical tool, can effective analysis and processing all kinds of incomplete information, and to discover the implicit knowledge, reveal the potential regularity [6, 7].

(I) Information System

An information system can be expressed as $S = (U, A, V, f)$; U is the domain of theory, composed of a finite number of object of study; $A = C \cup D$ is for attributes, among them C as the condition attribute set, D as the decision attribute set, V as the range and f for the map.

(II) The Attribute Reduction and Nuclear

$S = (U, R)$ as information systems:

(1) R is the equivalent of the relationship of U, and $r \in R$, if $U/IND(R) = U/IND(R-r)$, then r is R reducible to knowledge. (2) The irreducible attribute in R is called the nuclear properties of R, called as $Core(R)$, as the core of the R. (3) R is the theory of equivalence relation on the domain U, all the notes in R for reduction of reduction is called $RED(R)$. All nuclear is included in all reduction. Allows nuclear is an empty set.

72.3.2 Principal Component Analysis

Principal component analysis thoughts are numerous indicators into several comprehensive index, retain the original variables, the main information, simplify complex issues. If one of the main component of variance is largest, then the largest is called the first principal component, and as the basis of sorting [8, 9].

Principal component analysis, the steps are as follows:

(1) Standardize the raw data

In order to eliminate the influence of the dimensions and the indexes on the order of magnitude difference, need to adopt standardized treatment to Equation (72.1):

$$X_{ij}{}^{*} = \frac{X_{ij} - \overline{X_j}}{S_j}, \tag{72.1}$$

where $X_{ij}{}^{*}$ is the standardization of X_{ij} data, and $\overline{X_j}$, S_j are the j^{th} index of the sample mean and standard deviation.

(2) Establish a standardized data correlation coefficient matrix: $R = [r_{ij}]_{j\times j}$ which r_{ij} is correlation coefficient of $X^{*}{}_{i}$ and $X^{*}{}_{j}$.

(3) Get values of correlation matrix R, $\lambda_1 \geq \lambda_2 \geq \cdots \geq \lambda_p \geq 0$ and the corresponding eigenvectors $u_1, u_2, \cdots, u_p$.

(4) Write the principal components. Take feature vector $u_i = (u_{i1}, u_{i2}, \cdots u_{ip})$, $i =$

$1,2,\cdots,p$ and the known data $(X_1,X_2,\cdots,X_p)$ into Equation (72.2), we can obtain p principal components, which $F_i(i=1,2,\cdots,p)$ is the i^{th} main component:

$$F_i = u_{i1}X_1 + u_{i2}X_2 + \cdots + u_{ip}X_p. \tag{72.2}$$

(5) Construct the comprehensive selection function. Characteristic value λ_i is the main component of variance, its contribution rate is $\alpha_i = \lambda_i/\Sigma_{k=1}^{p}\lambda_k$. Selected to make the smallest integer greater than the cumulative contribution rate is more than 85% of the principal component, with the m principal component comprehensive selection function structure, namely:

$$F = \alpha_1 F_1 + \alpha_2 F_2 + \cdots + \alpha_m F_m. \tag{72.3}$$

72.4 Calculation Example

Based on the above method, this article evaluates 15 supply chain risk of real estate enterprises of Hebei Province region. According to rough set attribute reduction. Please five experts to research of the real estate enterprise supply chain risk, according to the raw data obtained by discretizing processing, divided into four levels, to as $\{4,3,2,1\}$, representative {excellent, good, general, poor }. Evaluation on enterprise can be divided into four types, as decision attribute, notes for $D=\{4,3,2,1\}$, representative {good, better, general, poor}. Because space is limited, this paper is no longer listed real estate index of supply chain risk reduction process. After the attributes reduction index system as shown in Table 72.1.

The index system removes the redundant information, greatly reducing the workload of next step. Now based on principal component analysis method, the selected 15 companies rated sorting. For the qualitative index in this paper, using expert scoring method, quantitative index data source, based on statistical yearbook of China and the actual survey. Specific data are as Table 72.2.

Use SPSS software in the "data reduction" Factor of the principal component analysis, and get the following Table 72.3 and Table 72.4. Value of the feature vector matrix in Table 72.4 is factor loading matrix of each column divided by the corresponding characteristic root.

From Table 72.3, we can see the first three characteristic roots are bigger than zero, and the cumulative contribution rate of 88.085%, so the three principal components is determined.

According to Equation (72.2), you can get different principal component values of F_1, F_2, F_3 and use the Equation (72.3): $F = 0.0537F_1 + 0.1032F_2 + 0.7239F_3$, and the comprehensive value, according to the $F$to ordering, samples are shown in Table 72.5.

Table 72.1 15 real estate enterprise supply chain risk evaluation index system in Hebei province

Goal	The first index	The second index	Index character	
			Qualitative indicators	Ration indicators
Real estate enterprise supply chain risk evaluation I	The risk of supply chain I_1	System structure I_{11}	√	
		Cost sharing I_{12}	√	
		Massage sharing I_{13}	√	
		Participation I_{14}	√	
		Subjective behavior I_{15}	√	
		Demand fluctuate I_{16}	√	
		Basic condition I_{17}	√	
	The risk of development I_2	The ratio of land to be developed area and development area I_{21}		√
		Housing construction area completion rate (%) I_{22}		√
	The risk of financing I_3	Solvency I_{31}	√	
		Policy stability I_{32}	√	
	The risk of tax I_4	Land transfer price I_{41}		√
		The ratio of construction land and farmland I_{42}		√

Table 72.2 Raw data of real estate enterprise supply chain risk in Hebei province

	I_{11}	I_{12}	I_{13}	I_{14}	I_{15}	I_{16}	I_{17}	I_{21}	I_{22}	I_{31}	I_{32}	I_{41}	I_{42}
1	89	92	83	79	88	90	91	0.51	42.23	86	85	4532.67	0.037
2	78	76	82	81	83	74	80	0.48	42.18	73	79	4200.35	0.032
3	87	90	89	85	87	86	88	0.56	30.25	95	93	4265.67	0.029
4	91	92	90	93	90	91	89	0.61	48.98	94	88	4578.32	0.030
5	78	79	76	82	80	76	79	0.46	30.40	74	76	4235.55	0.033
6	92	93	91	90	89	88	87	0.55	41.44	93	90	4683.58	0.028
7	90	91	93	88	89	90	91	0.49	40.87	89	86	4623.79	0.038
8	95	96	94	93	95	92	90	0.47	38.16	88	86	4799.98	0.035
9	74	75	80	76	74	76	78	0.46	29.85	75	72	4231.68	0.035
10	69	68	62	70	72	74	68	0.43	32.76	70	74	4042.78	0.030
11	69	78	74	72	70	68	65	0.42	30.98	68	64	3964.04	0.036
12	78	75	70	74	79	80	76	0.44	41.09	77	75	3586.68	0.034
13	91	83	86	87	92	89	90	0.52	38.97	92	87	4278.92	0.033
14	87	86	80	79	84	83	87	0.49	37.85	84	89	4009.46	0.27
15	90	95	96	93	94	92	79	0.54	43.08	93	94	4100.75	0.31

72.5 Results Analysis and Conclusion

From Table 72.4, we can analysis the first principal component index I_{11}, I_{12}, I_{13} and I_{14}, I_{15}, I_{16}, I_{31}, I_{32} coefficient large, all above 0.9, and they are clearly reflect

Table 72.3 The overall variance the explain tables

Factors	Initial Eigenvalues		
	Overall eigenvalue	Variance contribution rate	Cumulative variance contribution rate
1	9.411	72.390	72.390
2	1.342	10.322	82.712
3	0.699	5.373	88.085
4	0.497	3.824	91.909
5	0.413	3.180	95.089
6	0.211	1.622	96.711
7	0.163	1.256	97.967
8	0.124	0.955	98.922
9	0.057	0.441	99.363
10	0.048	0.366	99.729
11	0.021	0.163	99.892
12	0.013	0.100	99.992
13	0.001	0.008	100.000

Table 72.4 Factor loading and eigenvector matrices

	Factors					
	1	2	3	1	2	3
1	0.977	−0.013	−0.006	0.318	−0.004	−0.002
2	0.924	0.015	−0.176	0.798	0.013	−0.152
3	0.909	−0.044	−0.208	1.087	−0.053	−0.249
4	0.921	−0.052	−0.069	1.306	−0.074	−0.098
5	0.962	0.045	0.024	1.497	0.070	0.037
6	0.949	0.035	0.051	2.066	0.076	0.111
7	0.871	−0.220	0.015	2.157	−0.545	0.037
8	0.827	0.035	0.162	2.349	0.099	0.460
9	0.624	0.169	0.717	2.614	0.708	3.003
10	0.949	0.054	−0.035	4.332	0.246	−0.160
11	0.914	0.239	−0.065	6.307	1.649	−0.449
12	0.691	−0.603	−0.141	6.060	−5.289	−1.237
13	0.235	0.912	−0.224	2.35	9.12	−2.24

the supply chain risk and financing risk on the two aspects of information, synthetically the two aspects of the risk factors of real estate enterprise supply chain risk has a great influence. The second principal component index I_{32}, I_{42} coefficient is larger, reflects the policy total income tax accounting for financial stability and the construction industry the proportion of these two aspects of information, pointed out that in part real estate enterprise financing risk and financial risk's impact on the enterprise supply chain risk assessment. I_{21} third principal component in the index, coefficient of I_{22} is large, reflecting the influence of development risk to the enterprise supply chain risk. According to above analysis of the factors impact on the real estate enterprise supply chain risk, through the principal component analysis methods can draw from Table 72.5, and 15 real estate enterprises supply chain risk evaluation in Hebei province rank, the ranking topper, the risk smaller.

Table 72.5 Principal components value, comprehensive principal component value and sorting

No.	F_1	F_2	F_3	F	Sorting
1	29297.38	−23827.7	−5557.83	18450.90	5
2	27110.1	−22079.0	−5141.99	17070.35	10
3	27733.4	−22408.2	−5270.88	17480.69	7
4	29672.73	−24057.6	−24057.6	18696.65	4
5	27272.69	−22277.5	−5218.72	17163.42	8
6	30285.31	−24615.7	−5753.76	19074.22	2
7	29888.91	−24309.3	−5678.75	18822.91	3
8	30969.30	−25242.7	−5905.78	19496.49	1
9	27207.81	−22263.4	−5214.00	17118.16	9
10	25998.28	−21253.8	−4966.21	16360.08	13
11	25446.50	−20855.1	−4874.92	16006.69	14
12	23355.26	−18836.2	−4380.82	14727.73	15
13	27798.68	−22483.3	−5255.74	17520.95	6
14	26094.58	−21053.8	−4925.19	16452.63	12
15	26792.32	−21518.2	−5031.82	16904.07	11

Rough set method, the effective reduction of the redundant attributes and simplifies the calculation workload of next step. Principal component analysis method, to reduce information overlaps between the indexes, effective analysis data, the application of SPSS software, at the same time help to calculation, so that they can reach appropriate ranking among enterprises.

In this paper, by using the rough set and principal component method, analysis the influence real estate enterprise supply chain risk factors, the dominant influencing factors, and attempts to provide reasonable basis for real estate enterprises consider risk factors; On the other hand is for 15 empirical research for real estate enterprises in Hebei province, based on the above 13 kinds of risk factors, according to the expert scoring and statistical yearbook data, using econometric methods, discussed 15 real estate enterprises supply chain risk, so as to provide a quantitative basis for risk for real estate enterprises. Future studies should also pay attention to the following several aspects:

- When data acquisition, the risk factors of qualitative data is obtained by expert scoring, have certain subjectivity, will have certain influence on calculation. At the same time, the real estate industry is in the development, the future research should be dynamic, should fully consider the time value of the risk factors, data only reflect the size and enterprise ranking factors at some point, no persistence.
- This article evaluates risk factors of real estate enterprise supply chain, however, each industry has its own characteristics and personality. If we need for better research of risk management problem, we need to analyze risk factors according to the characteristics of the various industries.

- This paper uses the rough set and principal component analysis method, but in the actual process when many factors and complex relations about supply chain and involved in multiple interests at the same time when the body of the conflict and uncertainty factors, also need to try and use the new research methods. Or consider time sequence, or expansion of panel data, etc.

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Chapter 73
Influence of Hospital's Internal Service Quality to Staff Loyalty-in the Case of West China Hospital's Outpatient and Emergency Department

Zhuoying Li, Weiping Yu, Guimin Duan and Sihuan Liu

Abstract Medical staff's service attitude and ability increasingly become the key factors influencing the patients' satisfaction. This paper analyzed the impact of hospital's internal service quality on staff loyalty by interaction quality, physical environment quality and outcome quality from the perspective of internal marketing. By researching 245 staffs of West China hospital's Outpatient and Emergency department, we found that: the interaction quality and outcome quality both had positive impacts on medical staff satisfaction and loyalty. The interaction quality was the key factor influencing medical staff satisfaction, and the outcome quality is the key factor influencing medical staff loyalty; During the process of outcome quality influencing medical staff loyalty, medical staff satisfaction had completely mediate effect. And during the process of interaction quality influencing medical staff loyalty, the medical staff satisfaction had partially mediate effect; The medical staffs with different personal characteristics had differences on the internal service quality perceptionsatisfaction and loyalty.

Keywords Internal service quality · Medical staff satisfaction · Medical staff loyalty · West China Hospital's Outpatient and Emergency Department

73.1 Introduction

Mobilizing the medical personnel's positivity and creativity is one of the most important parts to deepen the reform of medical and health, and ease the doctor-patient relationship. According to the "2012 China Health Statistics Abstract", the number

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of patients in China from 2008-2011 was: 49.01, 54.88, 58.38, 62.71 (units/100 million). From 2009 to 2011, the growth rate of health personnel is 7.30%, 5.47%, 4.97%. Medical staff's service ability in our country is still difficult to meet people's growing medical service needs, it is necessary to reform the policy environment. At the same time, "The Fourth Survey Report of Chinese Physician Association on Physician's practice situation" showed that 48.51% of medical staff were not satisfied with the professional environment, only 19.02% are satisfied. Employee satisfaction is the basis of customer satisfaction, and it is necessary to provide high-quality internal service quality to make employees satisfied [1]. Frontline staff contacting with the patients, their service quality and work efficiency will directly influence the patient's medical experience and satisfaction.

Existing researches on internal service quality is based on the perspective of human resource, their main methods are also references to external service quality researches. It has not yet formed a mature scale to be suitable for the internal service quality of our country's medical service. And there also is not a system model which can be in-depth study of its mechanism. In this article, we focus on internal marketing. It revised the new concept of service quality model [2] with the features of medical service industry, and got a scale which is suitable for the hospitals in our country. At the same time, this paper structured a model of hospital's internal service quality influencing staff satisfaction and loyalty. We also explored the differences of the personal characteristics influencing the internal service quality perception, satisfaction and loyalty. The case of this study is West China Hospital, which is the largest single point of the world's hospital. Its Outpatient and Emergency department is one of the key resources for hospital as the window for patients admitted to hospital. The conclusions are useful to improve the internal service effectively, improving the staff satisfaction and loyalty, optimizing the allocation of hospital resources, increasing internal operation efficiency and improving the medical service quality and hospital's competitiveness.

73.2 Theory and Research Hypothesis

(1) Internal marketing and service profit chain

Internal marketing is the result of service marketing [3]. The goal of internal marketing was to develop customer orientation of employees; The enterprise can use similar marketing methods to motivate employees' sense of service and customer oriented.

Heskett et al [1] put forward the model of service profit chain. It shows that it can effectively improve the service quality with external customers by increasing internal service quality. The social exchange theory also shows if an organization can correctly treat the employees, when employees agree with the organization value and think it is fair to trade with the organization, they are willing to repay organization through positive attitude and work behavior [4].

(2) Internal service quality

Internal service quality is the result of an external service quality. As well as external marketing, internal marketing should treat employees as customers, and provide good internal service for their needs. Internal service quality is the service quality of individuals or groups in the company to receive supports and help each other. It included staff's attitude and service to each other. Marshall et al [6] thought internal service quality were two-way trading process between two individuals same or different of the organization. The relationship between internal service quality and the organizational work efficiency, performance, atmosphere,staff satisfaction, and consumer satisfaction are very tightness. Huang et al [7] put forward and prove the model of internal service quality, relationship quality influencing the internal consumer loyalty.

Brady and Cronin [2] put a new concept model of service quality including interaction quality, physical environment quality, and outcome quality; Many scholars used the SERVQUAL scale; Frost and Kumar [8] put forward the internal service quality model based on the gap model of service quality of PZB. But it is different between external and internal service, they should use different dimensions. Crawford and Getty [9] found external consumer paid attention to atmosphere, real-time, reliability, performance, value and the function of delivering service. But internal consumer paid attention to resources, clear responsibility, communication standard, decision-making autonomy and motivation; Brooks et al [10] found that there are eight in the 10 aspects of SERVQUAL scale can be used as internal service quality factors (reliability, responsiveness, competent, courtesy, communication, empathy and trust). And the other three were decision beforehand, paying attention to details, and leadership. Different internal customers had different requirements to internal service quality. Hallowell et al [11] came up with 8 dimensions of internal service quality influencing staff satisfaction, and it formed the internal service quality scale; In the field of medical services, Guo et al [12] developed an internal service quality measurement scale of large general hospital, and it had an empirical research. But most studies only get some thinking and strategy about internal marketing from the practical management experience.

(3) Internal consumer satisfaction and loyalty

Sasser and Arbeit [13] believed consumer is the frontline employees who directly contact with the market, not all members. Nagel et al [14]thought internal consumer should include all the members. They finished work by the product and service from interior. Varey [15] thought internal consumer was the employee accepting service in company. Satisfaction is different by industry. In the field of medical service, there were many studies on medical staff satisfaction. Most studies limited to the investigation and analysis of medical staff satisfaction and loyalty. They didn't study the root problem by standing in the perspective of internal marketing.

Study on staff loyalty is through four processes. Firstly is single factor theory, It looked employee loyalty as a whole variable; Secondly is two factors theory, and it divided employee loyalty into two dimensions including attitude and behavior loyalty; Thirdly is three factors theory, the QCQ scale of Modway, Steers and Porter [19] divided employee loyalty into 3 dimensions including value commitment, effort commitment and retention commitment; Fourthly is multifactor theory. Tan et al [16] put forward a five-factors model including affective commitment, normative commitment, ideal commitment, economic commitment and opportunity commitment.

(4) Research hypothesis

It can improve customer satisfaction if the enterprises provide a good service for employees [17]. Brady and Cronin [2] divided internal service quality into interaction quality, physical environment quality and outcome quality. In this, interaction quality is employee's perception on the interaction with service supplier in the process of service delivery between departments, medical personnel, departments and medical staffs in hospital. Physical environment quality is the employee's perception on workplace design, facilities, environment and so on by hospital. Outcome quality is the employee's perception on the return and so on from the internal service (like performance, Promotion, training and so on). It is the result of internal service behavior; Medical staff satisfaction is internal consumer satisfaction in hospital. It is the satisfaction degree of medical staff comparing their expection with perception after accepting or using the internal service of hospital. Based on the above, we got the following hypotheses:

H1 : Internal service quality of hospital has significantly positive impact on medical staff satisfaction:

H1a: Interaction quality has significantly positive impact on medical staff satisfaction;

H1b: Physical environment quality has significantly positive impact on medical staff satisfaction;

H1c: Outcome quality has significantly positive impact on medical staff satisfaction.

Medical staff loyalty is the internal consumer loyalty. It is the loyalty degree of medical staff on hospital; Huang et al [7] put forward internal service quality including interaction quality, physical environment quality and outcome quality had influence on internal consumer loyalty. Then, we got the following hypotheses:

H2 : Internal service quality of hospital has significantly positive impact on medical staff loyalty:

H2a: Interaction quality has significantly positive impact on medical staff loyalty;

H2b: Physical environment quality has significantly positive impact on medical staff loyalty;

H2c: Outcome quality has significantly positive impact on medical staff loyalty.

Hesktt et al [1] thought staff satisfaction is uesful to improving staff loyalty. Then, we got the following hypotheses:

H3 : Medical staff satisfaction has significantly positive impact on medical staff loyalty.

73.3 Study Design

(1) Scale choosing

The questionnaire is made of scales and three open questions. This article adopts the Likert 5 level scales to measure variables. We also collected medical staffs' personal information as control variables, including age, gender, job title, department and years of working.

Internal service quality scale references the concept model of internal service quality by Brady [2], the general hospital's internal service quality scale of Guo et al [12], the revised SERVQUAL scale of Parasuraman et al [5] and Telecom enterprise's internal service quality scale of Huang et al [7]. We combined with the features of medical industry and the outpatient emergency of West China Hospital to become the preliminary questionnaire. Then, we tested and corrected questionnaire by experts and preliminary research. At last, we used Exploratory Factor Analysis to purify the items, and formed hospital's internal service quality scale made of 3 dimensions including interaction quality, physical environment quality and outcome quality. It has 18 items in all.

This article used the scale of study on internal relationship quality by Crosby et al [18] to measure staff satisfaction. Medical staff loyalty is mainly refer to the QCQ scale of Mowday et al [19] to measure.

(2) Samples

The study investigated the medical staffs of West China Hospital's Outpatient and Emergency department by questionnaires. We distributed 280 questionnaires in all. There are 245 valid questionnaires and the valid rate is 87.5%. Among the samples, women account for 84.5%. There are 61.2%. Outpatient department's staff, and the Emergency department's staff account for 38.8%. As the surveyed department mainly is made of nurses, the gender proportion and doctor-nurse proportion have big differences in the sample. As for age, 73.9% are below 30 years old. And 56.3% are less than 5years of working (as shown in Table 73.1).

73.4 Data Analysis

(1) Reliability and validity

Cronbach's alpha were greater than 0.85, indicating that the questionnaire design with high reliability. The KMO value was 0.861, and the Bartlett was 0.00(< 0.05), indicating that the variables were suitable for factor analysis. In light of the results from the factor analysis, the items entered the respective factor normally, and has a good rate of factor explanation, which has a preferred statistical results and high Validity (as shown in Table 73.2).

(2) Analysis of West China Hospital's internal service quality, satisfaction and loyalty

The perception level of medical staff on internal service quality was high (Mean value = 3.8501), its loyalty and satisfaction were high, too (Mean value = 3.9837

Table 73.1 The samples

Project	Number	Percent
Gender		
male	38	15.5%
female	207	84.5%
Age		
< 25	99	40.4%
26-30	82	33.5%
31-35	21	8.6%
36-40	36	14.7%
41-45	7	2.9%
Department		
Outpatient	95	38.8%
Emergency	150	61.2%
Working years		
< 5	138	56.3%
5-10	49	20.0%
> 10	58	23.7%
Job title		
Uncertain	26	10.6%
Physician	28	11.4%
Physician-in-charge	7	2.9%
Associate chief physician	3	1.2%
Nurse	106	43.3%
Senior nurse	40	16.3%
Supervisor nurse	33	13.5%
Associate chief nurse	2	0.8%
Total	245	100%

Table 73.2 Reliability

	Dimension	Reliability	Item	Reliability
Internal service quality	Interaction quality Physical environment quality Outcome quality	0.921 0.854 0.907	9 3 6	0.95
Medical staff satisfaction	—	—	3	0.885
Medical staff loyalty	—	—	3	0.899

and 3.9796). And the Mean value of interaction quality, outcome quality and physical environment quality were 3.99, 3.80 and 3.51. The highest score of interaction quality is: the management level and overall quality of department leader, internal information transmission channel and department's participation decision-making; The scores of Workplace and safety in physical environment quality were low. But the score of equipment was high. The score of outcome quality was at the intermediate level. The item "I can do best to service patient under the good internal

service quality" got a high score. But the medical staff's perception of the learning opportunities and performance appraisal system got low scores.

At the same time, this study classified and counted the keywords mentioned in open problems. The top three of medical satisfaction were work team, learning and leader's care; The top three of medical dissatisfaction were hard work, bad environment and the doctor-patient contradiction. The top three of hopes were raising compensation, increasing the rest time, ensuring the safety of working environment.

(3) Analysis of the personal characteristic differences

Brooks [9] said that different internal consumers had different requirements for internal service quality. This paper regarded gender, age, title, working years and department as independent variables. And it regarded the internal service quality, medical staff satisfaction and loyalty as dependent variables. Then we got results by one-way ANOVA. It indicated it was different for medical staff perceptions on internal service quality with different age, title and department. It also was different for medical staff satisfaction with different age and department. And medical staffs in different departments had different loyalty.

In the age difference analysis, the levene significance of internal service quality perception and medical satisfaction were 0.796 and 0.961, which were greater than 0.05, indicating the variance between samples is homogeneous. Then we used LSD to explore the specific differences between matching groups. At 5% significance level, medical staffs who were less than 25 years old or been in 36-40 years old had higher perception on internal service quality compared with 26-30 or 31-35-year-old medical staffs. There were no significant difference between the medical staffs in other age groups. 36-40 year-old medical staff satisfaction were higher than the medical staffs who were 26-30, 31-35, 41-45 years old. Nurse perception is higher than physician's; And staffs of Outpatient department had higher perception, satisfaction and loyalty than staffs' of Emergency department.

Table 73.3 Regression analysis of internal service quality influencing medical staff satisfaction and loyalty

Variable	Medical staff satisfaction		Medical staff loyalty	
	First step	Second step	First step	Second step
(Constant)	3.827*	0.876*	3.754*	0.604*
Age	−0.020	0.041	−0.088	−0.023
Title	0.002	−0.009	0.021	0.009
Department	0.280*	0.017	0.300*	0.019
Gender	−0.034	−0.003	−0.052	−0.019
Working years	0.044	−0.004	0.126	0.074
Internal service quality		0.797*		0.851*
R^2	0.039	0.555	0.056	0.573
Adjusted R^2	0.019	0.544	0.036	0.562

(4) Regression analysis of hospital's internal service quality influencing staff loyalty

We did multiple level regression analysis here. Take medical staff satisfaction and loyalty as dependent variables, and take internal service quality as independent variable. And the age, title, gender, department and working years were taken as control variables. It indicated that VIF were less than 10, and there wasn't multicollinearity. Internal service quality had positive impact on medical staff satisfaction ($\beta = 0.797,\ p < 0.05$) and loyalty ($\beta = 0.851,\ p < 0.05$). It was shown as Table 73.3.

Do regression analysis of medical staff satisfaction which was regarded as dependent variable. Interaction quality, physical environment quality and outcome quality were regarded as independent variables. Then take age, gender, title, department and working years as control variables. The results showed VIF were less than 10, and there wasn't multicollinearity. Interaction quality ($\beta = 0.284,\ p < 0.05$) and outcome quality ($\beta = 0.509,\ p < 0.05$) had significant impacts on medical staff satisfaction. But physical environment quality ($\beta = 0.011,\ p > 0.05$) had no significant impact on medical staff satisfaction.

Do regression analysis of medical staff loyalty which was regarded as dependent variable, and the other is same. The results showed VIF were less than 10, and there wasn't multicollinearity. Interaction quality ($\beta = 0.284,\ p < 0.05$) and outcome quality ($\beta = 0.457,\ p < 0.05$) had significant impact on medical staff loyalty. But physical environment quality ($\beta = 0.009,\ p > 0.05$) had no significant impact on medical staff loyalty (as shown in Table 73.4).

Table 73.4 Regression analysis on 3 dimensions of internal service quality influencing medical staff satisfaction and loyalty

Variable	Medical staff satisfaction		Medical staff loyalty	
	First step	Second step	First step	Second step
(Constant)	3.827*	0.727*	3.754*	0.464*
Age	−0.020	0.046	−0.088	−0.021
Title	0.002	−0.008	0.021	0.010
Department	0.280*	0.096	0.300*	0.086
Gender	−0.034	−0.028	−0.052	−0.003
Working years	0.044	−0.011	0.126	0.068
Interaction quality		0.284*		0.395*
Physical environment quality		0.011		0.009
Outcome quality		0.509*		0.457*
R^2	0.039	0.577	0.056	0.588
Adjusted R^2	0.019	0.563	0.036	0.574

In a similar way, we took medical staff loyalty as dependent variable, and regarded satisfaction as independent variable. The age, title, gender, department and working years were control variables. Then VIF were less than 10 without multicollinearity. Medical staff satisfaction had significant impact on medical staff loyalty (as shown in Table 73.5).

Table 73.5 Regression analysis on 3 dimensions of internal service quality influencing medical staff satisfaction and loyalty

Variable	Medical staff loyalty	
	First step	Second step
(Constant)	3.754*	0.359
Gender	−0.052	−0.022
Age	−0.088	−0.070
Title	0.021	0.019
Working years	0.126	0.086
Department	0.300*	0.052
Medical staff satisfaction		0.887*
R^2	0.056	0.720
Adjusted R^2	0.036	0.713

Do regression analysis when medical satisfaction was taken as dependent variable, and the others were in a similar way. The determination coefficient of regression model is $R^2 = 0.754$, and VFI were less than 10 without multicollinearity. The significance probability of outcome quality was greater than 0.05, indicating medical staff satisfaction had completely mediate effect during the process of outcome quality influencing medical staff loyalty (shown in Table 73.6). The coefficient of Bate decreased, but it was significant. It indicated during the process of interaction quality influencing medical staff loyalty, the medical staff satisfaction had partially mediate effect. The final results were shown in Table 73.7.

Table 73.6 Analysis of medical staff's mediate effect

Variable	Medical staff loyalty		
	First step	Second step	Third step
(Constant)	3.754*	0.464	−0.023
Gender	−0.052	−0.003	−0.022
Age	−0.088	−0.021	−0.052
Title	0.021	0.010	0.016
Working years	0.126	0.068	0.076
Department	0.300*	0.086	0.022
Interaction quality		0.395*	0.205*
Physical environment quality		0.009	0.001
Outcome quality		0.457*	0.116
Medical staff satisfaction			0.670*
R^2	0.056	0.588	0.754
Adjusted R^2	0.036	0.574	0.745

Table 73.7 Results of hypothesis testing

NO.	Hypothesis	Results
H1	Internal service quality of hospital has significantly positive impact on medical staff satisfaction	√
H1a	Interaction quality has significantly positive impact on medical staff satisfaction	√
H1b	Physical environment quality has significantly positive impact on medical staff satisfaction	×
H1c	Outcome quality has significantly positive impact on medical staff satisfaction	√
H2	Internal service quality of hospital has significantly positive impact on medical staff loyalty	√
H2a	Interaction quality has significantly positive impact on medical staff loyalty	√
H2b	Physical environment quality has significantly positive impact on medical staff loyalty	×
H2c	Outcome quality has significantly positive impact on medical staff loyalty	√
H3	Medical staff satisfaction has significantly positive impact on medical staff loyalty	√

73.5 Conclusion

(1) Conclusion and discussion

This study analyzed the mechanism of internal service quality influencing on staff loyalty, taking staff satisfaction as a mediate variable, by measuring hospital's internal service quality.

Conclusion 1: Hospital's internal service quality can be measured by interaction quality, physical environment quality and outcome quality. The interaction quality and outcome quality both had significantly positive impacts on medical staff satisfaction and loyalty. The outcome quality had greater influence on medical staff satisfaction than interaction quality, and the interaction quality had greater influence on medical staff loyalty. But the physical environment quality had no significantly positive impact on medical staff satisfaction and loyalty, indicating the staff paid more attention to internal service comparing with environment. During the process of outcome quality influencing medical staff loyalty, medical staff satisfaction had completely mediate effect. And during the process of interaction quality influencing medical staff loyalty, the medical staff satisfaction had partially mediate effect.

So the hospital should pay attention to interaction quality and outcome quality. For example, the Outpatient and Emergency department of West China Hospital can implement democratic decision-making mechanism to improve medical staff's participation; It can reduce medical staff's work load by increasing the number of medical staffs and optimizing the workflow; It also can push the evaluation system of internal service, and link it to performance appraisal to promote the service. Hospital should provide more valuable training opportunity for medical staff, and improve the performance appraisal system for staffs' requirements;

Conclusion 2: Generally speaking, the perception on internal service quality, loyalty and satisfaction got high scores. The top three of medical satisfaction were work team, learning and leader's care; The top three of medical dissatisfaction were hard work, bad environment and the doctor-patient contradiction. The top three of hopes were raising compensation, increasing the rest time, ensuring the safety of working environment.

It provides a basis for the optimization of internal services for West China Hospital. It can start from the management of physical environment quality. The hospital should pay more attention to improve medical staffs' working conditions, and implement the culture, in addition to provide medical personnel with advanced medical equipment. At the same time, it should strengthen the security to reduce the doctor-patient conflict to ensure the safety of working environment.

Conclusion 3: The hospital should segment the internal market based on the personal characteristics of staffs to provide differentiated services for staff. In the case, medical staffs who were less than 25 years old or been in 36-40 years old had higher perception on internal service quality comparing with 26-30 or 31-35- year-old medical staff. 36-40 year-old medical staffs' satisfaction were higher than the medical staffs who were 26-30, 31-35, 41-45 years old. Nurse perception is higher than physician's; And staffs in Outpatient department had higher perception, satisfaction and loyalty than staffs' in Emergency department. We should focus on the medical staff of Emergency. They have been contacting with critically ill patients for a long time. And they had long working time and large load. But their income is not high. So we can provide good working conditions for them, arrange the work schedule reasonably, intensify support for the department's resources, provide more trains about stress management and improve their income. Hospital also can support more for new staffs with low income and full enthusiasm; It should provide more motivate and challenge opportunities for 41-45-year-old staff to get new breakthrough.

(2) Prospects for future research

The questionnaires was corrected and optimized based on the internal service quality of general service enterprise, future research could develop a scale for medical industry. Considering from sample selection, we only study one case. It depends on more samples to verify if the conclusions were right or be worth promoting; And future study could bring the culture into environment quality.

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Chapter 74
The Elements of Supply Chain Management in New Environmental Era

Hua Wen and Qianling Gu

Abstract There is a growing recognition that supply chain management (SCM) offers significant opportunities for firms to create strategic advantage and achieve mutually beneficial performance outcomes. So, academic filed and practice filed pay more attention on the basic elements of SCM. Coordination and information sharing are the popular elements in SCM. With the development of economy, environmental issues involve in SCM and affect numerous SCM decision. Environmental considerations are in all activities of whole supply chain. A more full and comprehensive understanding of SCM are needed. This paper looks into the new thought of SCM around environment, and discusses the context of SCM regarding environment.

Keywords Supply chain management · Environment · Green supply chain

74.1 Introduce

There is a growing recognition that supply chain management (SCM) offers significant opportunities for firms to create strategic advantage and achieve mutually beneficial performance outcomes. The evolution of management thought has been 100 hundred years from Taylor's Principles of Scientific Management in 1910s to today' supply chain management. During the period, all of the thoughts of operation, finance, marketing, logistics and human resource management are present in different time [4].

The term SCM was coined in 1982 by Laseter and Oliver [5]. The concept was enlarged by Houlihan [6] that expounded upon efficiencies and mutual benefits as-

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sociated with information sharing and decision coordinating up and down a supply chain in 1985. Follow-on work by Chen [7] used the beer distribution game as a prime example of empirically-based, to a lack of 'system thinking' by management. To 1990s, referred as 'decade of the environment', environment involving in SCM has become clear that the best practices call for integration of environmental management with ongoing operations.

Not only in academic field, but also in practice field, the SCM is concentrated. Universities introduced SCM major and logistics major. Wal-Mart, as a premier practitioner, honed SCM concepts by building worldwide communication and relationship networks with suppliers to improve reliable material flows and to get a network of worldwide suppliers, warehouses and retail stores. In 2005, the Council of Logistics management changed its name to the Council of Supply Chain Management Professionals (CSCMP). For academicians, it is an emergent field of study, where the primary outputs are theory, insights, and research. For practitioners, it is an emergent field of practice where the outputs involve new relationships, new development, and new practices [7].

74.2 Supply Chain Management

74.2.1 Definition of Supply Chain Management

SCM as now a business development and an academic field of study and research is relatively new and a 'fact of life'. Its origins can be traced to the work of Forrester [3] and system dynamics theory. Increasingly, managers, researchers, and educators recognize the importance of effective and efficient SCM and its impact on functional performance [7].

SCM can be defined as a philosophy of management that involves the management and integration of a set of selected key business processes from end user through original suppliers, that provides products, services, and information that add value for customers and other stakeholders through the collaborative efforts of supply chain members' [1]. It is a set of synchronized decisions and activities utilized to efficiently integrate suppliers, manufacturers, warehouses, transporters, retailers, and customers so that the right product or service is distributed at the right quantities, right locations, right prices, right condition, with the right information and at right time, in order to minimize system-wide costs while satisfying customer service level requirements [10]. These activities involve in sourcing and procurement, conversion, and all logistics management activities, and are locally controlled by various independent organizations or decision-making units.

Connotation and extension of supply chain and how it is managed is changing, from as a system primarily responsible for supply and production and managing the flow of raw resources and orders and information with immediate suppliers, to much broader scale. SCM should improve customer service, enhance continuity of supply, reduce the exposure of the firm to unanticipated risks, improve the new product design process, reduce environmental waste, improve environmental performance, and contribute to enhance product and service quality. A supply chain is more complex and that involves more and more. So, the definition of SCM or supply chain is not unique, the concept of SCM can be viewed as a network of organizations that are connected from the ultimate suppliers to the ultimate customers. In this connection, coordination and information sharing, which happens between activities and among members on the supply chain, plays an imperative role in SCM.

74.2.2 Supply Chain Integration

Supply chain integration (SCI) can be defined as synchronization among multiple autonomous business entities represented in it. SCI refers to linking major business functions and business processes within and across companies into a cohesive and high-performing business model. Improved coordination within and between various supply chain members and alignment of interdependent decision making processes constitutes an integral part of integration. SCM are moving to adopt closer relationships with each other.

Through a review of the literature pertaining to buy-supplier integration, Vachon and Klassen [14] reveal two broad categories of studies: (1) those focusing on the logistical linkage between buyers and suppliers, and (2) those associated with strategic activities such as process design or reengineering and product development. The first category mainly refers to tactical activities, and the second refers to more strategic issues and activities.

Integration has been recognized as vital to SCM. From internal and external perspective, SCM is a boundary-spanning activity that is both cross-functional and inter-organizational management efforts. From process view, which business process refers to a set of activities such as manufacturing, marketing, communications and other major elements of a company's operation, SCM should identify and understand explicitly all major business processes and relevant sub-processes for effective implementation of process management.

The key drivers of SCI are cost orientation and customer orientation [7]. While firms may take either formal or informal approach to integrating with external partners, such as suppliers, distributors, or third-party logistics providers, liking and simplifying supply chain processes presents and excellent opportunity to reduce both transaction related costs and production costs. All customers are integral to the supply chain. When customer's interest is put first, all functional activities and organizational processes need to be organized synergistically and focused toward anticipating and responding to changing market and customer requirement ahead of competitors.

74.2.3 Coordination of Supply Chain Management

Coordination of the supply chain has become strategically important as new forms of organizations. SCM is an effort to achieve a higher level of coordination, and coordination becomes the core concept in SCM. In SCM, the coordination is the management of dependencies among supply chain members who play imperative roles, and refers to the integration of different parts of an organization or of different organizations in a supply chain to accomplish a collective set of tasks and to achieve mutual benefits.

The development of Coordination theory receives benefits from the interdisciplinary literature of new product development, technology management, information systems, and organizational theory. The logistics and SCM literature has utilized coordination theory as well.

Coordination efforts in supply chain include logistics coordination, information sharing, incentive alignment, and collective learning [12]. According to the empirical study, coordination mechanisms have three types: (1) communication and information sharing; (2) involvement in the decision making of other partners; and (3) proactive planning with other partners [8].

Supply chain coordination should focus on two aspects mainly, configuration design and execution [11]. Design-oriented configuration issues that relate to the basic infrastructure on operates, which involves coordinating the upstream and downstream product flows; and execution-oriented coordination issues that relate to the actual execution of supply chains, which involves coordination of information among partners to synchronize their activities. The operation of supply chains is challenging due to the complexity in products, diversity of suppliers' geographical distribution, and the intertwined business relationships and processes among suppliers, manufacturers, distributors, retailers, and customers needed for coordination and control [9].

74.2.4 Information Sharing of Supply Chain

Coordination mechanism based on information system, and information sharing is an important element of coordination mechanism. Information sharing reflects the extent to which partners exchange decision-relevant information via different forms of communication, and synchronizes the partners' activities.

Information sharing reduces supply chain vulnerability. Information sharing issues receive attentions, such as reducing suppliers' cost by sharing customer inventory information, reducing inventory and associated costs by information sharing, and increasing the order fulfillment ratio by sharing forecasting information between retailer and supplier. The shared information may include customer needs, customer demand, product related data, costs related data, process related data and performance metrics.

The extent of process integration and information sharing is positively associated with sales growth and productivity of individual partnerships, and with profitability of individual partnerships [13]. With the advanced development of information technology, information sharing becomes possible and necessary in order to make valuable information become visible among supply chain members to make decisions rapidly and efficiently.

74.3 Environmental Consider

74.3.1 Environment Innovation

In the management literature of the last twenty years, environmental issues have received growing attention. Two environmental movements over the last thirty to forty years provide a foundation of current research studies addressing the relationship between economic development and the natural environment. The first environment happened in 1960's and 1970's with the debate over environmental quality versus economic growth and development. Much of the debate was over whether traditional development policies and practices could be pursued in the face of limits to growth. The second environmental movement happened in the late 1980's and early 1990's. The focus of the debate shifted the emphasis from focusing only on the practice of fencing off nature to viewing environmental quality and economic development as integrated concept. In other words, the focus was on how development could be achieved in an environmentally being way.

74.3.2 Environment and Engineering

Engineering have continually sought to improve the quality of life, transforming nature to provide better living conditions. Engineering has played an important role in developing practical applications using available knowledge and technology. The consequences of direct and indirect actions of engineering have brought/are bringing/will bring the dramatic changes in the environment and the economic systems in the past/present/future. The concerns require a new thinking about the nature of development, and about an expanded scope of engineering in decision-making process. Integrated systems thinking and synthesis are necessary and mean that an integrated and complete coherent system is combined by separate elements. In engineering industry, practices need to examine fully and systematically the aggregate long-term consequences of decisions, which may lead to more environmentally sustainable choices. More environmental sensitive and responsible economic methods to integrate environment and social conditions are necessary and indispensable.

Bossink presented two main considerations about environmental objectives in project [15]. The first is the scale of the impact of the choice made? The second is what is the effect of the choice made? Harmful choice will impact the ecosystem, which can vary from negative impact to individuals to impact to the whole ecology. The effect of the choice will affect the depletion of resources and disruption of natural cycles. The following is the environmental consideration in project management [15]: (1) The depletion of resources; (2) The disruption of natural cycles; (3) The scale of the effects, which vary from individual to global; (4) The organizational consequences of a particular decision involving the knowledge, tasks, responsibilities and powers of the various participants at various stages of the engineering. Natural ecosystems are the best representation of sustainability, so some sustainability criteria are presented [16]. They include integration/synergy, simplicity, input/output characteristics, functionality, adaptability, diversity, and carrying capacity.

74.3.3 Green Design

Green design (GD) has been proposed to a popular concept in the manufacturing industry: design for environment. Loeffler and Brown [18] defined GD as the comprehensively green approach to building design and construction management. When companies develop their abilities to handle new areas, the challenge is how to integrate so many activities, such as development the knowledge resources, communication linkages and interpretative structures, and routines allowing environmental concerns.

GD emphasizes both environmentally conscious design and life cycle assessment/analysis of products. The aim is to develop an understanding of how design decisions affect a product's environmental compatibility. It is also referred to as sustainable design, eco-design and design for environment, which means designing products with the principles of economic, social and environmental sustainability.

Green operations relate to all aspects, including product manufacture/remanufacture, usage, handing, logistics, and waste management, once the design has been finalized. So, the design is the most important in the operation. GD denotes designing products with certain environment considerations systematically, with environmental safety and health over the full product life cycle during new production and process development. Its scope encompasses many disciplines, including environmental risk management, product safety, energy efficiency, occupational health and safety, pollution prevention, resource conservation, environmentally beneficial materials, 'green' techniques, and waste reduction and management [17]. From microscopic perspective, expected benefits from the implementation of GD include: operating costs reduction, energy and water use reduction, air quality improvement, waste management costs minimization, optimized recycling strategies, productivity and occupant satisfaction improvement, and community and customer goodwill enhancement.

74.4 Supply Chain Involving in Environment

With the development of society and economy, the ideas of sustainability and environment are added into SCM. So, researchers afford many terms from different perspectives. Besides green supply chain management GrSCM, other terms are equally popular in linking environment with SCM, such as Sustainable SCM (SSCM) and environmental SCM (ESCM).

The integration between environment and SCM does not only concern the development of economy and growth of benefit but it also addresses environmental issues. The relation between SCM and environmental aspects is illustrated: any activity in supply chain may have an undesired impact on the environmental chain [20]. And vice versa, any disturbances in the ecological balance may affect production activities and social welfare in the long term. Environment awareness involving SCM should contribute to developing more efficient and sustainable methods, and using different environment-friendly infrastructures, thus improving the flow management in order to reduce the waste level.

74.4.1 Green Supply Chain Management

The importance of GrSCM is driven mainly by escalating deterioration of the environment, e.g. diminishing raw material resources, overflowing waste sites and increasing levels of pollution. GrSCM means that adding the 'green' component to SCM involves addressing the influence and relationships between SCM and the natural environment. The definition and scope of GrSCM has ranged from green purchasing to integrated green supply chains flowing from supplier to manufacturer to customer, and even reverse logistics (RL) [17]. So, GrSCM integrates environmental consideration into SCM, including product design, material sourcing and selection, manufacturing processes, delivery of the final product to the consumers as well as end of life management of the product after its useful life [17].

Green design and green operation are the important stages in GrSCM process. Green design is the systematic consideration of design issues associated with environmental safety and health over the full product life cycle. Green operations relate to all aspects related to product manufacture/remanufacture, usage, handling, logistics and waste management once the design has been finalized. Investment in greening can be resource saving, waste eliminating and productivity improving, and be viewed as potential source of competitive advantage.

74.4.2 Sustainable SCM and Environmental SCM

SSCM adds sustainability into SCM processes, so that these also consider the environment, social and economic impact of business activities. Linton et al transfer the concept of sustainability to SC and state that: a sustainable supply chain is a supply chain integrating issues and flows that extend beyond the core of SCM such as product design, manufacturing by-products, product management during use, product life extension and recovery process at end of life.

The item ESCM was used for efforts initiated by companies to improve and/or control environmental performance upstream and/or downstream in the supply chain. The environmental requirement is from external and internal factors, including governmental regulation, and staff requirements, and from changes happened in knowledge resources, values, routines and/or organizational structures.

When a company choose to integrate an environmental topic into business strategy, there depends on some factors [19]: governmental regulation, governmental regulation as public-private sector-based dialogue forum, governmental funding, public debate about environment, labor rules, health, salary etc., customer demands, expectation of market opportunities, and international economic structures. Given the current manufacturing processes and the different competitive pressures, it is generally accepted that both processes and products must be changed in order to maintain the pace of consumption in an environmentally sound and sustainable way. Manufacturing organizations have the sense of urgency to select and/or develop technologies to reduce the environmental impact of their production activities and their products, which is throughout the whole process not just end-of-pipe treatment.

74.5 Green Supply Chain Design

Within SCM, two problem classes can be distinguished: cooperation (vendor selection and outsourcing) and coordination (information exchange). Cooperation decisions in SCM can divided into strategic level (supply chain design), tactical level (planning), and operational level. That is means, managing the supply chain involves three interrelated topics: (1) defining the supply chain structure; (2) identifying the supply chain business process; and (3) identifying the business components [21]. Strategic decisions are typically made over a longer time horizon. Coordination in SCM plays a fundamental role to mitigate uncertainty.

Designing supply chain with environmental consciousness is an emphasized concept, and adopts different methodologies with a focus on minimizing: (1) resource and energy consumption; (2) release of pollutants into the air; (3) generated amounts of waste; (4) contributing environmental issue; (5) the impact of the environment are all taken into consideration [22]. In particular, companies need to analyze the supply chain to improve the customer service level without a concurrent uncontrolled growth in costs. In short, companies need to increase the efficiency of their logistics operations. It is therefore of fundamental importance to optimize the flow of goods and information among the actors of the supply chain, including suppliers, manufacturers, distribution centres, and customers.

74.5.1 Factors of The Supply Chain

A simple supply chain is made up of several elements that are linked by the movement of products. The supply chain starts and ends with the customers. So, these elements should be considered in designing SC.

- Customer: afford the service for the customers at right time, right place, right price, right quality, and right cost. The target is achieved more easily in a good supply chain.
- Planning: It will create a production plan to produce the products to fulfill the customer's orders. Purchase, materials flow and inventory should be considered.
- Inventory: The raw materials are received from the supplier, and products are stored for sale. From supply to sale, appropriate inventory can balance business risk, control cost and reduce waste.
- Production: Based on a production plan, the raw materials become the product through production efficiently and effectively.
- Transportation: It throughout whole process of SC. Transportation cost typically account for above 50% of total logistics cost. Efficient transportation would improve energy efficiency and benefit cost controlling.

74.5.2 The Targets of SC Design

For the manufacturers, efficiency, cost control, quality, and flexibility are the main competitive advantages. Capturing competences is the target of SCM. Table 74.1 shows the factors description. To achieve these targets, there some important dimensions should be taken into account, including three dimensions: strategic alliance, logistics facility/location, and SCM facility. Involving supply chain design, some key factors belong to the dimension of SCM should be considered, including logistics functions mainly: purchase, inventory, transportation, and customer service to keep the flexibility of manufacturer [23].

In the supply chain network with routing, a supply chain is in which suppliers send materials to manufacturers, and manufacturers send the products to distribution centres, and then to customers. The solution to the network problem involves material flow, manufacturer location, vehicle touting problems, and distribution centers. The problems to be solved are: (1) Which suppliers should provide materials to manufacturers? (2) Which routes should be selected for providing materials to manufactures? (3) How many and where manufacturers should be opened and operated? (4) Which manufacturers should provide products to distribution centers? (5) How many and where distribution centers should be opened and operated? (6) Which distribution centers should provide products to customers? (7)Which routes should be selected for providing products to customers [24]? Questions (1) and (2) belong to materials flow, supplier selection, purchase and inventory involved. Questions (3)

Table 74.1 Each factor in the dimension of supply chain targets

Target	Sub-dimension	Factor description
Supply chain targets	Time	Decrease purchasing time Decrease production time Decrease delivery time
	Cost	Reduce purchasing cost Reduce production cost Reduce inventory cost Reduce transportation cost
	Quality	Increase purchasing quality Increase good rate of production Improve logistics channel
	Flexibility	Flexibility in production Variety of product design

and (4) belong to manufactures location. Questions (5)-(7) belong to distribution, such as delivery, and distribution center location involved.

Supply chain, as a whole, is the strategic coordination of the core functions and partners within supply chain to improve the long-term performance of the individual organizations and whole supply chain. The ultimate target of green supply chain design includes: (1) waste elimination of all processes; (2) using efficient energy resources; (3) reducing greenhouse gas emissions; (4) using capacities and resources efficiently; (5) considering legal environmental factors [26].

As discussed above, the most significant factors affecting supply chain performance are channel governance, geographic dispersion and logistics integration [25].

74.5.3 Channel Governance

Material and product flow management is the foundation for the company, and material and product flow runs through the whole process of SCM. Fig. 74.1 shows the material flow and product flow is from supplier to customer.

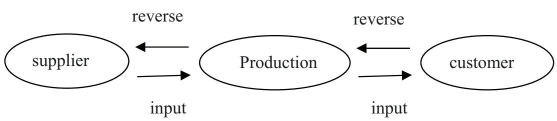

Fig. 74.1 The flow in the supply chain

Three categories are classified: buyer-vendor coordination, production-distribution coordination, and inventory-distribution coordination. In the flows, so many factors are included, such as vendor, purchasing, inventory, manufacturing, marketing, customer service, and more extension, the reverse logistics should be considered. The green design of supply chain requires managers to consider:

- the number, location, capacity, and type of manufacturing plants and warehouses;
- the suppliers selecting;
- the transportation channels;
- the amount of raw materials and products to produce and ship among suppliers, plans, warehouse, and customers; and
- the amount of raw materials, intermediate products, and finished goods to hold at various location in inventory.

For example, the purchasing function of an organization has to play a greater role in terms of procuring risk-free, and pollution-free materials and component, which finally go into setting the environmental characteristics of final products, so, the supplier selection is very important in the channel governance.

74.5.4 Geographic Dispersion

In a global business environment, distributed manufacturing process that requires a number of component suppliers, subassembly manufacturers, logistics service providers and users located in different geographical sites. The process is composed of a sequence of stages connected by material transporters and by information exchange.

Geographical dispersion, including the locations of suppliers, warehouses, manufactures, and distribution centers, affects seriously the cost of transport, and vehicle emissions are the biggest killer of environmental. The more geographical dispersed is the supply chain, the highest will be the external and internal cost of transport. Geographical dispersed requires a balance between fast responsiveness to customer requests and low inventory-cost exposure. Geographical dispersion has a direct impact on the economic and environmental performance of the supply chain. There should be ways of mitigating that negative impact of geographical dispersion on the sustainable performance of supply chain and transport. Logistics integration is not least important factor to mitigate the negative effect. Reasonable layout and operation is a great issue, not only for benefits but also for environment.

74.5.5 Green Consideration to Logistics Integration

Logistics function has long been under pressure to demonstrate its contribution to organizational performance. Generally, logistics is systematic link which is consisted of transportation, warehouse, loading and uploading, packaging, distribution processing, distribution and information management. Green logistics is that all of the issues pertain to regular logistics still apply with the added factor of environmental friendliness. All stakeholders should consider the impact of their actions on the environment. The main objective of green logistics is to coordination the activities within a supply chain in such a way that beneficiary needs are met at ‘least cost’ to the environment.

Transportation and warehousing process could involve the usage of facilities, and the more usage, the more negative impact on environment. Green warehouse management helps companies to accurately manage inventory and maximize storage capacity. A reduction in warehousing demands is one of the advantages of logistics. The energy and pollution reduction associated with better transportation planning, and the use of less packaging materials, is a part of the green logistics. Distribution incorporates the processes from customer order to the delivery of the product to the customers. Simultaneously, loading & uploading and packing are included.

Green consideration to logistics integration means that the functions of logistics are high efficiency, and generally the ratio of normal level of inputs to real level of outputs is better. Specifically, it is the ratio of resources utilized against the results derived. In a broader sense, it is the ability of the logistics function to manage resources wisely. Logistics function as a whole should product high level of logistics efficiency to positively affect the performance of the organization.

Several green initiatives, like geographical location of centre, green purchasing, waste minimization, logistics integration, channel management, and customer-focused approach, are influencing most companies to go green and manage their firms through GrSCM. The most serious corporate participants have taken the leading edge to integrate green environment-friendly strategies in their corporate missions and have undertaken GrSCM initiatives prominently.

74.6 Conclusions

The new environmental era represents a fresh challenge to manufacturing and production enterprises worldwide. The challenge is to develop way in which industrial development and environmental protection can symbiotically coexist.

Green supply chain is more complicated, and involves not only daily activities but also long-term strategies. The research about green initiatives is being undertaken from sustainability and ethical perspective incorporating social and economic influences. Popular green initiatives are often linked to concept like recycling, paperless practices, reduced reverse logistics flow, risk mitigation, optimal energy utilization, utility maximization of resources, and energy-efficient management, etc.

An increasing number of companies is considering eco-efficiency and green issues as a major source of strategic change. The concern for the environmental dimension in business strategies results from significant changes in the social system and competitive arena. China is the world leader in manufacturing sector and also one of the fastest developing economies in the world. Environment issue increasingly becomes the focus of attention with thirty years rapid economic development.

Environmental awareness in SCM would help business managers in China to operate environment-friendly.

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Chapter 75
Contracting to Share Bilateral Information in Supply Chain

Xinhui Wang and Xianyu Wang

Abstract This paper investigates the problem of information sharing under bilateral asymmetric information environment. More specifically, we consider a supply chain consisting of one risk-neural manufacturer and one risk-neural retailer for an innovation product. In order to facilitate the cooperation, the manufacturer and the retailer agree to share their private information that is known from the finished sample product. We give a relational contract specified the trading quantity and the corresponding transfer payments. We show that the wholesale price relational contract cannot induce the two parties to share their information truthfully and analyze how the false information affects the supply chain's profit. In order to create sufficient incentives and internalize the supply chain's objective, we design a new set of transfer payments specified the allocation rule based on the two parties' information rents. We show that the relational contract with the new transfer payments can achieve truthful information revealing and allocate the ex post profit reasonably.

Keywords Supply chain · Bilateral asymmetric information · Relational contract · Information rents

75.1 Introduction

In a supply chain, the separated firms are often cooperated by contracts. However, in some cases, the firms cannot write a precise contract on some key parameters facing some uncertain future information. For instance, prior to developing an innovative

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product, the manufacturer and the retailer cannot contract on the price or trading quantity associated with their production information. At this point, the informal agreement (i.e. relational contract) is often proposed to ensure the cooperation relationship. Unfortunately, without a court-enforceable contract, the manufacturer and the retailer may share their information falsely after being informed for a better individual benefit. Thus, if two parties both misreport their private information, the bilateral asymmetric information environment is formed. How the asymmetric information affects the supply chain and how to induce the firms share their private information truthfully is a key issue.

This paper focuses on the bilateral asymmetric information sharing and aims to design the relational contract mechanism that revealing information truthfully. While so many literatures have studied the information revealing mechanism, we have a different focus. We consider a relational contract that is non-enforceable contract, and design a set of transfer payments that create incentives for not deviating from equilibrium.

Our contributions to the literature will be three aspects: first, in contrast to the existing literature, we construct the model of the supply chain with bilateral asymmetric information based on the relational contract mechanism. Second, we design a set of transfer payments, which require essentially that each party appropriates the externality he actions impose on other party. In this way, each party is induced to internalize the whole supply chain's decision and is effectively maximizing the system's objective. Third, we consider an allocation rule based on the expected information rents. They denote the negotiation power under the bilateral asymmetric information environment.

75.2 Literature Review

This paper can be regarded as a study of the contract mechanism designing of supply chain. In order to highlight our contributions, we review only the literature that is particularly relevant to our study.

Macaulay [1] demonstrate that instead of relying on formal, court-enforceable contracts, firms cooperate relying on informal agreement. Levin [2] consider an agency problem with moral hazard or hidden information. Recently, many researchers have explored these contracts in operation management. Taylor and Plambeck [3] compare two different relation contracts. The former commit the buyer to purchase a fixed quantity, whereas the latter only specify a per-unite price. Taylor and Plambeck [4] consider a supply chain for an innovation product. Instead of the court-enforceable contracts, the firms adopt an informal agreement (rational contract) to create incentives for cooperation. Information sharing mechanism has attracted substantial attention by many scholars. To mitigate the presence of asymmetric information and improve the supply chain's performance, many scholars investigate the information sharing mechanism. These related studies regarding the unilateral asymmetric information are mainly centralized on the asymmetric demand information (see for instances, [5–8]) and the asymmetric cost information (see for instances, [9–13]). However, that the private information is asymmetric to one party, as implicitly assumed in the literatures above mentioned, has practical limitations.

More recently, a few researchers were motivated to explore supply chain models under the bilateral asymmetric information scenario. Chatterjee and Samuelson [14] analyze that the seller and the buyer achieve bilateral asymmetric information by bargaining strategy, and their private information is the evaluation of commodity price. Zhang and Luo [15] explore the trade credit in coordinating supply chain under bilateral information senior. In the proposed model, the manufacturer possesses the private information regarding its own capital cost while the retailer has the private information about the budget constraint or capital cost. Esmaeili and Zeephongsekul [16] consider a supply chain, in which the buyer and seller have the private information about demand information and purchase costs respectively. Wang et al [17] examine the supply chain efficiency under the bilateral information case. Some other bilateral asymmetric information problem can be seen in the areas of auction (see for instances, [18–21]).

This paper is organized as follows. Sect. 75.2 reviews literature in the areas of information revealing mechanism designing. Sect. 75.3 introduces the model assumption and constructs the basic model. Sect. 75.4 presents the contract mechanism of information sharing. Sect. 75.5 concludes this paper. Proofs are presented in the appendix.

75.3 The Model

75.3.1 Model Assumptions

Consider a two-firm supply chain consisting of one manufacturer and one retailer for an innovation product. Prior to production, the manufacturer and the retailer commit a informal agreement to ensure the latter trading. The informal agreement includes the trading quantity depending on the production cost and the retail price, which are not clear at this point and the corresponding transfer payments. When the sample product is finished, the true production cost can be obtained by the manufacturer and the retail price can be determined by the retailer, thus the production cost and retail price are their private information respectively. Then the two firms share their acquired private information to determine the trading quantity according to the ex ante informal agreement (The sequence of events can be seen in Fig. 75.1). The retailer buys the product from the upstream manufacturer and sells it to a market in which demand is stochastic. The manufacturer and the retailer are both risk neutral. In order to simplify notation, without loss of generality, we also assume the goodwill cost and the salvage cost are both zero.

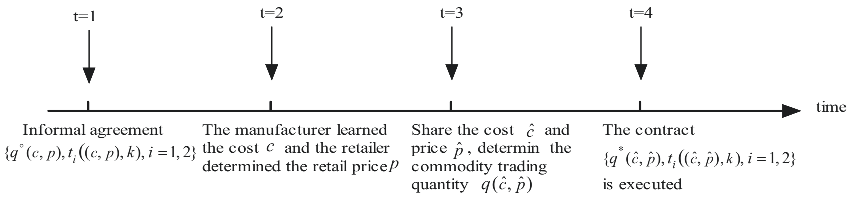

Fig. 75.1 Timing of the contracting game

The notation used throughout our study is summarized below:

$q^{\circ}(\cdot)$: Optimal order quantity of the supply chain in full information case;
$q^{*}(\cdot)$: Optimal order quantity of the supply chain in asymmetric information case;
$t_1(\cdot)$: Transfer payment to the manufacturer;
$t_2(\cdot)$: Transfer payment to the retailer;
$c, \hat{c}$: Manufacturer's true unit Production cost and announcing unit Production cost, belong to $[\underline{c}, \bar{c}]$;
$p, \hat{p}$: Retail price per unit and announcing unit retail price, belong to $[\underline{p}, \bar{p}]$;
$F_1(\cdot), f_1(\cdot)$: Strictly increasing distribution function and corresponding density function of c;
$F_2(\cdot), f_2(\cdot)$: Strictly increasing distribution function corresponding density function of p;
$G(\cdot), g(\cdot)$: Strictly increasing distribution function and corresponding density of stochastic demand;
$E_p(\cdot)$: Expectation function with respect to $F_2(\cdot)$;
$E_c(\cdot)$: Expectation function with respect to $F_1(\cdot)$;
$E_{cp}(\cdot)$: Bilateral expectations function with respect to $F_1(\cdot)$ and $F_2(\cdot)$;
$E(\cdot)$: Expectation function with respect to $G(\cdot)$;
$y > 0$: Market stochastic demand during the selling season;
$S(q(\cdot))$: Expected sales for the retailer, equals $E(\min(q(\cdot), y))$;
$\prod(\cdot)$: Profit function of the total supply chain;
$\prod_1(\cdot)$: Manufacturer's profit function with $t_1(\cdot)$;
$\prod_2(\cdot)$: Retailer's profit function with $t_2(\cdot)$.

As usual, we assume that $p \geq w$ and $p \geq c$ in order to ensure nonnegative profit of the system or parties. We also assume that $\partial^2 q(\cdot)/\partial \hat{p}^2 \leq 0$ holds, it means that the commodity trading quantity rate of the change in price is decreasing.

75.3.2 The Model

In this subsection, we give the relational contract under bilateral asymmetric information case. The relational contract consists of the trading quantity and the corresponding transfer payments.

In order to analyze our model and put insight into the impact of asymmetric information on the supply chain, we first present the symmetric information case, where the manufacturer and the retailer share the information of the production cost and the retail price truthfully, as a benchmark.

The profit of the manufacturer is:

$$\prod\nolimits_1 (q(c,p)) = -cq(c,p)) + t_1(c,p) \tag{75.1}$$

and the profit of the retailer is:

$$\prod\nolimits_2 (q(c,p)) = pE\left(\min(q(c,p),y)\right) + t_2(c,p), \tag{75.2}$$

where the transfer payments $t_i(c,p), i = 1,2$ satisfy the relationship: $t_1(c,p) + t_2(c,p) = 0$. Thus, the total profit of the supply chain can be expressed as:

$$\begin{aligned} \prod (q(c,p)) &= \prod\nolimits_1 (q(c,p)) + \prod\nolimits_2 (q(c,p)) \\ &= p\left(q(c,p) - \int_0^{q(c,p)} G(y)dy\right) - cq(c,p). \end{aligned} \tag{75.3}$$

The concave property of $\prod (q(c,p))$ in $q(c,p)$ is satisfied and then the corresponding conclusion is given in the following proposition.

Proposition 75.1. *Under the full information case, the optimal order quantity of the supply chain satisfies the following equation:*

$$q^{\circ}(c,p) = G^{-1}\left((p-c)/p\right). \tag{75.4}$$

If the transfer payment $t_1(c,p)$ equals to $wq(c,p)$, the contract can be seen as the wholesale price relational contract under bilateral asymmetric information case. With the transfer payments, the manufacturer and the retailer's expected profits are given by:

$$\begin{aligned} E_p\left(\prod\nolimits_1 (q(\hat{c},p),c)\right) &= E_p\left[-cq(\hat{c},p)) + t_1(\hat{c},p)\right] \\ &= E_p\left[wq(\hat{c},p) - cq(\hat{c},p)\right], \end{aligned} \tag{75.5}$$

$$\begin{aligned} E_c\left(\prod\nolimits_2 (q(c,\hat{p}),p)\right) &= E_c\left[pE\left(\min(q(c,\hat{p}),y)\right) + t_2(c,\hat{p})\right] \\ &= E_c\left[pS(q(c,\hat{p})) - wq(c,\hat{p})\right]. \end{aligned} \tag{75.6}$$

The first-order conditions of the expected profit function $E_p \prod_1 (\hat{c},p)$ with respect to $\hat{c}$, we have:

$$\frac{\partial E_p \prod_1 (\hat{c},p)}{\partial \hat{c}} = E_p\left[(w-c)\frac{\partial q(\hat{c},p)}{\partial \hat{c}}\right] \le 0, \tag{75.7}$$

This indicates that the manufacturer may announce a lower production cost for better expected profit. In the similar way, the retailer's first-order condition at $\hat{p}$ is satisfied:

$$\frac{\partial E_c \prod_2(c,\hat{p})}{\partial \hat{p}} = E_c\left[(p(1-G(q(c,\hat{p}))-w)\frac{\partial q(c,\hat{p})}{\partial \hat{p}}\right]. \tag{75.8}$$

However, the sign of the second-order condition at $\hat{p}$ is ambiguous,

$$\left.\frac{\partial^2 E_c \prod_2(c,\hat{p})}{\partial \hat{p}^2}\right|_{\hat{p}=p} = E_c\left[-pg(q(c,\hat{p})\left(\frac{\partial q(\hat{c},p)}{\partial \hat{p}}\right)^2 + (c-w)\frac{\partial^2 q(c,\hat{p})}{\partial \hat{p}^2}\right]. \tag{75.9}$$

Equation (75.9) means that announcing the true retail price may not be the retailer's best response from the perspective of the expectation.

Thus, we have the following proposition.

Proposition 75.2. *The wholesale price relational contract cannot achieve information sharing under bilateral asymmetric information case.*

Proposition 75.2 states that the transfer payments specified wholesale price cannot provide sufficient incentives for truthful sharing their information. In this case, the total profit of the supply chain is given by:

$$\prod(q(\hat{c},\hat{p})) = \hat{p}S(q(\hat{c},\hat{p})) - \hat{c}q(\hat{c},\hat{p}). \tag{75.10}$$

The optimal trading quantity under bilateral asymmetric information case is

$$q^*(\hat{c},\hat{p}) = G^{-1}\left((\hat{p}-\hat{c})/\hat{p}\right). \tag{75.11}$$

Since the distribution function $G(\cdot)$ is strictly increasing, it is clear that $q^*(\hat{c},\hat{p}) = q^\circ(c,p)$ only if $\hat{c}=c$ and $\hat{p}=p$ hold simultaneously. However, the decisions of manufacturer and the retailer may deviate from the equilibrium $\{\hat{c}=c, \hat{p}=p\}$ without sufficient incentives are provided in the wholesale price relational contract. Because the supply chain's profit is concave in the trading quantity, any case $q^*(\hat{c},\hat{p}) \neq q^\circ(c,p)$ damages the total supply chain's profit.

75.4 Contract Mechanism of Information Sharing

75.4.1 Transfer Payments

How to induce the two firm's information sharing truthfully and facilitate them to cooperate is a key issue. Now, we consider a set of new transfer payments to achieve the incentives to share truthful information and align the individual's objective with the supply chain's objective.

$$t_1 = kpS(q) + (1-k)cq, \tag{75.12}$$

$$t_2 = -kpS(q) - (1-k)cq, \tag{75.13}$$

where, k is a parameter, $k \in (0,1)$.

If the manufacturer and the retailer announce their information $\hat{c}$ and $\hat{p}$ respectively, their transfer payments will be:

$$t_1(\hat{c},\hat{p}) = kpS(q(\hat{c},\hat{p})) + (1-k)cq(\hat{c},\hat{p}), \tag{75.14}$$
$$t_2(\hat{c},\hat{p}) = -kpS(q(\hat{c},\hat{p})) - (1-k)cq(\hat{c},\hat{p}). \tag{75.15}$$

Thus, the manufacturer and the retailer's expected profit can be written as:

$$\begin{aligned} E_p\left(\prod\nolimits_1 (q(\hat{c},p),c)\right) &= E_p\left[-cq(\hat{c},p)) + t_1(\hat{c},p)\right] \\ &= kE_p\left[pS(q(\hat{c},p)) - cq(\hat{c},p)\right], \end{aligned} \tag{75.16}$$
$$\begin{aligned} E_c\left(\prod\nolimits_2 (q(c,\hat{p}),p)\right) &= (1-k)E_c\left[pE\left(\min(q(c,\hat{p}),y)\right) + t_2(c,\hat{p})\right] \\ &= (1-k)E_c\left[pS(q(c,\hat{p})) - cq(c,\hat{p})\right]. \end{aligned} \tag{75.17}$$

Now, we can get the following proposition:

Proposition 75.3. *For* $k \in (0,1)$ *and be a constant, the transfer payments can induce the manufacturer and the retailer share their private information truthfully, i.e.,* $\hat{c} = c, \hat{p} = p$.

Proposition 75.3 indicates that the transfer payments integrate the two parties as a whole by undertaking the cost and sharing the profit commonly. In this way, each party is induced to internalize the whole supply chain's decision and is effectively maximizing the system's objective.

75.4.2 Allocation Rule

The parameter k and $1-k$ are the two firms' allocation proportions of the total supply chain's profit, respectively. As usual, the allocation proportion also denotes the negotiation power in the economic game. In the unilateral asymmetric information problem of the supply chain, the information rent for revealing information truthfully is seen as a reservation profit, and this denotes the informed party's negotiation power. Thus, we define an allocation proportion of supply chain's profit based on the manufacturer and retailer's expected information rents at ex ante stage.

We first compute the two firms' expected information rents. According to Proposition 75.3, announcing cost information truthfully ($\hat{c} = c$) means that the following formula is satisfied.

$$E_p \prod\nolimits_1 (q(c,p),c) \geq E_p \prod\nolimits_1 (q(\hat{c},p),c). \tag{75.18}$$

In the similar way, for the retailer it holds that

$$E_c \prod\nolimits_2 (q(c,p),p) \geq E_c \prod\nolimits_2 (q(c,\hat{p}),p). \tag{75.19}$$

By the Equations (75.18) and (75.19), we have the proposition below.

Proposition 75.4. *Conditions Equations (75.18) and (75.19) can be reduced to two differential equations and two monotonicity constrains,*

$$\frac{\partial \prod_1(c,p)}{\partial c} = -q(c,p), \quad \frac{\partial \prod_2(c,p)}{\partial p} = S(q(c,p)),$$
$$E_p \frac{\partial q(c,p)}{\partial c} \le 0, \quad E_c \frac{\partial S(q(c,p))}{\partial p} \ge 0.$$

By the differential equations in Proposition 75.4, we can obtain that:

$$\prod\nolimits_1 (c,p) = \prod\nolimits_1 (\bar{c},p) + \int_c^{\bar{c}} q(s,p)ds, \tag{75.20}$$
$$\prod\nolimits_2 (c,p) = \prod\nolimits_2 (c,\underline{p}) + \int_{\underline{p}}^{p} S(q(c,t))dt. \tag{75.21}$$

Equations (75.20) and (75.21) can be regarded as the information rents for the manufacturer and retailer, which can be seen in the contract theory on bilateral asymmetric information (see for instance [22]). Hence the expected information rents of the manufacturer and the retailer at ex ante age are:

$$E_{cp} \prod\nolimits_1 (c,p) = E_p \prod\nolimits_1 (\bar{c},p) + E_{cp} \left(\int_c^{\bar{c}} q(s,p)ds \right), \tag{75.22}$$
$$E_{cp} \prod\nolimits_2 (c,p) = E_c \prod\nolimits_2 (c,\underline{p}) + E_{cp} \left(\int_{\underline{p}}^{p} S(q(c,t))dt \right). \tag{75.23}$$

As usual, we can assume that at the optimum the least efficient manufacturer and retailer receive their reservation utilities: $E_p \prod_1 (\bar{c},p) = 0$ and $E_c \prod_2 (c,p_{\_}) = 0$.

Definition 75.1.

$$k = H_1/(H_1 + H_2), 1 - k = H_2/(H_1 + H_2),$$

where

$$H_1 = E_{cp} \left(\prod\nolimits_1 (c,p) \right) = \int_{\underline{c}}^{\bar{c}} \int_{\underline{p}}^{\bar{p}} \int_c^{\bar{c}} q(s,p)dsdpdc,$$
$$H_2 = E_{cp} \left(\prod\nolimits_2 (c,p) \right) = \int_{\underline{p}}^{\bar{p}} \int_{\underline{c}}^{\bar{c}} \int_{\underline{p}}^{p} S(q(c,t))dtdcdp.$$

This allocation proportion is also a parameter, and it will not damage the incentives for sharing truthful information. Thus, we have the following proposition.

Proposition 75.5. *The rational incentive contract* $\{q^\circ(c,p), t_i((c,p),k)\}$ *can induce the manufacturer and the retailer to announce their information truthfully and divide the supply chain's profit reasonably.*

75.5 Conclusions and Future Research

In this paper, we address the information sharing in a supply chain under bilateral asymmetric information environment and design a relational contract mechanism.

Firstly, we construct a basic supply chain model. In our model, the manufacturer and the retailer commit an informal contract to ensure the latter trading when their private information are acquired. We consider a wholesale price contract associated with the production cost information and the retail price information. We find that the wholesale price relational contract cannot achieve truthful information sharing, and the false information decreases the supply chain's profit. It is because the transfer payments specified wholesale price cannot provide sufficient incentives.

In order to overcome the issue, we design a set of transfer payments which is related to the information of the two firms and allocation proportion of total supply profit. Furthermore, the designed transfer payments require essentially that each party appropriates the externality he actions impose on the other party. Thus, both the manufacturer and retailer share their information truthfully.

A relational contract consisting of the trading quantity related to the private information and the transfer payments that is dependent on the allocation rule associated with the expected information rents is given. We have confirmed that the contract mechanism cannot only reveal information truthfully but also guarantee the ex post reasonable profit allocation.

Of course, the weakness of this paper is that the market demand distribution is symmetric for the manufacturer and retailer. Additionally, some factors such as leftover inventory, lost-sales have been omitted for simplicity. One would expect to incorporate those features in the further researches.

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Appendix A

Proof of Proposition 75.1:

Proof. The firs-order condition and second-order condition of the chain's profit function $\prod(q(c,p))$ with respect to$q(c,p)$, respectively, we have:

$$\frac{\partial \prod(q(c,p))}{\partial q(c,p)} = p(1 - G\,(q(c,p)) - c, \tag{75.24}$$

$$\frac{\partial^2 \prod(q(c,p))}{\partial (q(c,p))^2} = -pg\,(q(c,p)) \leq 0. \tag{75.25}$$

From Equation (75.24) and Equation (75.25), we can get the optimal system order quantity $q^{\circ}(c,p)$ satisfies the formula $G(q^{\circ}(c,p)) = (p-c)/p$. We can easily obtain $q^{\circ}(c,p) = G^{-1}\left((p-c)/p\right)$, for $G(\cdot)$ is a strictly increasing distribution function.

Proof of Proposition 75.4:

Proof. From Equation (75.18), we obtain that $E_p(\hat{c}-c)(q(c,p)-q(\hat{c},p)) \geq 0$, which implies $E_p\left(\partial q(c,p)/\partial c\right) \leq 0$. By Envelope Theorem, we have $\partial \prod_1(c,p)/\partial c = -q(c,p)$. In the similar way, for the Equation (75.19), we also obtain that: $E_c\left(\partial q(c,p)/\partial p\right) \geq 0$, $\partial \prod_2(c,p)/\partial p = S(q(c,p))$. Thus the Equations (75.18) and Equation (75.19) can be rewritten as two differential equations and two monotonicity constraints,

$$\frac{\partial \prod_1(c,p)}{\partial c} = -q(c,p),\ E_p\frac{\partial q(c,p)}{\partial c} \leq 0;\ \frac{\partial \prod_2(c,p)}{\partial p} = S(q(c,p)),\ E_c\frac{\partial q(c,p)}{\partial p} \geq 0.$$

Proof of Proposition 75.3:

Proof. The expected utility functions of the supplier and the retailer can be expressed as:

$$\begin{aligned} E_p\left(\prod\nolimits_1 (q(\hat{c},p),c)\right) &= kE_p\left[pS(q(\hat{c},p)) - cq(\hat{c},p)\right], \\ E_c\left(\prod\nolimits_2 (q(c,\hat{p}),p)\right) &= (1-k)E_c[pS(q(c,\hat{p})) - cq(c,\hat{p})]. \end{aligned}$$

(1) The first-order conditions of the expected profit functions $E_p\prod_1(\hat{c},p)$ and $E_c\prod_2(c,\hat{p})$ with respect to $\hat{c}$ and $\hat{p}$, respectively; we have:

$$\begin{aligned} \frac{\partial E_p \prod_1(\hat{c},p)}{\partial \hat{c}} &= kE_p\left[(p(1-G(q(\hat{c},p))-c)\frac{\partial q(\hat{c},p)}{\partial \hat{c}}\right], \\ \frac{\partial E_c \prod_2(c,\hat{p})}{\partial \hat{p}} &= (1-k)E_c\left[(p(1-G(q(c,\hat{p}))-c)\frac{\partial q(c,\hat{p})}{\partial \hat{p}}\right]. \end{aligned}$$

(2) The second-order conditions of the expected profit functions $E_p\prod_1(\hat{c},p)$ and $E_c\prod_2(c,\hat{p})$ with respect to $\hat{c}$ and $\hat{p}$, respectively; we have:

$$\frac{\partial^2 E_p \prod_1(\hat{c},p)}{\partial \hat{c}^2} = kE_p\begin{bmatrix} -pg(q(\hat{c},p)\left(\frac{\partial q(\hat{c},p)}{\partial \hat{c}}\right)^2 \\ +(p(1-G(q(\hat{c},p))-c)\,\frac{\partial^2 q(\hat{c},p)}{\partial \hat{c}^2} \end{bmatrix}, \tag{75.26}$$

$$\frac{\partial^2 E_c \prod_2(c,\hat{p})}{\partial \hat{p}^2} = (1-k)E_c\begin{bmatrix} -pg(q(c,\hat{p})\left(\frac{\partial q(\hat{c},p)}{\partial \hat{p}}\right)^2 \\ +(p(1-G(q(c,\hat{p}))-c)\,\frac{\partial^2 q(c,\hat{p})}{\partial \hat{p}^2} \end{bmatrix}. \tag{75.27}$$

when $\hat{c} = c$,$\hat{p} = p$, by the formula $G(q(c,p) = (p-c)/p$, we have the following formulas:

$$\left.\frac{\partial^2 E_p \prod_1(\hat{c},p)}{\partial \hat{c}^2}\right|_{\hat{c}=c} = kE_p\left[-pg(q(c,p)\left(\frac{\partial q(c,p)}{\partial \hat{c}}\right)^2\right] \leq 0, \tag{75.28}$$

$$\left.\frac{\partial^2 E_c \prod_2(c,\hat{p})}{\partial \hat{p}^2}\right|_{\hat{p}=p} = (1-k)E_c\left[-pg(q(c,p)\left(\frac{\partial q(c,p)}{\partial \hat{p}}\right)^2\right] \leq 0. \tag{75.29}$$

Equations (75.28) and (75.29) show that the supplier and the retailer have maximized their expected profits for $\hat{c} = c$ and $\hat{p} = p$.

Chapter 76
A Closed-loop Supply Chain Network Equilibrium Model with Multi-criteria and Stochastic Demand

Bing Xu and Kun Jiang

Abstract Consider a multi-commodity flow closed-loop supply chain network consisting of many manufacturers, retailers, recovery enterprises, demand and recovery markets, respectively manufacturing, selling, consuming same kinds of new products, and recycling and supplying the used products. Manufacturer makes decision to maximize its profit and the benefit of environmental protection. Logit model is used to characterize the consumer behavior on product choice with insufficient information. Firstly, based on Nash equilibrium theory, competitive behaviors of manufacturers, retailers and recovery enterprises are analyzed respectively together with the corresponding variational inequality equilibrium models. The stochastic equilibrium conditions of demand markets with stochastic demand are obtained. The equilibrium of recovery markets is realized if and only if the quantities and prices of supply and demand are balanced. Then a variational inequality model is obtained to characterize the equilibrium of multi-commodity closed-loop supply chain network with multi-criteria and stochastic demand. Finally, a numerical example shows the reasonability of the model and the sensitivity analysis of the factors of consumers' environment value and government's subsidy.

Keywords Equilibrium model of closed-loop supply chain network · Variational inequality · Logit model · Stochastic demand · Multi-criteria decision

76.1 Introduction

Closed-loop Supply chain network consists of material suppliers, manufacturers, wholesalers, retailers, recycling enterprises, demand markets and recovery markets, and includes both forward flow of commodity and reverse flow of recycling used

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products. In the past decade there is a growing trend that more and more enterprisers pay attention to the sustainable development and the operation mode based on closed-loop supply chain. But, how to characterize the competitive behaviors of all agents and the equilibrium of closed-loop supply chain network is a difficult theoretic problem, and cries for more studies.

Nagurney etc. have used variational inequality method to respectively set up the variational ineauality equilibrium models of supply chain network with un-random demand and random demand (See [1, 2]). Xu and Zhu [3] analyzes the affection of the product differentiation of region and brand on consumer by using stochastic utility theory and multinomial Logit model, and put forward a variational inequality equilibrium model of the multi-commodity flow supply chain network. Xu and Zhu [4] further studies the supply chain network equilibrium model with multi-commodity in consideration of heterogeneous substitutable products under the assumption that customers' preference for product characters varies from class to class by using multi-criteria decision theory. Xu and Zhu [5] uses nested Logit model to character the consumers' choice, i.e., the consumers being stochastic multi-criteria decision-makers firstly choose which retailer they transact with, and then make their consumption decisions with deficient information, and further puts forward a variational inequality equilibrium model of supply chain network equilibrium with stochastic multicriteria decision.

All these papers mentioned above don't relate to closed-loop supply chain. Recycling used products becomes the social responsibility of enterprises because of the enhancement of people's environmental protection consciousness and the enforcement of environmental protection laws. "The recovery management regulation of used electric products" in China rules that the electronics manufacturers should directly recycle or authorize retailers, maintenance agents, after-sales service organizations and recovery enterprisers to recycle the used electric products. The reuse ways of used product include direct reuse, maintenance, regeneration and remanufacturing. Manufacturers can remanufacture used products into new ones by taking operations as disassembly, overhaul, and replacement. There exist three kind of reverse channel structures for the collection of used products from customers that the manufacturer collects them itself directly, or she provides suitable incentives to an existing retailer to induce the collection, or she subcontracts the collection activity to a third party (See [6]). Yang [7] sets up a variational inequality equilibrium model of closed-loop supply chain network consisting of manufacturers, retailers and consumers, where retailers recycle the used products. Yang and Wang [8] further studies the effects of parameters on the equilibrium shipments and net revenues in the equilibrium model of closed-loop supply chain network. Xu and Zhang [9] studies the reverse flow of used products from the owners to recycle plants then to remanufacturing factories, and set up a variational inequality model of closed-loop supply chain network with un-random demand.

This paper studies manufacturers' multi-criteria decision and consumer's behavior on product choice, set up a variational inequality equilibrium model of the multi-commodity flow closed-loop supply chain network with Multi-criteria and stochastic demand, which consists of many manufacturers, retailers, recovery enterprises, demand markets and recovery markets, and includes both forward flow of commodity and reverse flow of recycling used products.

76.2 A Multi-commodity Closed-loop Supply Chain Network Equilibrium Model with Multi-criteria and Stochastic Demand

Consider a closed-loop supply chain network consisting of I manufacturers, J retailers, N recovery enterprises, one demand and recovery market, who engage in manufacturing, selling and consuming L kinds of commodities, recycling and supplying corresponding used products. The same kind products produced by different manufacturers are homogeneous, consumers choose product based on the retail price and the recovery remanufacture rate of product. Manufacturer tries to maximize its profit and the benefit of environmental protection. The competitive behavior of manufacturers, retailers and recovery enterprises are analyzed respectively, and the closed-loop supply chain network equilibrium model is put forward by using variational inequality method.

76.2.1 The Competitive Equilibrium of Manufacturers

Denote a typical manufacturer by i, a typical retailer by j, a typical recovery enterprises by n, a typical kind product by l. Assume that manufacturer i can manufacture product l by two modes such as full using original material or partial using recovery parts, and denote corresponding production outputs by $q_i^{lr}$and q_i^{lu}, production cost functions by $f_i^{lr}(q^{lr})$ and $f_i^{lu}(q^{lu})$, which respectively depend on the entire vector of production outputs $q^{lr} = (q_1^{lr}, \cdots, q_i^{lr}, \cdots, q_I^{lr}) \in R_+^I$ and $q^{lu} = (q_1^{lu}, \cdots, q_i^{lu}, \cdots, q_I^{lu}) \in R_+^I$ because of the material competition among manufacturers. Denote the transaction price and quantity of product l between manufacturer i and retailer j by ρ_{ij}^l and q_{ij}^l, and the corresponding transaction cost born by manufacturer i is $c_{ij}^l(q_{ij}^l)$. Group manufacturer i's production outputs and transaction quantities into the vector $Q_i = (q_i^{1r}, q_i^{2r}, \cdots, q_i^{Lr}; q_i^{1u}, q_i^{2u}, \cdots, q_i^{Lu}; q_{i1}^1, \cdots, q_{ij}^l, \cdots, q_{iJ}^L)$, and let $Q = (Q_1, Q_2, \cdots, Q_I)$. Denote the transaction price and quantity of used product l between manufacturer i and recovery enterprise n by ρ_{in}^l and q_{in}^{lu}, and the conversation rate of used product l is $0 < \varphi_l < 1$, i.e., $1/\varphi_l$ used product l can be remanufactured into one new product l. Denote per purchase price of raw material by ρ^{lr}.

Let $\phi_i^l = q_i^{lu} / (q_i^{lr} + q_i^{lu})$ denote the manufacturer i's remanufacturing rate of product l, and v_l denote the benefit of environmental protection from remanufacturing per used product l. Each manufacturer i makes decision to maximize both its profit and the benefit of environmental protection with nonnegative weights α_i^1 and α_i^2. The multi-criteria decision model of manufacturer i can be expressed as:

$$\begin{cases} \max\limits_{Q_i \geq 0} \ \pi_i(Q_i) = \sum\limits_{l=1}^{L} \left\{ \alpha_i^1 \left[\sum\limits_{j=1}^{J} (\rho_{ij}^l q_{ij}^l - c_{ij}^l(q_{ij}^l)) - f_i^{lr}(q^{lr}) \right.\right. \\ \qquad \left.\left. - f_i^{lu}(q^{lu}) - \rho^{lr} q_i^{lr} - \sum\limits_{n=1}^{N} \rho_{in}^l q_{in}^l \right] + \alpha_i^2 v_l \sum\limits_{n=1}^{N} q_{in}^l \right\}, \\ \text{s.t. } \ q_i^{lr} + q_i^{lu} \geq \sum\limits_{j=1}^{J} q_{ij}^l, q_i^{lu} \leq \varphi_l \sum\limits_{n=1}^{N} q_{in}^l, \ \forall l. \end{cases} \tag{76.1}$$

For Equation (76.1), the objective of manufacturer i is profit-maximization when $\alpha_i^1 = 1$ and $\alpha_i^2 = 0$; the objective of manufacturer i is benefit-maximization of environmental protection when $\alpha_i^1 = 0$ and $\alpha_i^2 = 1$; and manufacturer i will pay equal attention to the profit and the benefit of environmental protection when $\alpha_i^1 = \alpha_i^2$. Here, assume $\alpha_i^1 > 0$ and let $\alpha_i = \alpha_i^2 / \alpha_i^1$ denote the money value of environmental protection. Consequently, the multi-criteria decision model of manufacturer i is equal to:

$$\begin{cases} \max\limits_{Q_i \geq 0} \ \overline{\pi}_i(Q_i) = \sum\limits_{l=1}^{L} \left[\sum\limits_{j=1}^{J} (\rho_{ij}^l q_{ij}^l - c_{ij}^l(q_{ij}^l)) - f_i^{lr}(q^{lr}) \right. \\ \qquad \left. - f_i^{lu}(q^{lu}) - \rho^{lr} q_i^{lr} - \sum\limits_{n=1}^{N} \rho_{in}^l q_{in}^l + \alpha_i v_l \sum\limits_{n=1}^{N} q_{in}^l \right], \\ \text{s.t. } \ q_i^{lr} + q_i^{lu} \geq \sum\limits_{j=1}^{J} q_{ij}^l, q_i^{lu} \leq \varphi_l \sum\limits_{n=1}^{N} q_{in}^l, \ \forall l. \end{cases} \tag{76.2}$$

Assume that $f_i^{lr}(q^{lr})$, $f_i^{lu}(q^{lu})$ and $c_{ij}^l(q_{ij}^l)$ are continuous, differentiable and convex, then $\overline{\pi}_i(Q_i)$ is continuous, differentiable and concave. Each manufacturer determines his optimal production outputs and transaction quantities to maximize his objective. The competition equilibrium of manufacturers is Nash equilibrium, which can be expressed as the following variational inequality:

$$\begin{aligned} &\sum_{l=1}^{L}\sum_{i=1}^{I}\left\{ \left(\frac{\partial f_i^{lr}(q^{lr*})}{\partial q_i^{lr}} + \rho^{lr} - \gamma_{i1}^l \right)(q_i^{lr} - q_i^{lr*}) + \left[\frac{\partial f_i^{lu}(q^{lu*})}{\partial q_i^{lu}} - \gamma_{i1}^l + \gamma_{i2}^l \right](q_i^{lu} - q_i^{lu*}) \right. \\ &\quad + \sum_{j=1}^{J} \left[\frac{\partial c_{ij}^l(q_{ij}^{l*})}{\partial q_{ij}^l} - \rho_{ij}^l + \gamma_{i1}^l \right](q_{ij}^l - q_{ij}^{l*}) + \left(q_i^{lr} + q_i^{lu} - \sum_{j=1}^{J} q_{ij}^l \right)(\gamma_{i1}^l - \gamma_{i1}^{l*}) \\ &\quad \left. + \left(\varphi_l \sum_{n=1}^{N} q_{in}^l - q_i^{lu} \right)(\gamma_{i2}^l - \gamma_{i2}^{l*}) + \sum_{n=1}^{N} (\rho_{in}^l - \alpha_i v_l - \varphi_l \gamma_{i2}^l)(q_{in}^l - q_{in}^{l*}) \right\} \geq 0, \\ &\quad \forall (Q, \gamma_1, \gamma_2) \geq 0, \end{aligned} \tag{76.3}$$

where γ_{i1}^l and γ_{i2}^l are Lagrange multipliers of constraint conditions in Equation (76.2), $\gamma_{i1} = (\gamma_{i1}^1, \gamma_{i1}^2, \cdots, \gamma_{i1}^L)$, $\gamma_{i2} = (\gamma_{i2}^1, \gamma_{i2}^2, \cdots, \gamma_{i2}^L)$, $\gamma_1 = (\gamma_{11}, \gamma_{21}, \cdots, \gamma_{I1})$ and $\gamma_2 = (\gamma_{12}, \gamma_{22}, \cdots, \gamma_{I2})$.

The economic interpretation of optimality conditions in Equation (76.2) is that only if the price that the retailer is willing to pay equals to the marginal total cost including production cost, transaction cost, purchase cost of material and used product, manufacturer will produce product and transact with retailer.

76.2.2 The Competitive Equilibrium of Retailers

Retailer j transacts with manufacturers i to obtain the products, as well as with the consumers at the demand market to earn an honest dollar. Denote the retail price of product l at retailer j by p_{ij}^l and the use value of product l by $V_l > 0$. Consumers concern the environmental protection, whose value on remanufacturing rate is $\beta > 0$. The utility of product l produced by manufacturer i is:

$$u_{ij}^l = V_l + \beta \phi_i^l - p_{ij}^l.$$

Consumers choose product to maximize the utility with insufficient information, which can be characterized by Logit model based on the random utility theory. Denote the purchase rate of product l produced by manufacturer i at retailer j by $\omega_{ij}^l \in [0,1]$, satisfying $\sum_{i=1}^{I} \omega_{ij}^l = 1$. We have:

$$\omega_{ij}^l = \frac{\exp(\theta u_{ij}^l)}{\sum\limits_{i=1}^{I} \exp(\theta u_{ij}^l)} = \frac{\exp[-\theta(p_{ij}^l - \beta \phi_i^l)]}{\sum\limits_{i=1}^{I} \exp[-\theta(p_{ij}^l - \beta \phi_i^l)]}, \ \forall i, \tag{76.4}$$

where $\theta > 0$ denotes the sufficient degree of information known by consumers. When consumers know full information (i.e. $\theta \to +\infty$), all consumers will buy the products with maximal utilities.

Assume that the stochastic demand of product l at retailer j, $d_j^l(p_j^l)$, is the function of average price $p_j^l = \sum_{i=1}^{I} \omega_{ij}^l p_{ij}^l$, whose density function and distribution function are $f_j^l(x, p_j^l)$ and $F_j^l(x, p_j^l)$, satisfying $F_j^l(0, p_j^l) = 0$. So, the stochastic demand of product l produced by manufacturer i at retailer j is $d_{ij}^l = \omega_{ij}^l d_j^l$, whose density function $f_{ij}^l(x, p_{ij}^l)$ and distribution function $F_{ij}^l(x, p_{ij}^l)$ satisfy:

$$F_{ij}^l(x, p_{ij}^l) = P\{d_{ij}^l \le x\} = P\{\omega_{ij}^l d_i^l \le x\} = \int_0^{\frac{x}{\omega_{ij}^l}} f_j^l\left(t, p_j^l\right) dt,$$

$$f_{ij}^l(x, p_{ij}^l) = \frac{\mathrm{d}F_{ij}^l(x, p_{ij}^l)}{dx} = \frac{1}{\omega_{ij}^l} f_j^l\left(\frac{x}{\omega_{ij}^l}, p_j^l\right).$$

For product l produced by manufacturer i at retailer j, the actual sale is $\min(q_{ij}^l, d_{ij}^l)$. Denote the excess supply by $\Delta_{ij}^{l+} = \max(0, q_{ij}^l - d_{ij}^l)$, and the shortage by $\Delta_{ij}^{l-} = \max(0, d_{ij}^l - q_{ij}^l)$. So, the expected values of sale, excess supply and excess demand of retailer j are as follows:

$$E[\min(q_{ij}^l, d_{ij}^l)] = q_{ij}^l - \int_0^{q_{ij}^l} F_{ij}^l(x, p_{ij}^l) dx, \; e_{ij}^{l+}(q_{ij}^l, p_{ij}^l) = E(\Delta_{ij}^{l+}) = \int_0^{q_{ij}^l} F_{ij}^l(x, p_{ij}^l) dx,$$

$$e_{ij}^{l-}(q_{ij}^l, p_{ij}^l) = E(\Delta_{ij}^{l-}) = \int_{q_{ij}^l}^{+\infty} (x - q_{ij}^l) f_{ij}^l(x, p_{ij}^l) dx.$$

For retailer j, the unit penalty of excess supply is $\lambda_{ij}^{l+} > 0$, the unit penalty of shortage is $\lambda_{ij}^{l-} > 0$. Then, the expected total penalty is given by:

$$E(\lambda_{ij}^{l+}\Delta_{ij}^{l+} + \lambda_{ij}^{l-}\Delta_{ij}^{l-}) = \lambda_{ij}^{l+}e_{ij}^{l+}(q_{ij}^{l}, p_{ij}^{l}) + \lambda_{ij}^{l-}e_{ij}^{l-}(q_{ij}^{l}, p_{ij}^{l}).$$

Retailer j is faced with a handing cost which includes the display and storage cost associated with the product l. Assume that this handing cost $c_j^l(q_j^l)$ is a continuous, differentiable, and convex function of the total quantities $q_j^l = \sum_{i=1}^{I} q_{ij}^l$. Group retailer j's transaction quantities of product l and all kinds products into the vector $Q_j^l = (q_{1j}^l, q_{2j}^l, \cdots, q_{Ij}^l)$ and $\overline{Q}_j = (Q_j^1, Q_j^2, \cdots, Q_j^L)$, and let $\overline{Q} = (\overline{Q}_1, \overline{Q}_2, \cdots, \overline{Q}_J)$. The profit-maximization decision model of retailer j can be expressed as:

$$\max_{\bar{Q}_j \geq 0} \pi_j(\bar{Q}_j) = \sum_{l=1}^{L}\left\{\sum_{i=1}^{I}[p_{ij}^l E(\min(q_{ij}^l, d_{ij}^l)) - E(\lambda_{ij}^{l+}\Delta_{ij}^{l+} + \lambda_{ij}^{l-}\Delta_{ij}^{l-}) - \rho_{ij}^l q_{ij}^l] - c_j^l(q_j^l)\right\}.$$

The competition equilibrium of retailers is Nash equilibrium when retailers compete against each other in the same demand market to maximize their profits, which can be expressed as the following variational inequality:

$$\sum_{l=1}^{L}\sum_{j=1}^{J}\sum_{i=1}^{I}\left\{\lambda_{ij}^{l+}F_{ij}^l(q_{ij}^{l*}, p_{ij}^l) - (\lambda_{ij}^{l-} + p_{ij}^l)[1 - F_{ij}^l(q_{ij}^{l*}, p_{ij}^l)]\right.$$
$$\left. + \frac{\partial c_j^l(q_j^{l*})}{\partial q_{ij}^l} + \rho_{ij}^l\right\}(q_{ij}^l - q_{ij}^{l*}) \geq 0, \ \forall \overline{Q} \geq 0. \tag{76.5}$$

The economic interpretation of optimality conditions in Equation (76.5) is that retailer j will transact product l with manufacturer i, if and only if the retail price p_{ij}^l with the probability $1 - F_{ij}^l(q_{ij}^{l^*}, p_j^l)$ equals to the penalty of shortage with probability $1 - F_{ij}^l(q_{ij}^{l^*}, p_j^l)$ (when the actual demand is greater than the order quantity) subtracted from the sum of transaction price ρ_{ij}^l, the marginal handling cost, and the penalty of excess demand with probability $F_{ij}^l(q_{ij}^{l^*}, p_j^l)$ (when actual demand is less than the order quantity).

76.2.3 The Equilibrium of Demand and Recovery Market

Consumers consume the new products and offer the used products. The equilibrium conditions associated with the transactions between retailer and consumer are stochastic economic equilibrium, which can be expressed as follows:

$$d_{ij}^l(p_{ij}^l)\begin{cases} \leq q_{ij}^l, & \text{a.e. } \ p_{ij}^l = 0, \\ = q_{ij}^l, & \text{a.e. } \ p_{ij}^l \geq 0, \end{cases} \ \forall i, j, l. \tag{76.6}$$

Recovery enterprise n recycles the used product l from the owners. Denote the recovery quantity and recovery price by q_n^l and ρ_n^l. Denote the reverse supply function of used product l by $g^l(q^l)$, which is a monotone increasing function of total recovery quantity: $q^l = \sum_{n=1}^N q_n^l$. The equilibrium conditions associated with the transactions between recovery enterprise and owner of used product are as follows:

$$g^l(q^l)\begin{cases} \geq \rho_n^l, & q_n^l = 0, \\ = \rho_n^l, & q_n^l > 0, \end{cases}$$
$$\text{s.t.} \quad \sum_{n=1}^N q_n^l \leq \sum_{i=1}^I \sum_{j=1}^J q_{ij}^l, \ \forall n, l. \tag{76.7}$$

Combining Equation (76.7) with Equation (76.6), we have the variational inequality equilibrium of the demand and recovery market as follows.

$$\sum_{l=1}^L \Bigg\{ \sum_{j=1}^J \sum_{i=1}^I [q_{ij}^l - d_{ij}^l(p_{ij}^{l*})](p_{ij}^l - p_{ij}^{l*}) + \sum_{n=1}^N [g^l(q^l) - \rho_n^l + \gamma_3^{l*}](q_n^l - q_n^{l*})$$
$$+ \left(\sum_{i=1}^I \sum_{j=1}^J q_{ij}^l - \sum_{n=1}^N q_n^l \right)(\gamma_3^l - \gamma_3^{l*}) \Bigg\} \geq 0, \ \forall (\widetilde{Q}, \gamma_3, P) \geq 0, \tag{76.8}$$

where γ_3^l is Lagrange multiplier of the constraint condition in Equation (76.7), and $\gamma_3 = (\gamma_3^1, \gamma_3^2, \cdots, \gamma_3^L)$, $\widetilde{Q} = (q_1^1, \cdots, q_n^l, \cdots, q_N^L)$, $P = (p_{11}^1, \cdots, p_{ij}^l, \cdots, p_{IJ}^L; \rho_1^2, \cdots, \rho_n^l, \cdots, \rho_N^L)$.

76.2.4 The Competitive Equilibrium of Recovery Enterprises

Recovery enterprise n has to bear the recovery and disposal cost $c_n(\sum_{l=1}^L q_n^l)$, which includes the cost of picking up, inspecting and shipping the used products, the transaction cost $\widehat{c}_{ni}^l(q_{in}^l)$ when he transact with manufacture i, and the handling cost of scrap material. Denote unit handling cost of scrap material by $\overline{c}$. The total handling cost of scrap material born by recovery enterprise n equals to $\overline{c}\sum_{l=1}^L (1-\varphi_l)q_n^l$ since the conversion rate of the used product l is φ_l. Denote the unit subsidy from the government such as the Environment Protection Agency to recovery enterprise by s^l. So, recovery enterpriser n determines the recovery quantity q_n^l of product l with recovery price ρ_n^l, and transfer them to manufacturer i with price ρ_{in}^l. Group the recovery and transfer quantities of recovery enterpriser n into the vector $\widehat{Q}_n = (q_{1n}^1, \cdots, q_{in}^l, \cdots, q_{In}^L;\ q_n^1, q_n^2, \cdots, q_n^L)$. The profit-maximization decision model of recovery enterprise n can be expressed as:

$$\max_{\widehat{Q}_n \geq 0} \pi_n(\widehat{Q}_n) = \sum_{l=1}^L \left[\sum_{i=1}^I \rho_{in}^l q_{in}^l - \rho_n^l q_n^l - \sum_{i=1}^I \widehat{c}_{ni}^l(q_{in}^l) - \overline{c}(1-\varphi_l)q_n^l + s^l q_n^l \right] - c_n\left(\sum_{l=1}^L q_n^l \right),$$

$$\text{s.t.} \quad \sum_{i=1}^{I} q_{in}^{l} \le q_{n}^{l}, \ \ \forall l. \tag{76.9}$$

Assume that $c_n(\sum_{l=1}^{L} q_n^l)$ and $\widehat{c}_{ni}^{\,l}(q_{in}^l)$ are continuous, differentiable and convex, then $\pi_n(\widehat{Q}_n)$ is continuous, differentiable and concave. Each recovery enterpriser determines his optimal recovery and transfer quantities to maximize his profit. The competition equilibrium of recovery enterprisers is Nash equilibrium, which can be expressed as the following variational inequality:

$$\begin{aligned}
&\sum_{l=1}^{L}\sum_{n=1}^{N}\left\{\sum_{i=1}^{I}\left(\frac{\partial \widehat{c}_{ni}^{\,l}(q_{in}^{l*})}{\partial q_{in}^{l}} - \rho_{in}^{l} + \gamma_{4n}^{l*}\right)(q_{in}^{l} - q_{in}^{l*}) + \left[\frac{\partial c_n(\sum_{l=1}^{L} q_n^{l*})}{\partial q_n^l} + \rho_n^l - s^l\right.\right.\\
&\quad \left.\left. + \bar{c}(1-\varphi_l) - \gamma_{4n}^{l*}\right](q_n^l - q_n^{l*}) + \left(q_n^l - \sum_{i=1}^{I} q_{in}^{l}\right)(\gamma_{4n}^{l} - \gamma_{4n}^{l*})\right\} \ge 0,\\
&\quad \forall(\widehat{Q}, \gamma_4) \ge 0,
\end{aligned} \tag{76.10}$$

where γ_{4n}^{l} is Lagrange multiplier of constrain condition in Equation (76.9), $\gamma_4 = (\gamma_{41}^{l}, \gamma_{42}^{l}, \cdots, \gamma_{4N}^{L})$ and $\widehat{Q} = (\widehat{Q}_1, \widehat{Q}_2, \cdots, \widehat{Q}_N)$.

The economic interpretation of optimality conditions in Equation (76.10) is that only if the price that the manufacturer is willing to pay equals to the marginal total cost including disposal cost, recovery cost, handling cost of scrap material and transaction cost, recovery enterpriser will recycle the used products and transact with manufacture.

76.2.5 A Multi-commodity Closed-loop Supply Chain Network Equilibrium Model

The closed-loop supply chain network will attain equilibrium state under the market mechanism. At equilibrium state, the production outputs of products and the transaction prices provided by the manufacturers must be equal to the order quantity and the prices that the retailers are willing to accept; the retail prices and sales quantity that the retailers provide to the demand markets must equal the prices that the consumers are willing to accept and the demand quantity under this price level; the recovery quantity of used products and the unit entrusting free provided by the manufacturers must be equal to the transfer quantity and the prices that the recovery enterprisers are willing to accept; the recovery prices and recovery quantity that the recovery enterprisers provide to the recovery markets must equal the prices that the owners are willing to accept and the supply quantity under this price level. Thus, variational inequalities (76.3), (76.5), (76.8) and (76.10) are held simultaneously, i.e., their sum is held. So, the variational inequality model of closed-loop supply chain with multi-criteria and stochastic demand is as following:

$$\sum_{l=1}^{L}\sum_{n=1}^{N}\left\{\left[\frac{\partial c_n\left(\sum_{l=1}^{L} q_n *\right)}{\partial q_n^l}+g^l(q^l)-s^l+\bar{c}(1-\varphi_l)-\gamma_{4n}^{l*}+\gamma_3^{l*}\right](q_n^l-q_n^{l*})\right.$$
$$\left.+\left(q_n^l-\sum_{l=1}^{L} q_{in}^l\right)(\gamma_{4n}^l-\gamma_{4n}^{l*})\right\}+\sum_{l=1}^{L}\sum_{i=1}^{I}\left\{\left[\frac{\partial f_i^{lr}(q^{lr*})}{\partial q_i^{lr}}+\rho^{lr}-\gamma_{i1}\right](q_i^{lr}-q_i^{lr*})\right.$$
$$+\left[\frac{\partial f_i^{lu}(q^{lu*})}{\partial q_i^{lu}}-\gamma_{i1}^l+\gamma_{i2}^l\right](q_i^{lu}-q_i^{lu*})+\sum_{j=1}^{J}\left[(q_{ij}^l-d_{ij}^l(p_{ij}^{l*}))(p_{ij}^l-p_{ij}^{l*})\right.$$
$$+\sum_{n=1}^{N}\left(\frac{\partial \bar{c}_{ni}^l(q_{in}^{l*})}{\partial q_{in}^l}-\alpha_i\nu_l-\varphi_l\gamma_{i2}^l+\gamma_{4n}^{l*}\right)(q_{in}^l-q_{in}^{l*})+\left(\frac{\partial c_{ij}^l(q_{ij}^{l*})}{\partial q_{ij}^l}+\frac{\partial c_j^l(q_j^{l*})}{\partial q_{ij}^l}\right.$$
$$\left.\left.+\lambda_{ij}^{l+}F_{ij}^l(q_{ij}^{l*},p_{ij}^l)(1-F_{ij}^l(q_{ij}^{l*},p_{ij}^l))+\gamma_{i1}^l\right)(q_{ij}^l-q_{ij}^{l*})\right]+\left(q_i^{lr}+q_i^{lu}-\sum_{j=1}^{J} q_{ij}^l\right)$$
$$\left.(\gamma_{i1}^l-\gamma_{i1}^{l*})+\left(\varphi_l\sum_{n=1}^{N} q_{in}^l-q_i^{lu}\right)(\gamma_{i2}^l-\gamma_{i2}^{l*})\right\}+\sum_{l=1}^{L}\left[\sum_{i=1}^{I}\sum_{j=1}^{J} q_{ij}^l-\sum_{n=1}^{N} q_n^l\right]$$
$$(\gamma_3^l-\gamma_3^{l*})\geq 0,\ \forall(Q,\overline{Q},\widetilde{Q},\widehat{Q},P,\gamma_1,\gamma_2,\gamma_3,\gamma_4)\geq 0. \quad (76.11)$$

76.3 Numerical Examples

Consider a close-loop supply chain network with two kinds of products consisting of two manufacturers, two retailers, two recovery enterprises. By questionnaire survey, cost analysis and statistical analysis of sales and recovery data, we can obtain or estimate the parameters of model. The meaning of variables can be found in the Sect. 76.2, whose units are out of consideration.

- Decision variables. We have to solve the following variables, i.e. manufacturers' production output q_i^{lr},q_i^{lu}, volume of product flow q_{ij}^l from manufacturers to retailers, volume of recovery used product flow q_{in}^l from recovery enterprisers to manufacturers, volume of recovery used product flow q_n^l from recovery markets to recovery enterprisers.
- The production costs functions, $f_i^{lr}(q^{lr})$ and $f_i^{lu}(q^{lu})$, for manufacturers are given by:

$$\begin{aligned}
&f_1^{1r}(q^{1r})=(q_1^{1r})^2+q_1^{1r}q_2^{1r},\ f_2^{1r}(q^{1r})=(q_2^{1r})^2+q_1^{1r}q_2^{1r};\\
&f_1^{1u}(q^{1u})=(q_1^{1u})^2+q_1^{1u}q_2^{1u}, f_2^{1u}(q^{1u})=(q_2^{1u})^2+q_1^{1u}q_2^{1u};\\
&f_1^{2r}(q^{2r})=(q_1^{2r})^2+q_1^{2r}q_2^{2r},\ f_2^{2r}(q^{2r})=(q_2^{2r})^2+q_1^{2r}q_2^{2r};\\
&f_1^{2u}(q^{2u})=0.7(q_1^{2u})^2+q_1^{2u}q_2^{2u},\ f_2^{2u}(q^{2u})=0.6(q_2^{2u})^2+q_1^{2u}q_2^{2u}.
\end{aligned}$$

The handing costs including the storing and the displaying cost functions, $c_j^l(q_j^l)$, faced by retailer are:

$$c_1^1(q_1^1) = 1.5\left(\sum_{i=1}^{2} q_{i1}^1\right)^2, \quad c_2^1(q_2^1) = 1.5\left(\sum_{i=1}^{2} q_{i2}^1\right)^2;$$
$$c_1^2(q_1^2) = 0.6\left(\sum_{i=1}^{2} q_{i1}^2\right)^2, \quad c_2^2(q_2^2) = 0.5\left(\sum_{i=1}^{2} q_{i2}^2\right)^2.$$

The recovery and disposal functions, $c_n(\sum_{l=1}^{L} q_n^l)$, faced by recovery enterprise are given by:

$$c_1(q_1^1 + q_1^2) = 0.4(q_1^1 + q_1^2)^2, \quad c_2(q_2^1 + q_2^2) = 0.3(q_2^1 + q_2^2)^2.$$

The reverse demand functions, $g^l(q^l)$, of two kinds of products are given by:

$$g^1(q^1) = 0.3\left(\sum_{n=1}^{2} q_n^1\right) + 1, \quad g^2(q^2) = 0.3\left(\sum_{n=1}^{2} q_n^2\right) + 2.$$

Simply assume that the transaction costs, $c_{ij}^l(q_{ij}^l)$ between manufacturer and retailer, and $\widehat{c}_{ni}^{\,l}(q_{in}^l)$ between manufacturer and recovery enterpriser are zero. Assume: $\alpha_1 = \alpha_2 = 1$, $\beta = 2$, $v_1 = 3$, $v_2 = 4$, $\rho^{1r} = 1$, $\rho^{2r} = 2$, $\varphi_1 = 0.85$, $\varphi_2 = 0.9$, $\overline{c} = 1$, $s^1 = 2$, $s^2 = 3$. Based on survey, we can obtain the distribution function of stochastic demand. Here simply assume that the stochastic demand $d_{ij}^l(p_{ij}^l)$ is uniform distribution in $[0, b_j\phi_i^l/p_j^l]$, $b_j = 10$, $\lambda_{ij}^{l+} = \lambda_{ij}^{l-} = 1$ $(i, j, l = 1, 2)$.

Based on Matlab, the modified projection algorithm (See [1, 2]) is programmed to solve this problem. The convergence criterion utilized is that the absolute value of the product flows and prices between two successive iterations differed by no more than 0.005. And the constant step g is set to 0.001 in the algorithm. We have the following equilibrium pattern as shown in the Tables 76.1 $\sim$ 76.3.

According to the above Tables 76.1 $\sim$ 76.3, we can see that the competitive ability of close-loop supply chain depends on the operational efficiency across its whole supply chain. For example, closed-loop supply chain network has symmetrical structure for product 1, so the equilibrium flows are symmetrical too. For product 2, the production efficiency by used products of manufacturer 2 is higher than manufacturer 1, so his production output is higher. The marginal handling cost of retailer 2 is less than that of retailer 1, so retailer 2 sells more products with less retail price.

Sensitive analysis on the consumer's value on remanufacturing rate and the unit subsidy are performed.

According to Table 76.4, the more consumers pay value on environmental protection, they are willing to pay more for remanufacturing products, so the higher the remanufacturing rate is.

According to Table 76.5, the more government pays unit subsidy for recycling used products, the more recovery enterpriser and manufacturer will obtain revenue from recovery and remanufacturing, so the higher the remanufacturing rate is.

Table 76.1 Production volume q_i^{lr} and q_i^{lu}, and remanufacturing rate φ_i^l

	Production volume by full using original material q_i^{lr}		Production volume by partial using recovery parts q_i^{lu}		Remanufacturing rate ϕ_i^l	
	Product 1	Product 2	Product 1	Product 2	Product 1	Product 2
Manufacturer 1	0.3044	0.3199	0.3863	0.5373	0.5593	0.6268
Manufacturer 2	0.3044	0.3034	0.3863	0.6175	0.5593	0.6706

Table 76.2 Volume of product flow q_{ij}^l from manufacturers to retailers and retail prices p_{ij}^l

(q_{ij}^l, p_{ij}^l)	Retailer 1		Retailer 2	
	Product 1	Product 2	Product 1	Product 2
Manufacturer 1	(0.3426, 8.8505)	(0.3909, 8.6745)	(0.3426, 8.8505)	(0.4009, 8.6436)
Manufacturer 2	(0.3426, 8.8505)	(0.4389, 8.6467)	(0.3426, 8.8505)	(0.4508, 8.6127)

Table 76.3 Volume of used product flow q_{in}^l from recovery enterprisers to manufacturers and total volume q_n^l

	Manufacturer 1		Manufacturer 2		Total of scrap product	
	Product 1	Product 2	Product 1	Product 2	Product 1	Product 2
Recovery enterprise 1	0.1821	0.3263	0.2642	0.3848	0.5561	0.7524
Recovery enterprise 2	0.1821	0.3477	0.2642	0.4361	0.7590	0.8686

Table 76.4 Sensitive analysis on the consumer's value on remanufacturing rate: β

Remanufacturing rate ϕ_i^l	$\beta = 2$		$\beta = 4$		$\beta = 6$	
	Product 1	Product 2	Product 1	Product 2	Product 1	Product 2
Manufacturer 1	0.5593	0.6268	0.5944	0.6528	0.6211	0.6739
Manufacturer 2	0.5593	0.6706	0.5944	0.7130	0.6211	0.7521

Table 76.5 Sensitive analysis on the unit subsidy: s

Remanufacturing rate ϕ_i^l	$s^1 = 3,\ s^2 = 4$		$s^1 = 3.5,\ s^2 = 4.5$		$s^1 = 4,\ s^2 = 5$		$s^1 = 4.5,\ s^2 = 5.5$	
	Product 1	Product 2	Product 1	Product 2	Product 1	Product 2	Product 1	Product 2
Manufacturer 1	0.6505	0.7110	0.6655	0.7163	0.6845	0.7239	0.6954	0.7508
Manufacturer 2	0.6505	0.7720	0.6655	0.7943	0.6845	0.8143	0.6954	0.8362

76.4 Conclusion

Assume that manufacturer entrusts professional recovery enterprise to recycle and process used products, manufacturer manufactures new product by two modes such as full using original material or partial using recovery parts to maximize both its profit and the benefit of environmental protection, we firstly analyze the competitive equilibrium of manufacturers, retailers and recycle enterprises as well as the equilibrium conditions of demand and recovery market respectively by using the variational inequality theory and Nash equilibrium method. Logit model based on the random utility theory is used to characterize consumers' product choice with insufficient information. Then this paper sets up the equilibrium model of closed-loop supply chain network with multi-criteria and stochastic demand, which includes both forward commodity flow and reverse recycle flow of used products. The model in this paper can characterize the flow quantities and transaction prices at the equilibrium state of close-loop supply chain network. It will be more interesting and valuable to further research on the problems of closed-loop supply chain network equilibrium with delivery time, delivery period, inventory control, supply chain contracts, supply chain coordination and multiclass consumers.

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Chapter 77
Sustainable Development-Oriented Supply Chain Management for Tourism E-commerce

Lei Xu and Yanfei Deng

Abstract The supply chain management for tourism refers to the planning, organizing, coordinating and controlling of information flow, capital flow and service flow in the supply chain for tourism. The application of e-commerce and related information technology is the new business models and inevitable choice of tourism upgrade and sustainable development, and promotes the transformation of the production factors in traditional tourism industry. As a result, the asymmetrical and incomplete information problem can be solved, and tourism resources can be exploited deeply and the structure of tourism products can be optimized at the same time. This article describes the promotion of tourism e-commerce to industrial upgrading, analyzes the tourism supply chain structure in the e-commerce environment, and proposes the optimization strategies of e-commerce for supply chain management in tourism.

Keywords Tourism supply chain · E-commerce · Industrial structure upgrading · Operation mechanism · Management strategies

77.1 The Proposition of Tourism Supply Chain Management

The earliest concept of supply chain management originates from manufacturing industry. It refers to the integrated pattern of a functional chain structure consists of various aspects of the individual connections from supplying, manufacturing, distributing, retailing to users etc, which is the controlling of information flow, logistics and fund flow in the whole process which is around the core business, starting from the procurement of raw materials to intermediate products and final products made,

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to delivery of the products to the consumers at last through the marketing network [1]. For tourism, the whole industry belongs to the industry aggregation which is to meet the travel consumer demand for a variety of products, and contains various industries such as Catering, accommodation, transport, communications, tourism, shopping, entertainment etc. Thus, a perfect tourist product chain is built by various tourism related industries, instead of a single industry. With the increase of personalized and customized requirements for current tourism products, the integration needs of tourism market is more significant, which promotes the proposition of supply chain management for tourism.

United Nations World Tourism Organization (UNWTO) is the first that proposed supply chain management for tourism issue in a report related to tourism distribution channels in 1975. Page first introduced a multi-level network structure of travel suppliers in 2003 [2]. Tapper et al made it clear in reference [3] that tourism supply chain consisted of all suppliers offering tourism products and services to travel consumers, including all suppliers offering products and service to meet customers' requirements in Tourism product supply system, as well as the tourism destination and other suppliers offering products or service during the process of travel. The products or service offered by these suppliers contain "food, housing, line, travel, shopping, entertainment", the system of arts and crafts, food production and waste disposal, and tourism infrastructure supports the development of the tourism industry etc. Therefore, tourism supply chain is a network organization consisting of participants providing different types of travel products and services, and broadly contains the departments of enterprises and governments, as well as the direct and indirect suppliers. Tourism Supply Chain Management refers to the planning, organizing, coordinating and controlling of information flow, capital flow and service flow in the supply chain for tourism, centralizing on the demand of tourism customers' demand and based on the cooperation of travel trade partners, in order to explore the effective methods of enhancing the value addition [4]. From the view of domestic and international tourism development, tourism supply chain can be divided into travel suppliers (travel agents) as the core, which is suitable for tourism supply chain pattern of "dotted line style" tourism products, and tourist attractions (destination) as the core, which is suitable for tourism supply chain pattern of "plate style" tourism products [5]. The former is the main tourism supply chain pattern in traditional concept, while the later regards the tourist destination distributors individual tourists service agencies as the operation core, and coordinates the tourism related enterprises in the destination as to offer travel services with time and space advantages to individual tourists as the main customers.

Nowadays, the research on tourism supply chain management in domestic is still in its infancy, and the most understanding about the tourism supply chain is from the point of view on the supply chain of the tourism industry and the tourism products [6]. Throughout the research status, the research on tourism supply chain management is in static superficial stage aimed mainly at the basic structure. Deep research and analysis on the generation and evolution process and dynamic mechanism of tourism supply chain have not appeared yet. The core content of the tourism supply chain related researches is tourism supply chain management, and the current

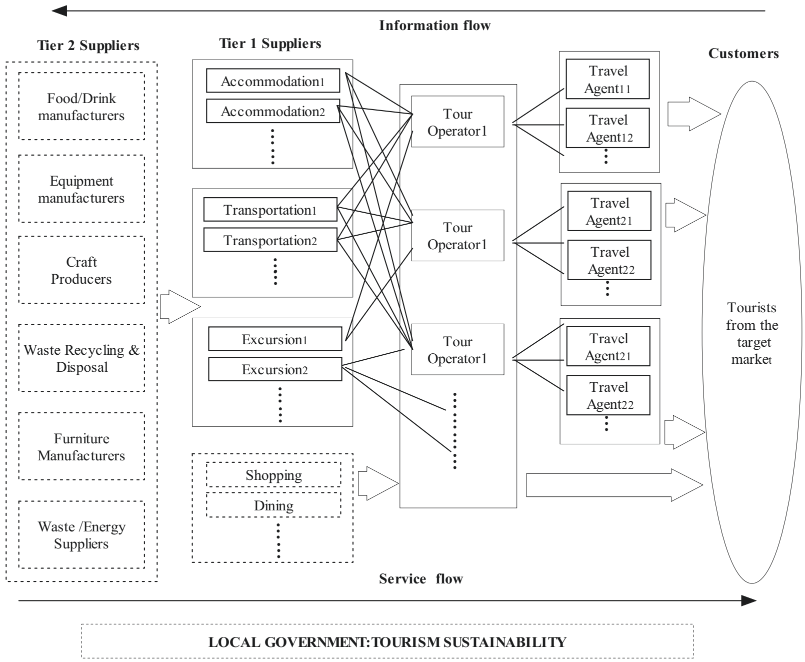

Fig. 77.1 Typical framework of tourism supply chain [4]

research is focus on the micro perspective. While the study on tourism supply chain management from a macro perspective has too few results. The research on information technology in the tourism supply chain management in the country is much more fewer. The research on tourism supply chain management overall lags behind that of other areas supply chain management [7]. This article briefly describes promotion of the tourism e-commerce to industrial upgrading and the construction of the tourism supply chain in e-commerce environment, and analyzes the optimization and management strategies of e-commerce on tourism supply chain.

77.2 The Enchantment of E-commerce on the Tourism Industry

77.2.1 The Basic Status of Tourism E-commerce

With the rapid development of the domestic and international network economic, the e-commerce is coming to tourism industry with advantages of low cost and wide dissemination etc. Tourism e-commerce quickly sprung up everywhere and has become a main application of e-commerce and a new business model in the development and upgrade of tourism industry. Based on the Internet platform, with the application of advanced information technology, such as the communication and dissemination of tourism information and business information via Network, tourism e-commerce aims at realizing the electronic of various aspects about tourism business activities, tourism marketing and carrying out tourism service before and after sales by electronic means. Consumers can do query, booking travel and electronic payment through the network. It also contains the electronic of the internal processes of the tourism-related enterprises and the application of management information system etc. In the tourism business electronic process, electronic data interchange (EDI) system, management information system (MIS), customer relationship management system (CRM), geographic information system (GIS), and Internet of things (IOT) etc combine with each other, constructing an e-commerce platform for the tourism supply chain. China is entering the era of individual travel, which requires the enterprises in tourism supply chain change their roles accordingly from creators and guiders of tourism consumption demand to subsidiary and service providers. Since the beginning of the tourism e-commerce, the tourism industry has been widely recognized for its broad prospects for development, so the tourism e-commerce has become the inevitable choice for the development of tourism [8].

77.2.2 The Upgrading of Production Factors in Tourism Industry

The increasing development and application of e-commerce and information technology in the tourism industry benefits greatly the development, utilization and share of travel information resources, and further promotes the transformation of the production factors in traditional tourism industry. Therefore, it solves the asymmetrical and incomplete information problems in tourism market, and deeply develops tourism resources and optimizes the structure of tourism products [9].

First, the asymmetrical and incomplete information problems in tourism economic system can be solved. In the e-commerce environment, tourist information resources tends are symmetrical and transparent. For travel consumers, they can quickly and easily search for all kinds of travel-related information via the Internet at low-cost, such as travel destination information, travel products information, the market price etc, which helps travelers make consumption decisions. For tourism related enterprises, e-commerce promotes the tourism market supply and demand information, tourism pricing information spreading quickly, and directly affects the consumption decisions of the main tourism market, forming the feedback and self-regulation mechanism of the tourism market economy. Consumer demand for tourism over time is uncertain and dynamic. When the information about superfluous or insufficient service capabilities of the destinations spreads, the travel consumers can adjust their plans accordingly, which enables the tourism market operators to engage in flexible coordination arrangements and optimal allocation of resources. In a certain period of time, the tourism-related enterprises can do tourism consumers information mining, response quickly to supply and demand in the travel market and pricing information, and adjust tourism product categories, composition and price instantly in order to improve their informatization level of decision-making and market competitiveness.

Second, information can be knowledge and intellectual resources of production factors in the tourism industry, direct the development and design of tourism products, as well as improvement and innovation in operating activities in order to deeply exploit tourism resources and optimize tourism product structure. As domestic tourism consumers' behavior continues to mature, their expectation of the intangible value of tourism products is increasing, their personalized, customized, flexible, demand are growing, and their demand for connotation and cultural quality of tourism products is also increasing. In other words, their value of tourism products and internal demand have changed. These changes mean that the standardized, simple and rough, relatively rigid tourism products lack of the connotation provided by tourism-related enterprises can not meet the new demand of the market. It is greatly needed for tourism-related enterprises to make changes and provide more personalized more diverse and flexible tourism products according to the travel consumers' preferences and willingness. Besides, levels of knowledge and technology in tourism products will continue to enhance. For concrete and tangible tourism products, tourism products with high-tech are growing rapidly. For soft and intangible tourism products, personalized and culture implanted tourism products are more preferred by customers.

Nowadays, tourism products have developed to a complex combination of products from simple standardized products, leisure products from business tourism to the resort, and individual and self helped tours products from groups tourism etc. At the same time, e-commerce brings a special opportunity to the research and development of tourism products, because it enables tourism-related enterprises better provide fine specialized products for different market segments. Although the structure of the tourism products supply doesn't change, fine differentiated customization services can only be achieved by means of e-commerce.

77.3 Tourism Supply Chain Structure in the E-commerce Environment

Tourism supply chain can be divided into travel suppliers, travel intermediaries and travel consumers three levels from the traditional vertical division system. The travel suppliers mainly include restaurants, hotels, transport companies, tourist attractions, shopping malls, entertainment and destination inbound travel agents etc. And the travel brokers mainly refer to the travel wholesalers and distributors retailers. As the composition of travel suppliers is very complex and the tourism consumers often take cross-regional activities, travel intermediaries often communicate with the tourism consumers on their needs. With the development of net economy and e-commerce, travel intermediaries in traditional travel supply chain face a great challenge, leading the change of the structure of the tourism market. Tourism supply chain structure in the e-commerce environment has changed with the change of the structure of the tourism market.

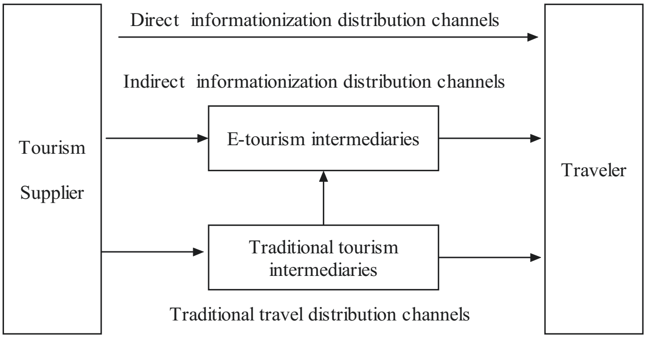

Fig. 77.2 Tourism e-commerce market structure

The changes first come from the travel suppliers' direct sales model online. E-commerce platform and its tools enables travel suppliers communicate easily with travelers around the world throughout the day without the help of cross-border tourism intermediaries. This communication pattern is at low-cost, and the tourism-related enterprises and their tourism products can be promoted without the constraints of time and place. Besides, the intermediate links are reduced, and the flexibility of interaction of supply and demand, sales controllability and market reaction speed are in a higher level. Thus, travel suppliers will focus on its tourism products to carry out a more efficient network direct sales model.

Second, under the influence of e-commerce, changes of travel intermediaries' information technology and business transformation have taken place. In the traditional tourism supply chain, travel brokers have strong advantages of product portfolio, procurement and distribution due to its multi-source products. With the help of electronic means, they can transplant and expand the traditional business online properly as to strengthen the advantage of e-commerce. At thee same time, the traditional tourism intermediaries can reduce their cost and improve their service in order to enhance their market competitiveness.

The development of e-commerce and its information technology also gave birth to a new kind of travel brokers. These new electronic travel brokers, which are different from traditional travel intermediaries that do e-commerce operation with industry resources offline, provide intermediary services about tourist information on Internet-based platform. Besides, they are greater independent from up supply chain constraints, and provide a wide range of travel information for travel consumers as an interactive and compatible platform, as well as online booking of travel products and electronic payment. Compared to traditional travel intermediaries, they have advantages of more powerful procurement and distribution network and lower cost.

The above three mentioned changes in the travel supply chain structure will promote the optimization of the tourism market and tourism, indicating that tourism under e-commerce has the trend towards lower cost and higher efficiency.

Changes in the structure of tourism supply chain under e-commerce environment also causes a significant change of operation patterns in domestic tourism and has a tremendous impact on the traditional the tourism supply chain system whose core is travel suppliers and travel agents. Now the main problem of domestic tourism supply chain is that the tourism supply chain commissioned relationship is too long, which distorts tourist information in the transmission process and leads to a gap between travel consumer expectations and their actual experience. What is more, in the tourism supply chain system with the travel agency as its core, the travel agency have weak control over travel suppliers such as hotels and scenic spots in every hot tourist season, leading to increasing market risk of the industry in an unorganized tourism supply chain. The domestic tourism market is in a period of transition to aiming mainly at leisure travel from aiming mainly at business sightseeing, during which the individual travel gradually increases while group travel gradually decreases. Therefore, tourist attractions (destinations) should continue to enhance their publicity and marketing efforts, and more directly contact with tourism consumers as to develop more new products as the tourism consumers' demand is more complicated [5]. The development and maturity of tourism e-commerce is bound to improve the tourism supply chain management model, which will change from the traditional vertical integration into horizontal integration, in order to meet new market demand. Tourism supply chain under e-commerce environment should be the tourism supply chain model that regards tourist attractions (destination) as its core [10].

77.4 Optimization of Tourism Supply Chain Management under E-commerce Environment

In the e-commerce environment, tourism-related enterprises have more supports of integration, division of labor and the development of network interconnection. Besides, a lot of medium and small tourism related enterprises gain the opportunity of development and competition with tourism market efficiently through their special tourism products and services. E-commerce and its application of information technology can optimize the tourism supply chain operation mechanism, contribute to the formation of the tourism industry structure with appropriate scale, competitive and orderly and complementary advantages, and promote positively the formation of the ideal organizational structure of tourism industry which has the features of large tourism enterprises integration, medium-sized tourism enterprises specification and small-scale tourism enterprises networking.

77.4.1 Establish the Tourism Supply Chain Cooperation Mechanism

In tourism supply chains regarding scenic as its core, travel destinations and travel agencies play an important role in guaranteeing the smooth functioning of the supply chain nodes. Travel agency has strong dependence on the upstream and downstream industries in the supply chain. However, the relationships among nodes in the tourism supply chain are still more loosely. As a result, there is a great need to strengthen the communication between tourism destinations and travel agencies, and establish precise cooperation mechanism for each node in the tourism supply chain in order to joint information flow, service flow and capital flow smoothly and improve the control stability and market competitiveness of the tourism supply chain.

77.4.2 Implement the Tourism Supply Chain Incentives

Tourism supply chain cooperation mechanism in the e-commerce environment guarantees the quality and speed of service and information delivery among nodes in the tourism supply chain. Besides, establish and improve the performance evaluation and incentives in order to promote supply chain enterprises to continuously improve. The Association of Industrial Cooperation participated by the government, tourism and scientific research units, and enterprises should be established. Thus, the incentives mechanism of scenic governance, between scenic and travel agency, among scenic spots and major service providers such as hotels can be implemented and the performance evaluation criteria should be created in the association so as to regulate and control the overall operation of the tourism supply chain from macro view as well as further improve the tourism supply chain integration.

77.4.3 Build the Tourism Supply Chain Management Information Systems and Decision-Making Mechanism

In order to solve problems like real-time sharing and processing of information in the supply chain and the information delay in traditional tourism supply chain management, tourism supply chain management information system should be established, which can be divided into two levels of the internal network and external network that are seamless connection open architectures in order to assist the enterprise internal information management at each node in the tourism supply chain and integrate and support the transmission of information between enterprises, and realize the exchange and sharing of information among core partners involved in tourism-related enterprises and tourism consumers. At the same time, the pricing of tourism products and other important decision-making mechanism can be formulated and implemented, and the distribution of benefits management of the tourism supply chain can be balanced so as to maintain the supply chain operate steady with the help of the management information system.

77.4.4 Enhance the User-friendly and Personalized Customer Relationship Management Mechanism

For the tourism supply chain model regarding scenic as its core, there is a need to strengthen the overall service quality of the enterprises at each node of tourism supply chain according to the individual traveler market to play their respective advantages. As a result, the user-friendly and personalized customer relationship management mechanism should be enhanced to meet the travelers' differentiated demand. Its service process is as: build the customer database, implement the precise and one-to-one interactive network tourism marketing according to the product demand and consumption habits of different customers; second, design personalized and customized travel products and provide personalized travel program to make travel consumers participate fully in the design process of the tourism product, improve the sense of identity and added value of the products and expand the profit margin; Last, put the pre-sale and after-sale preference of tourism consumers into the customer database so as to let the tourism consumers get the best user experience when the service is provided according to their preference and habits.

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Chapter 78
Demand Disruption Risks as Opportunity Costs in JIT Supply Chain Coordination

Kurt A. Masten and Avijit Banerjee

Abstract Recently, an opportunity cost reflecting the buyer's loss of future flexibility from a finite contract commitment has been incorporated into the solution to the buyer-supplier jointly optimal production and delivery policies in a lot-splitting, Just-In-Time (JIT) supply chain. This cost plays a logical role in the model and is required to prevent an infinite contract quantity as the solution to the optimal joint policy. Current models in this area of Supply Chain Coordination (SCC) assume that this opportunity cost is given, with little or no guidance on setting an appropriate value. Demand disruption risks are cited as a major justification for the inclusion of this commitment cost in the model. This paper provides practitioners an easy-to-understand interpretation and application of this recent conceptual addition to the joint buyer-supplier JIT model. Our work provides guidance for determining an appropriate minimum commitment cost for a common situation, where the probability of obsolescence of the contracted part is known, or can be estimated (e.g. from history or from industry norms) prior to the joint optimization of the relevant policy variables. A numerical example explores the impact of this commitment cost on the optimal decisions of both parties.

Keywords Supply chain management · Supply chains · Just-in-time production

78.1 Introduction & Literature Review

Supply chain coordination (SCC) models address the optimal ordering and decision policies of buyers and suppliers willing to work together to outperform the suboptimal uncoordinated individual decisions. Most current models build on the early JIT models of Banerjee [2] and Banerjee and Kim [1]. Kelle et al [4] introduced a

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cost in the model (L_B) to reflect the increasing opportunity cost (OC) to the buyer of committing to larger contract quantities, thus reducing the buyer's future flexibility to, for example, switch suppliers or take advantage of price changes. Many recent JIT models require or implicitly assume a purchase contract between the buyer and supplier. This commitment to future deliveries allows the supplier to produce in quantities greater than the current shipment size, when, for example, the setup costs are much greater than the holding costs. As Kelle et al [6] point out, without either a limit on the order quantity or some cost factor proportional to it, the optimal order quantity that minimizes the total joint cost is unbounded. To address this issue, Kelle et al [4] earlier added to the model a buyer's opportunity cost to account for undelivered units on the contract. This opportunity cost of commitment is similar in function to the more familiar opportunity cost of capital tied up in inventories, although instead of a charge based on units-on-hand, the contract commitment OC is a charge based on units-yet-to-be-delivered [5].

The literature on JIT is vast with the area of supply chain coordination also receiving much attention in the last 25 years. A cursory search produced approximately 1000 articles referring to both JIT and supply chain coordination. Adding "opportunity cost" to this search narrowed results to fewer than 50 papers, with most of these addressing the opportunity cost of lost sales and holding inventory or capital. Few papers were found that address the opportunity cost of commitment in JIT supply chain coordination. The most notable of these is Kelle et al [4], which introduces the concept as used in the current research. This concept solves a mathematical quandary in the model, which would otherwise drive the joint optimal contract quantity to infinity. Huang [3] incorporated random yield into the optimal decision, but without consideration to the buyer's commitment cost. Kelle et al [6] combines Huang's random yield consideration with the OC concept of Kelle et al [4]. It should be noted that Huang's paper relies heavily on the work of Salameh and Jaber [10] as well as Kim and Ha [7]. Qi et al [9] considers demand disruptions in a one-supplier-one-retailer environment after the planning horizon for individual profit maximizers. Gerard [8] thoroughly explored SCC with contracts for profit maximizing firms, but not in cooperative, joint optimizing JIT environments, such as the one discussed here. Since this concept of opportunity cost of commitment is quite novel to most of the previous research, it is worthwhile to expand on exactly what this cost represents and why it needs to be investigated more closely.

78.1.1 The Opportunity Cost of Commitment

The commitment OC can be visualized by interpreting Fig. 78.1. Ignoring any cost to the buyer for committing to larger and larger contract quantities, the overall joint cost is minimized with an infinite contract size since the relative ordering cost will be driven towards zero (see the red line labeled "inefficiency loss"). Another way to interpret this is to recognize that larger contracts reduce the impact of fixed costs on the total cost, so that the larger the contracted quantity, the lower the incremental cost of additional quantity commitments become. Obviously, an infinite contract size is not feasible in any practical sense. One solution to this predicament is seen in long-term partnerships between a buyer and supplier where one assumes or both share the inevitable cost of breaching the contract. These costs may include disposing of unusable inventories or nondepreciated tooling. This partnership scenario is common and the subject of much current research. However, suppose a supply chain with players wishing to jointly optimize a lot-splitting, finite horizon supply chain, but having suppliers which require contracts. This may be seen where, for example, due to expensive raw materials, custom products, or thin margins, the suppliers cannot risk unsold product and require a commitment from the buyer for the entire contract size. The buyer in this scenario must consider the repercussions for committing to the contract quantity. By committing to the contract quantity, the buyer forgoes the opportunity to take advantage of price breaks from other suppliers or drops in commodity prices. The buyer will also have additional expense should a design change be desired. This loss in flexibility or cost of commitment to undelivered parts is represented by the blue line in Fig. 78.1 labeled "opportunity loss". Of course, there may be both positive and negative commitment costs. An example of a negative commitment cost is committing to higher quantities before prices increase. However, as we commit to larger and larger contracts, we fully expect the costs to outweigh the benefits. Therefore, the exact shapes of the lines are not critical, as we will surely reach the same conclusion.

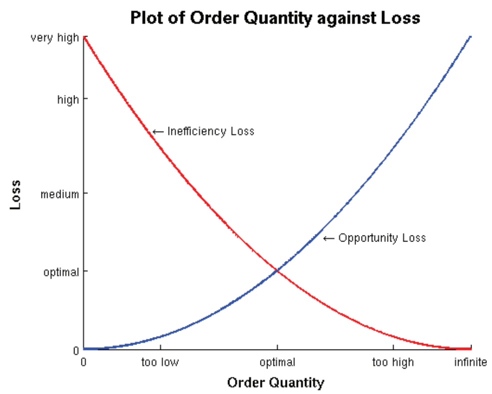

Fig. 78.1 Plot of order quantity against losses

78.2 Demand Disruptions as an Opportunity Cost

Until now, the opportunity cost of commitment has been considered a given (or estimate) used to help calculate the optimal JIT ordering policy. Specifically, the decision variables are number of shipments (n) per order, the number of lots (m)

per production batch, and the shipment size (q), which together implies the optimal contracted order size ($Q_B = nq$) and optimal supplier batch size ($Q_S = mq$). While this commitment cost concept solves the particular mathematical problem of an infinite contract, it is not necessarily an intuitive or tangible figure to the typical practitioner. One recent empirical study by Kelle et al [5] confirms that buyers are wary of committing to large contract quantities, especially where demand is uncertain. Nevertheless, little research has been done on demand disruptions in supply chain coordination [9]. Our goal is to provide practitioners with an easy-to-understand interpretation and application of this recent addition to the joint optimal buyer-supplier JIT model, for a common demand disruption scenario, where the possibility of a sudden end of demand during the contract period exists. This could occur with, for example, product obsolescence or a regulatory change. We will provide a numerical example to illustrate the impact of this recent addition to the model and show how knowing the demand disruption risk during the planning phase can affect the optimal decisions.

The previous research assume an infinite planning horizon. The optimal decision variables (q^*, m^*, n^*) minimize the joint average total relevant cost. Therefore, we also know the optimal contract size and the (finite) contract period. However, there is no limitation on the relation between n and m. This gives rise to a situation where we need to assume contract renewals will occur or else the supplier may be left with stock in excess of the contract commitment. One can quickly see the logical contradiction of requiring a contract and including a cost for the commitment of undelivered units on that contract, yet assuming future contracts are a given. While this allowed for well-behaved mathematics, we do not believe this is a reasonable assumption. We will address this issue by requiring an integer ratio of n to m. This ensures no leftover units or incomplete runs at the supplier. At best, this will yield the same joint cost and potentially much higher joint costs than in cases without this limitation. However, this solution will more accurately reflect the situation we are interested in, where future business (and demand) beyond the current contract period is not guaranteed.

Finally, it should be noted that there exists other possible contributing factors to a final opportunity cost, including other types of supply chain disruptions, price hedging, and quality of parts (yield) concerns, but these are beyond the scope of this paper and are left as areas of future research.

78.3 Model for End of Demand During Contract Period

Consider a buyer seeking to jointly optimize their planning parameters with a supplier who together will share system-wide gains through some external vehicle. Suppose this buyer knows historically there is some chance p per period over the planning horizon that a demand disruption such as an engineering design change or marketing decision will occur which negates the need for any future deliveries on the contract. Assume current stock-on-hand can be used, but all undelivered stock committed to under contract must still be delivered and paid for (salvaged). The total annualized cost for the buyer, TC_B, as summarized by Kelle et al [5] is as follows:

$$\mathrm{TC}_B(q,n) = HRC + OFC = \left[h_B\frac{q}{2} + Z_B\frac{D}{q}\right] + \left[A_B\frac{D}{nq} + L_B C_B\frac{nq}{2}\right],$$

where HRC is the annualized holding and receiving costs and OFC is the annualized ordering and flexibility costs. The following notation is mostly consistent with Kelle's paper and is summarized below:

h_B : the buyer's periodic inventory carrying cost with $h_B = r_B C_B$, where r_B is the buyer's inventory carrying cost rate and C_B is the unit price paid by the buyer
Q_B : the contract quantity where $Q_B = nq$ and n is the number of shipments and q is the shipment size
Z_B : the buyer's receiving cost, paid for each shipment
A_B : the buyer's setup or ordering cost which includes all one-time contract costs
D : the buyer's demand rate (i.e. units per period)
L_B : the buyer's cost rate of losing flexibility, comparable to r_B

Given that we expect to have an end-of-demand (EOD) event with some uniform and memoryless probability p, we need to add an additional charge for the expected amount of the committed, but undelivered, units remaining on the contract. Assuming a period of one year, this potentially confusing p can be simply interpreted by the practitioner as "In the next year, there is a probability of obsolescence of p, equally likely to occur at any time." Let us call the charge for this potential event the ELC (expected leftover cost) and add it to TC_B such that $\mathrm{TC}_B(q,n,p) = \mathrm{HRC} + \mathrm{OFC} + \mathrm{ELC}$. The derivation of ELC is straight-forward and is summarized below:

The length of the contract if no EOD occurs is Q_B/D periods and the expected length of contract if an EOD occurs is $Q_B/2D$ periods. Therefore, with a constant p, the expected length of the contract is:

$$p\frac{Q_B}{2D} + (1-p)\frac{Q_B}{D} = \frac{2Q_B - pQ_B}{2D} = \frac{Q_B(2-p)}{2D}.$$

The expected units consumed during the contract is:

$$\frac{Q_B(2-p)}{2D} * D = \frac{Q_B(2-p)}{2} = Q_B\left(1-\frac{p}{2}\right).$$

The expected number of units leftover is simply $Q_B - Q_B\left(1-\frac{p}{2}\right) = p\frac{Q_B}{2} = p\frac{nq}{2}$, with an expected cost of $\overline{C_B}p\frac{nq}{2}$, where $\overline{C_B}$ is the unsalvageable cost, (C_B is the salvage value) per leftover unit with $0 < \overline{C_B} \le C_B$ and $0 \le p \le 1$. There is also an implicit constraint of $p\frac{Q_B}{2D} \le 1$ since the buyer should not create a contract longer than the expected life of the unit and we would thus underestimate the expected cost of the leftover units. One could imagine a pathological combination of extreme setup costs and/or high salvage value where the buyer might wish to commit to higher quantities, but this is outside the scope of the common JIT situation.

Adding this expected leftover cost to the buyer's total cost yields:

$$\begin{aligned}\mathrm{TC}_B(q,n) &= \mathrm{HRC}+\mathrm{OFC}+\mathrm{ELC}\\ &= \left[h_B\frac{q}{2}+Z_B\frac{D}{q}\right]+\left[A_B\frac{D}{nq}+L_BC_B\frac{nq}{2}\right]+\left[\overline{C_B}p\frac{nq}{2}\right].\end{aligned}$$

Note that the expected demand rate is still D despite a potential end-of-demand. This is because we are committed to receive the remaining units on contract, whether an EOD event has occurred or not. If we wish to assume that the buyer will not need to receive the outstanding units (but still pay for them), we may update the demands above to an expected demand, $\hat{D} = D\left(1-\frac{p}{2}\right)$, to reflect the fewer expected receipts during the contract.

If the unsalvageable cost of the leftover units is close to the unit price, as expected for custom products, then $\overline{C_B} \approx C_B$. Substituting this approximation back into the equation for the total cost of the buyer, we get:

$$\begin{aligned}\mathrm{TC}_B(q,n) &= \left[h_B\frac{q}{2}+Z_B\frac{D}{q}\right]+\left[A_B\frac{D}{nq}+L_BC_B\frac{nq}{2}\right]+\left[C_Bp\frac{nq}{2}\right]\\ &= \left[h_B\frac{q}{2}+Z_B\frac{D}{q}\right]+\left[A_B\frac{D}{nq}+(L_B+p)C_B\frac{nq}{2}\right].\end{aligned}$$

Consequently, we can easily see the equivalence between L_B, the cost of commitment, and p, the probability of obsolescence. This is of importance, since the typical practitioner may not have any conception of an appropriate opportunity cost of commitment, but likely has some idea of how common an EOD event is, whether historically, through an educated guess, or group consensus. A relationship between the opportunity cost rate and demand uncertainty has been suggested, but never explicitly related to each other as shown above.

78.3.1 The Updated Optimal Joint Policy

The supplier's total cost is unchanged since the entire risk of a demand disruption lies with the buyer. From Kelle [5], the total cost to the supplier is:

$$\mathrm{TC}_S(q,m) = h_S\frac{mq}{2}\left[1-\frac{D}{P}-\frac{1}{m}+\frac{2D}{mP}\right]+Z_S\frac{D}{q}+A_S\frac{D}{mq},$$

where a subscript of S refers to the supplier's cost of the parameters similarly defined with subscript B above and P is the production rate of the supplier. Thus, the total joint cost is:

$$\mathrm{TC}_J(q,m,n) = \left[h_B\frac{q}{2}+Z_B\frac{D}{q}\right]+\left[A_B\frac{D}{nq}+(L_BC_B+p\overline{C_B})\frac{nq}{2}\right]+\left[A_S\frac{D}{mq}\right]$$
$$+\left[h_S\frac{mq}{2}\left[1-\frac{D}{P}-\frac{1}{m}+\frac{2D}{mP}\right]+Z_S\frac{D}{q}\right].$$

By relaxing the integer and integer ratio requirements, we can use the first order optimality conditions to find a new joint optimal solution for shipment size as a function of m and n:

$$q_J^*(m,n) = \sqrt{\frac{2D\left[\frac{A_B}{n}+Z_B+\frac{A_S}{m}+Z_S\right]}{(L_B+p)n+h_Sm\left[1-\frac{D}{P}\right]+h_B+h_S\left[\frac{2D}{P}-1\right]}}.$$

Similarly, the optimal m as a function of q is:

$$m^*(q) = \frac{1}{q}\sqrt{\frac{2A_SD}{h_S\left[1-\frac{D}{P}\right]}}$$

and the optimal n as a function of q is (assuming no salvage value):

$$n^*(q) = \frac{1}{q}\sqrt{\frac{2A_BD}{(L_B+p)C_B}}$$

or when there is a salvage value to excess units, the optimal n as a function of q is:

$$n^*(q) = \frac{1}{q}\sqrt{\frac{2A_BD}{L_BC_B+p\overline{C_B}}}.$$

From these equations, we can clearly see that for a given shipment size, the n (and thus the contract quantity) will decrease as p increases, as one would intuitively expect, and vice versa. We also see see for a given n, q will decrease. However, as we also require q, n and m to be integers and n to be an integer multiple of m, we will likely need to violate one or more of the above first order conditions to provide the optimal decisions. This optimal joint policy can be found either through iteration or a mathematical programming procedure. In the following numerical example, we will use a mathematical programming solution technique (branch and bound) to minimize the total annualized joint costs.

78.4 Numerical Example

Using the above results and mathematical programming, we can explore the impact of this opportunity cost of commitment through a numerical example. First, we will show the impact to the buyer of neglecting to account for a possible demand disruption. For the sake of this example, we will assume $L_B = .03$ to account for all other net (non-disruption) opportunity costs for the buyer's contract commitments such as supplier flexibility and price hedging. All other base case values are duplicated from Kelle [4] for ease of comparison. Each variable was increased or decreased by 50% from the base case to demonstrate the relative impact of other variables compared to the EOD probability. Additionally, each of these scenarios were compared at three levels of $p(0, 0.01, 0.05)$. See Table 78.1 for problem scenario details and base values. For the base case scenario, the optimal decision variables are $(q,m,n) = (54,8,16)$ yielding a joint cost of \$1185. Note that this is slightly lower than Kelle's computed optimal of \$1189 using $(q,m,n) = (47,10,18)$ [4] despite the requirement of an integer ratio for $n : m$ in the current model. This demonstrates an advantage of using the mathematical programming method.

Table 78.1 Summary of model variables used in numerical example

Variable	Description	Base value and unit for numerical example
Z_B	Buyer's receiving cost	\$1/shipment
D	Periodic demand rate	1000 units/period
A_B	Buyer's fixed ordering cost	\$225/order
C_B	Buyer's unit cost	\$20/unit
$\overline{C_B}$	Unsalvageable value	\$20/unit
r_B	Buyer's inventory holding rate	0.2/period
C_S	Seller's unit cost	\$10/unit
r_S	Seller's inventory holding rate	0.18/period
P	Production rate	2500 units/period
A_S	Fixed setup cost	\$100/production run
Z_S	Fixed shipment cost	\$4.5/shipment

As can be seen in Table 78.2, properly accounting for a possible demand disruption can have a huge impact on the optimal solution. With only a 1% risk rate for an EOD event, we shorten our optimal contracts an average of 13.8% and incur an average 9.6% cost increase. With a plausible 5% risk rate, we shorten our contracts by 40.8% on average and incur a 28.2% average cost increase, which are significant amounts. This price increase was very consistent across the various scenarios. To put this in perspective, the average cost change from altering each of the variables in the table from 50% of its base value to 150% of its base value is 22.5%.

78.5 Extensions and Future Areas

The results of this research encourage further investigations of this overlooked area of the buyer's opportunity cost. The current research considers the possibility of an abrupt end-of-demand event during the execution of the contract. An alterna-

Table 78.2 Sensitivity of optimal Q_B and annualized cost against various p values

Variable changed	Base value	Vs. base	$p=0$		$p=0.01$		$p=0.05$		$p=0$ to $p=0.05$	
			Q_B	Cost	Q_B	*Cost*	Q_B	Cost	ΔQ_B	Δ Cost
None	–	–	864	\$1185	798	\$1267	495	\$1520	−42.7%	28.3%
Z_B	1	−50%	864	\$1175	800	\$1258	486	\$1511	−43.8%	28.6%
		+50%	880	\$1194	798	\$1276	495	\$1529	−43.8%	28.1%
D	1000	−50%	574	\$876	528	\$930	430	\$1120	−25.1%	27.8%
		+50%	1152	\$1375	1062	\$1485	649	\$1772	−43.7%	28.9%
A_B	225	−50%	742	\$1044	477	\$1094	399	\$1267	−46.2%	21.4%
		+50%	1155	\$1306	896	\$1400	708	\$1717	−38.7%	31.5%
$C_B, \overline{C_B}$	20	−50%	1260	\$967	1185	\$1028	800	\$1202	−36.5%	24.3%
		+50%	774	\$1356	704	\$1465	430	\$1753	−44.4%	29.3%
r_B	0.2	−50%	860	\$1119	800	\$1202	492	\$1454	−42.8%	30.0%
		+50%	860	\$1234	792	\$1316	504	\$1570	−41.4%	27.2%
C_S	10	−50%	990	\$1065	702	\$1138	550	\$1384	−44.4%	30.0%
		+50%	972	\$1289	720	\$1365	590	\$1627	−39.3%	26.1%
r_S	0.18	−50%	990	\$1065	702	\$1138	550	\$1384	−44.4%	30.0%
		+50%	972	\$1289	720	\$1365	590	\$1627	−39.3%	26.1%
P	2500	−50%	828	\$1026	752	\$1105	576	\$1365	−30.4%	33.0%
		+50%	826	\$1221	756	\$1301	472	\$1564	−42.9%	28.1%
A_S	100	−50%	870	\$1049	810	\$1133	550	\$1380	−36.8%	31.5%
		+50%	972	\$1294	880	\$1386	530	\$1618	−45.5%	25.0%
Z_S	4.5	−50%	860	\$1138	792	\$1221	492	\$1474	−42.8%	29.5%
		+50%	868	\$1222	792	\$1305	496	\$1558	−42.9%	27.4%
Average			911	\$1166	784	\$1247	537	\$1495	−40.8%	28.2%
Standard Deviation			151	\$133	150	\$145	94	\$172	5.2%	2.6%

tive scenario worth considering is a probability of a demand shift, rather than an end, throughout the contract period or perhaps an abrupt shift due to some external market force.

Dropping the integer ratio requirement for number of shipments per production run and number of shipments would allow for better joint performance. This could be accomplished in two ways. First, we could allow the supplier to carry stock between production runs. This adds considerable complication to the model as the average supplier inventory calculation becomes more involved. Second, we could allow for the last run to be shorter than the rest. Of course, this would also complicate the model in multiple ways.

Another area of potential interest to practitioners is price hedging. Given a probability of a price change in the future, independent of demand, an increased opportunity cost for paying more in the future could be incorporated. Another such area is random yield consideration. Results have been recently developed by Kelle et al [6]. The results separate the effects of random yield and opportunity costs. However, in all cases of uncertain demand and supply, whether from random yield or stochastic demand, there is a possibility of improvement by switching to a different supplier. This is obviously difficult with a contract, and this restriction can be viewed as an opportunity cost. Assistance in the calculation or estimation of an opportunity cost related to this risk would be useful. An overall framework for opportunity costs would be:

$$L_B = \sum \mathrm{DR} + \sum \mathrm{SR} + \sum \mathrm{PR},$$

where DR are demand risks (as addressed by the present research and extensions), SR are supply risks, and PR are price and price hedging risks. Some of these may be positive opportunity costs (e.g. risk of end-of-demand event) and some may be negative (e.g. locking in low prices).

78.6 Conclusions

The area of SCC has received increased attention recently. An important avenue of supply chain coordination involves optimizing the joint decisions of the buyers and suppliers to outperform what is possible without coordination. The most recent models for determining these joint optimal policies for order quantities, shipment sizes, and production sizes all depend on having a quantitative value for the lost opportunity of committing to large order quantities so that order quantities are not being driven to infinity. This research adds to the understanding of this concept and provides additional breadth, depth, and utility to the existing models. Demand disruption is just one possible contributing factor to opportunity costs, but it is beneficial for the research to begin with a matter of applicable importance to practitioners.

From the results, it can be seen that even if no good estimate of opportunity cost can be made, a minimal figure can be used based on the historic or best guess estimate of the probability of obsolescence. In our numerical example, it was shown that even a small risk rate of obsolescence can have a significant impact on the jointly optimal solution.

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Chapter 79
Logistics Distribution Centers Location Problem under Fuzzy Environment

Muhammad Hashim, Liming Yao, Abid Hussain Nadeem, Muhammad Nazim and Muhammad Nazam

Abstract Logistics distribution centers location problem is concerned with how to select distribution centers from the potential set for minimizing cost and fulfill the demand. This paper aims at multi-objective optimization for three-echelon supply chain architecture consisting of manufacturer, distribution centers (DCs) and customers. The key design decisions considered are: the number and location of distribution centers, the quantity of products to be shipped from manufacturer to DCs and then from DCs to customers. The present study mainly investigates the proposed problem under fuzzy environment and the uncertain model is converted into a deterministic form by the expected value measure. The approximate best solution of the model is provided using fuzzy simulation. A numerical example is used to illustrate the effectiveness of the proposed model and solution approach.

Keywords Distribution center location problem · Multi-objective model · Expected value measure · Fuzzy programming method

79.1 Introduction

Manufacturer, customer and supplier are three important members of a supply chain. To some extent, the success of a manufacturer depends on its ability to connect these members seamlessly. In the real logistic system, distribution centers required to connect the manufacturer and their customers to facilitate the movements of goods. The term logistics refers to the science of ensuring the movements of goods in supply chain are carried out efficiently. It involves the location of plants and distribution centers, and selecting the best strategy for the allocation of product from plants to distribution centers and then from distribution centers to customers. The purpose

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of logistics distribution centers location is to minimize the cost and improve the service quality. Therefore, the distribution centers location is a long-term strategic problem, which not only determines where a new set of facilities should be located to facilitate the customers, but also how much capacities should be allocated to new facilities.

The optimal location of distribution centers has been an area of considerable research. Determining good locations for distribution centers in order to meet growing demands has continued to be of significant interest to researchers. A good location planning gives a clear strategic advantage to a firm over its competitors in the market. Consequently, a number of studies have been conducted for the development of mathematical models for distribution centers location planning [1, 2, 11, 13], [15], such as network location models, continuous location models and mixed integer programming models. Perl et al [1] presented a mixed integer programming formulation for warehouse location-routing problem and proposed a heuristic solution method. Aksen et al [2] reported the static conversion from brick-and-mortar retailing to the hybrid click-and-mortar business model from the perspective of distribution logistics. Amiri [3] developed a mixed integer programming model for the distribution network design problem in supply chain system that involves the location of plants and distribution centers, and determining the best strategy for distributing the products from plants to distribution centers and from distribution centers to customers. Syam [4] investigated an integrated model and methodologies for the location problem with logistical components. Chen et al [5] proposed a multiple criteria decision-making method to solve the distribution center location selection problem under fuzzy environment. Yang et al [6] employed chance-constrained programming model for logistics distribution centers location problem under fuzzy environment. Moreno et al [7] have investigated fuzzy location problems on networks with fuzzy values. Klose et al [10] reviewed some of the contributions to the current state of facility location models for distribution systems. Shankar et al [14] presented a multi-objective optimization of single-product for four echelon supply chain architecture consisting of suppliers, production plants, distribution centers and customer zones. Keshteli [21] presented a model for the selection of potential places as distribution centers in order to supply demands of all customers. So, a significant research has been done in this field on fuzzy and random parameters [8, 9].

In traditional supply chain, minimizing cost or maximizing profit is the primitive objective in most of the supply chain network design models [16, 17]. To minimize the cost or maximize the profit is not the only objective in supply chain network, but satisfying customer demand is also equally important. In fact, the success of any manufacturer depends entirely on the quality of its order fulfillment and its level of customer satisfaction. Usually, the customer satisfaction level and the cost control are two key factors to measure the level of a logistics system. However, although distribution location problem has been studied widely in the last decade. Most of the research, addresses deterministic model with single objective. Thus, constructing a multi-objective programming model is necessary for improving the service. In real decision making, the situation is often not deterministic, and some factors such as customer demand and transportation cost are usually changing, therefore distribution center location problem should be consider under fuzzy environment.

This paper investigates the logistics distribution centers location problem under fuzzy environment from another point of view, in which transportation cost, setup cost and demand are supposed to be fuzzy variables. The remainder of the paper is organized as follows: Sect. 79.2 explains the research problem and distribution center location problem under uncertain environment, Sect. 79.3 describes mathematical programming model under fuzzy environment and expected value operator to deal with fuzzy parameters, Sect. 79.4 states the solution method for solving the model, Sect. 79.5 presents a numerical example, results and sensitivity analysis, and finally, the concluding remarks are given in Sect. 79.6.

79.2 Problem Statement

Generally, distribution centers location problem involves how to select the location of distribution centers from a potential set and how to transport the products from manufacturer to customers via distribution centers so that the total relevant costs should be minimized and customer service level should be maximized. The choice of locations for distribution centers is an important question in an efficient logistics systems. A well-designed distribution centers location not only reduces the transportation and operational cost but also increases the customer service level and profits. The cost of distribution centers and customer service level provided by the design system are directly effected by the locations, size and number of distribution centers. So there is a need to find a best plan to design the solution of this problem. It is not easy to change the locations of distributions centers, because it is not only directly related to the operating expenses but also has a great influence on working and the control of whole logistics system.

It is a complicated problem and determining the best locations for new facilities is thus an important strategic challenge for decision makers [22]. For solving the above problem this paper considers four kinds of logistics costs:
(1) Distribution centers setup cost.
(2) Transportation cost from manufacturer to distribution centers.
(3) Transportation cost from distribution centers to customers.
(4) Operational cost of distribution centers.

Decision makers have the following two tasks: (i) select the locations of distribution centers from the potential set. (ii) determine the transported quantity of products from manufacturer to distribution centers and also from selected distribution centers to customers. So, manufacturer should supply the material to selected distribution centers and then from distribution centers to customers. For the understanding of this problem see Fig. 79.1.

In real life, decision making takes place in an environment where the objectives, constraints or parameters are not known precisely. It is hard to describe the problem parameters as known due to the complexity of social and economic environment

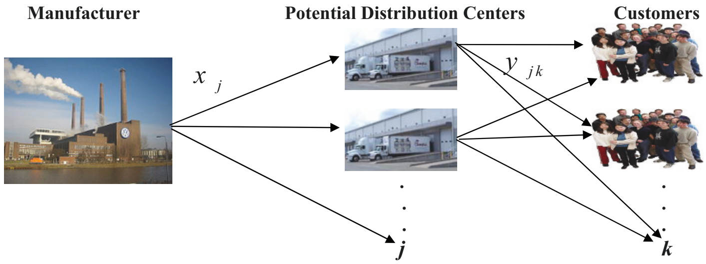

Fig. 79.1 Supply chain layout of logistics distribution centers location problem

as well as some unpredictable factors such as bad weather and vehicle breakdowns. These challenges increased the importance of stochastic and fuzzy programming for solving the real world problems where data are not known precisely. Many scholars have been presented stochastic distribution location models that are closer to real situations. Most of them have modeled the uncertainty (e.g., demand and transportation cost) by using probability distribution. Although probability theory has been proved to be a useful tool for dealing with uncertainty, some times it may not be suitable due to the lack of historical data. For example, if a decision maker makes the annual plan for the next year, it is not easy for him to obtain the exact values of some parameters indeed, e.g., distribution setup cost, transportation cost and demand. So many parameters like customer demand and transportation costs are usually uncertain rather than deterministic and it is very difficult to determine exact costs due to the fluctuation in the values. In fact, the decision maker cannot obtain perfect information for each parameter in the decision system. As different people have different feeling about the uncertain demand and cost and since there is no clear definition of this change. Thus in such kind of problem, it can be characterized by uncertainty of fuzziness and stochastic models may not be suitable. Some scholars have observed this uncertainty and imprecision and dealt with them using fuzzy theory [18, 19]. However, distribution centers location problem often faced with uncertain environment where fuzziness is exists in a decision making process. Therefore, fuzzy variables that can take into account fuzziness are favored by decision-makers to describe the uncertainty.

In this paper, uncertain parameters (i.e demand, transportation cost and setup cost) are represented by fuzzy numbers that can be further characterized by triangular fuzzy numbers. The decision makers can not get the exact information for each uncertain variable. So in this situation, the decision maker can describe the parameters into triangular fuzzy numbers that are more suitable to explain the uncertainty such as demand is about D_m but definitely not less than D_l and grater than D_u (see Fig. 79.2).

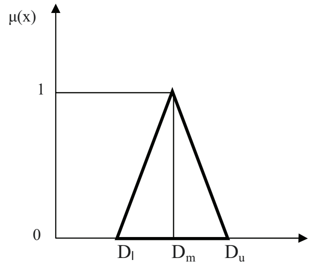

Fig. 79.2 Triangular fuzzy variable

79.3 Model Formulation

In this paper the problem is formulated as a multi-objectives programming problem with fuzzy coefficients, in which the decision makers have two objectives first minimize the relevant cost and second is to maximize the fill rate (service quality).

79.3.1 Notations

Suppose that there is one manufacturer, j distribution centers and k customer markets. The task is to transfer products from plant to DCs and then from DCs to customers.

Indices

Ω : set of potential distribution centers, j is an index, $j \in \Omega = \{1,2,3,\cdots,J\}$;
Φ : set of customer markets, k is an index, $k \in \Phi = \{1,2,3,\cdots,K\}$.

Parameters

$\widetilde{d}_{jk}$: demand of customer markets k at distribution centers j;
$\widetilde{tr}_j$: unit transportation cost of transported product from manufacture to distribution centers j;
$\widetilde{tr}_{jk}$: unit transportation cost of transported product from distribution centers j to customer market k;
a_j : distribution centers j capacity;
$\widetilde{C}$: setup cost of the distribution centers j;
t_j : operational cost of the distribution centers j.

Decision variables

X_j : this variable denotes the transported quantity from manufacturer to distributer centers j;
Y_{jk} : this variable denotes the transported quantity from distribution centers j to customer market k.

For the proposed problem, there is a need to select the distribution centers from the potential set $1,2,3,\cdots,J$. In this paper binary variable w_j is used to denote whether the distribution center j is selected or not, that is,

$$w_j = \begin{cases} 1, \text{ if distribution center } j \text{ is open,} \\ 0, \text{ otherwise.} \end{cases}$$

79.3.2 Modelling Formulation

The mathematical formulations of objectives are as follows.

In this model, the first objective function is to minimize the cost, which typically consists of its product transporting, operational and setup costs.

$$\min F_1 = \sum_{j=1}^{J} E^{Me}[\widetilde{tr}_j].X_j + \sum_{j=1}^{J}(t_j).X_j + \sum_{j=1}^{J}\sum_{k=1}^{K} E^{Me}[\widetilde{tr}_{jk}].Y_{jk} + \sum_{j=1}^{J} E^{Me}[\widetilde{C}_j]w_j. \tag{79.1}$$

Second objective function maximizes the fill rate.

$$\max\ F_2 = \sum_{j=1}^{J}\sum_{k=1}^{K} Y_{jk} \Big/ \sum_{j=1}^{J}\sum_{k=1}^{K} E^{Me}[\widetilde{d}_{jk}]. \tag{79.2}$$

Generally speaking, some mandatory conditions must be satisfied when the decision maker makes the decision and these are listed below:

The first constraint states that manufacturer supply should be greater than or equal to DCs supply.

$$\sum_{j=1}^{J}\sum_{k=1}^{K} Y_{jk} \leq \sum_{j=1}^{J} X_j. \tag{79.3}$$

Second constraint states that manufacturer supply should be less than DCs capacity.

$$\sum_{j=1}^{J} X_j \leq \sum_{j=1}^{J} a_j w_j. \tag{79.4}$$

Third constraint states that DCs should not exceed from the given numbers.

$$\sum_{j=1}^{J} w_j \leq N. \tag{79.5}$$

Fourth constraint states that fill rate can vary from 80% to 100%. If it exceed the define maximum limit it shows that supply is greater than demand which will be not acceptable by customers. In other case, if it is less than the define limit then it shows that supply is less than the customer need. So it should be within the defined limit.

$$0.8 \leq \sum_{j=1}^{J} \sum_{k=1}^{K} Y_{jk} \Big/ \sum_{k=1}^{K} E^{Me}[\widetilde{d}_k] \leq 1. \tag{79.6}$$

If a distribution center j is opened then X_j and Y_{jk} will be greater than zero and if not then X_j and Y_{jk} will be equal to zero.

$$X_j, Y_{jk} \geq 0, \quad w_j = 0 \text{ or } 1, \quad j \in \Omega, \quad k \in \Phi. \tag{79.7}$$

From the above discussion, by integration of Equations (79.1) to (79.7), a fuzzy multi-objective programming model can be formulated as follows:

$$\begin{cases} \min F_1 = \sum\limits_{j=1}^{J} E^{Me}[\widetilde{tr}_j].X_j + \sum\limits_{j=1}^{J} (t_j).X_j + \sum\limits_{j=1}^{J} \sum\limits_{k=1}^{K} E^{Me}[\widetilde{tr}_{jk}].Y_{jk} + \sum\limits_{j=1}^{J} E^{Me}[\widetilde{C}_j] w_j, \\ \max F_2 = \sum\limits_{j=1}^{J} \sum\limits_{k=1}^{K} Y_{jk} \Big/ \sum\limits_{j=1}^{J} \sum\limits_{k=1}^{K} E^{Me}[\widetilde{d}_{jk}], \\ \text{s.t.} \begin{cases} \sum\limits_{j=1}^{J} \sum\limits_{k=1}^{K} Y_{jk} \leq \sum\limits_{j=1}^{J} X_j, \\ \sum\limits_{j=1}^{J} X_j \leq \sum\limits_{j=1}^{J} a_j w_j, \\ \sum\limits_{j=1}^{J} w_j \leq N, \\ 0.8 \leq \sum\limits_{j=1}^{J} \sum\limits_{k=1}^{K} Y_{jk} \Big/ \sum\limits_{k=1}^{K} E^{Me}[\widetilde{d}_k] \leq 1, \\ X_j, Y_{jk} \geq 0, \ w_j = 0 \text{ or } 1, \quad j \in \Omega, \quad k \in \Phi. \end{cases} \end{cases}$$

It is very difficult to handle a multi-objective problem when it involves uncertain variables. So it is necessary to convert the fuzzy model into a deterministic one. In this paper expected value model is used to solve the proposed problem. For calculating the expected values of the triangular variables, a new fuzzy measure with an optimistic-pessimistic adjusting index is applied to characterize the problem. The detail information of this fuzzy measure Me can be found in [20]. It is a convex combination of possibility (Pos) and necessity (Nec) and the basic knowledge for measure (Pos) and necessity (Nec) can be found in [26]. Let $\widetilde{F}$= $(\gamma_1, \gamma_2, \gamma_3)$ denotes a triangular fuzzy variable. Based on the definition and properties of expected value operator of fuzzy variable using measure Me [20], if the fuzzy variable $\widetilde{F}$= $(\gamma_1, \gamma_2, \gamma_3)$, where $\gamma_1, \gamma_2, \gamma_3 > 0$, then the expected value of $\widetilde{F}$ should be:

$$E^{Me}[\widetilde{F}] = \frac{1-\lambda}{2}(\gamma_1 + \gamma_2) + \frac{\lambda}{2}(\gamma_2 + \gamma_3), \ \ \lambda \in [0,1]. \tag{79.8}$$

79.4 Solution Approach

The fuzzy programming [23, 24] is very useful and efficient tool to overcome problems under uncertainty. A classical and stochastic programming method may cost a lot to obtain the exact coefficient value, while fuzzy programming method does not cost too much [25]. From this fact, fuzzy programming method is very suitable when the coefficients are not known precisely. It offers a powerful mean of handling optimization problems with fuzzy parameters and has been used in different ways in the past. Zimmermann [27] introduced this method for multi-objective programming problems and later has been advanced by Sakawa et al [28]. In this method, the fuzziness in the decision making process is represented by using the fuzzy concept which has been studied widely and many results have been published [29, 30]. This method can be used for both linear and nonlinear multi-objective programming. Under the fuzzy programming method a multi-objective problem is equivalent to:

$$\begin{cases} \max \ \{-F_1(x), F_2(x)\}, \\ \text{s.t. } x \in X. \end{cases}$$

Considering the imprecise nature of the decision makers judgement for each objective function of problem, the fuzzy goals such as make $F_1(x)$ and $F_2(x)$ approximately larger than a certain values are introduced and then problem is converted into:

$$\begin{cases} \max \ \{\mu_1(-F_1(x)), \mu_2(F_2(x))\}, \\ \text{s.t. } x \in X. \end{cases}$$

The fuzzy goal is characterized by the following linear membership function:

$$\mu_i(F_i(x)) = \begin{cases} 1, & F_i(x) > F_i^1, \\ \frac{F_i(x) - F_i^0}{F_i^1 - F_i^0}, & F_i^0 \leq F_i(x) \leq F_i^1, \\ 0, & F_i(x) < F_i^0 \end{cases}$$

and F_i^1 and F_i^0 denote the maximum and minimum values of the objective functions $F_i(x)$, which could be determined as follows:

$$F_i^1 = \max_{x \in X} F_i(x), \ F_i^0 = \min_{x \in X} F_i(x), \ i = 1, 2. \tag{79.9}$$

For each objective function $\mu_i(F_i(x))$, assume that the decision maker can specify the so-called reference membership function value $\bar{\mu}_i$ which reflects the desired membership function value of $\mu_i(F_i(x))$. The corresponding Pareto optimal solution, which is nearest to the requirements in the minimax sense or better than that if the reference membership function value is attainable, is obtained by solving the following minimax problem:

$$\begin{cases} \min \ \max \ \{\bar{\mu}_i - \mu_i(F_i(x))\}, \ i = 1, 2, \\ \text{s.t. } x \in X. \end{cases}$$

By introducing auxiliary variable y, the above problem will be equivalent to:

$$\begin{cases} \min\ y, \\ \text{s.t.} \begin{cases} \bar{\mu}_i - \mu_i(F_i(x)) \le y, \quad i = 1,2, \\ 0 \le y \le 1, \\ x \in X. \end{cases} \end{cases}$$

It shows that above problem is a convex programming problem and the global optimal solution can be easily obtained from this method.

79.5 Numerical Example

In this section, a numerical example is used to show the application of the model. In this paper, we supposed that a decision maker needs to select the 3 distribution centers from 5 potential distribution centers to serve 5 customers. The data is shown in the Tables 79.1, 79.2 and 79.3:

Table 79.1 Customer demand

Customer (k)	1	2	3	4	5
Demand ($\widetilde{d}_{jk}$)	(55,60,65)	(95,100,105)	(155,160,165)	(120,125,130)	(60,65,70)

Table 79.2 Transportation cost of unit product from distribution centers to customers (Y_{jk})

$k \setminus j$	1	2	3	4	5
1	(0.31,0.35,0.39)	(0.80,0.84,0.88)	(0.19,0.23,0.27)	(0.32,0.36,0.40)	(0.39,0.43,0.47)
2	(0.42,0.46,0.50)	(0.41,0.45,0.49)	(0.30,0.34,0.37)	(0.18,0.22,0.26)	(0.20,0.24,0.28)
3	(0.19,0.23,0.27)	(0.30,0.34,0.37)	(0.28,0.32,0.36)	(0.63,0.67,0.71)	(0.19,0.23,0.27)
4	(0.32,0.36,0.40)	(0.18,0.22,0.26)	(0.42,0.46,0.50)	(0.48,0.52,0.57)	(0.21,0.25,0.29)
5	(0.39,0.43,0.47)	(0.20,0.24,0.28)	(0.83,0.87,0.91)	(0.59,0.63,0.67)	(0.32,0.36,0.40)

Table 79.3 Distribution centers operational cost, transportation cost, setup cost and capacity

Distribution centers j	1	2	3	4	5
t_j	(0.47)	(0.59)	(0.52)	(0.28)	(0.50)
$\widetilde{tr}_j$	(0.51,0.56,0.60)	(0.63,0.67,0.71)	(0.39,0.43,0.47)	(0.61,0.65,0.69)	(0.94,0.98,0.102)
$\widetilde{C}_j$	(16,19,21)	(26,29,31)	(12,15,17)	(15,17,21)	(16,20,21)
a_j	(124)	(185)	(294)	(102)	(290)

79.5.1 The Result of the Numerical Example

The optimal solution is obtained on based fuzzy simulation and set optimistic-pessimistic index $\lambda = 0.5$. The approximate best object values are $F_1 = 710.25$, $F_2 = 1$, and corresponding optimal solution is $W_1 = 1$, $W_3 = 1$, $W_4 = 1$, $X_1 = 124$, $X_3 = 286$, $X_4 = 100$, $Y_{13} = 59$, $Y_{31} = 60$, $Y_{42} = 100$, $Y_{15} = 65$, $Y_{33} = 101$, $Y_{34} = 125$ and the values of other decision variables are equal to zero. The distribution center 1 serves the customers 3,5; the distribution center 3 serves the customers 1,3,4; the distribution center 4 serves the customer 2. In order to understand this approximate optimal solution by a straightforward way, this paper refer to Fig. 79.3.

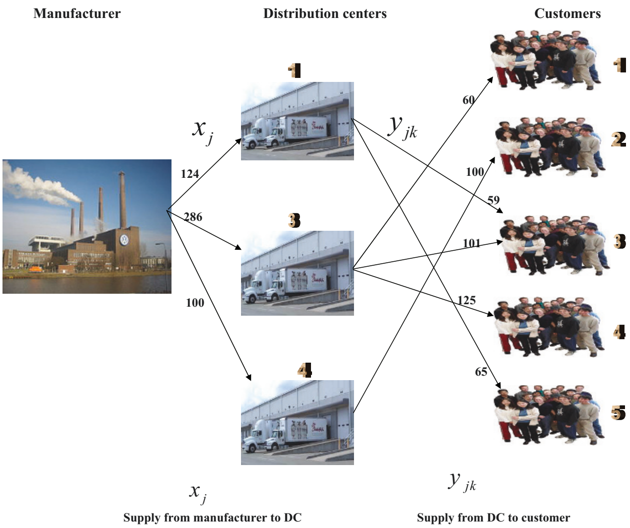

Fig. 79.3 Optimal solution layout

79.5.2 Sensitivity Analysis

The optimal objective is dependent on the value of parameter λ, thus it is meaningful to investigate the sensitivity of the optimal objectives with respect to λ, with the increase in λ values the objectives values are increased and vice versa. Fig. 79.4 shows that the optimal objective will increase with increasing value of λ. Actually, the sensitivity of the result can be tested for other values of parameter λ (see Table 79.4). The decision maker wants to minimize the cost and maximize the customer satisfaction. In real life, it is very difficult for a decision maker to achieve the desirable level of objective function due to uncertain parameters. Since there exists operational cost in each distribution center, it is suitable that all quantity in each distribution center could be transported to satisfy the demands of the customers. For minimizing the total cost, it is reasonable to suppose that the total quantity transported from manufacturer is just the total demands of the customers. So, we could see the impact of increase or decrease in supply from demand in Table 79.5.

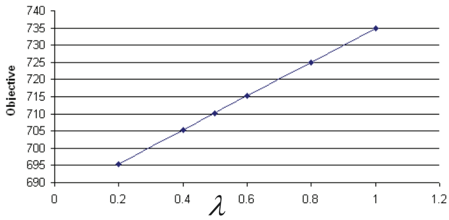

Fig. 79.4 Sensitivity of optimal objective with different λ

Table 79.4 Sensitivity with respect to parameter λ

λ	0.2	0.4	0.5	0.6	0.8	1
Objective value (F_1)	695.424	705.308	710.25	715.192	725.076	734.96

Table 79.5 Objective function values

Actual demand	Demand satisfied	Total cost (F_1)	Fill rate (F_2)
510	570	793.782	1.11
510	510	710.25	1
510	450	626.67	0.88
510	390	542.88	0.76

79.6 Conclusion

This paper mainly investigates a multi-objective programming model with fuzzy coefficients for solving the logistics distribution center location problem. As a result, fuzzy expected value programming is constructed as a decision model to convert the uncertain model into a deterministic one. Fuzzy programming method is proposed to seek the approximate best transportation plan and customers assignment plan for the distribution centers. At last, the effectiveness of the proposed model is tested by a numerical example. In addition, sensitivity of the optimal objective value with respect to the parameter is also discussed in this example. The proposed model and fuzzy programming discussed in this paper will be helpful to solve the realistic problem and further it will help the managers to make a good decision.

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Chapter 80
The Entropy Mechanism of Organization Knowledge Governance Based on Value Chain

Xuebing Xiong and Xiaoping Li

Abstract Based on value chain, this article employs entropy theory into organization knowledge governance, and conducts theoretical study on the evolution of the entropy mechanism of organization knowledge governance system and organization knowledge governance entropy. The study lays a foundation for analyzing organization knowledge governance performance qualitatively and quantificationally.

Keywords Organization knowledge governance (OKG) · Entropy mechanism · Entropy theory · Value chain

80.1 Introduction and Research Background

According to Einstein, entropy theory is the first law of all the physical sciences, the first principle of all scientific principles. It reflects all the evolutionary rules of the physical world. It has deeply influenced the establishment and development of the theoretical science. Hou [12] considered the entropy principle as the supreme law of philosophy in the universe. They all understood entropy from epistemology and methodology. Because of the increasingly important role of knowledge in organization governance, and the increasing need for managing the knowledge, knowledge governance, as a new governance form, is being attached high importance widely in recent years [1]. It has a powerful support to meet new challenges and an important means of updating technology enhancing competition ability and helping it make intelligent decision for an organization [2]. The development of knowledge governance shows that organizations should focus on the knowledge governance, constructing a new strategic governance mode. With the rapid development of the knowledge economy, an organization has to pay more attention to planning its inte-

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gration strategies and knowledge strategies, inspiring potential knowledge, so as to create special competition ability and sole market position [3].

"Unable to measure, unable to manage" implies the important role of OKG [26], as it's indispensable in knowledge governance. Entropy, originated from the classical thermodynamic theory, is a concept that refers to the status of confusion and disorder in a complicated system. Einstein once commented on the law of Entropy, the theory with simpler presupposition contains more. Entropy has been applied to various fields [4]. As the increasing market competition and the development of globalization, knowledge governance has been playing a role that cannot be substituted in the development of core competition ability of an organization [5].

As to the related literature, there are lots of researches on performance evaluation of OKG, with the typical ones as follow: Anne Burukin [7] indicates in her book "Intelligent Capital-the Application and Governance of the Third Source" that evaluating the intelligent capital in an organization should begin with the organization's market capital, intellectual property capital, basic structure capital and human resource capital [6]. Combining with new and old standard, Baruch [7] adds knowledge capital with book capital, basing on the governance performance, thus create a new concept "General Value", establishes the first knowledge capital scoreboard, which is used to measuring the economic benefit of the investment of knowledge capital.Skandia Mode that was charged by Edvinsson and Sullivan [9] for its design has most influences on knowledge capital. The model analyzes and evaluates the knowledge capital with 111 index in terms of financial condition, consumer satisfaction, process, innovation & development and human resource governance [7]. To some extent, it overcomes the disadvantage that the traditional financial statement only focus on the result in current period, strengthens the organization's monitor of inner operation process, so that the mode can reflect not only the governance result but also anticipate the developing trend [8].

On the basic of Balance Scorecard (BSC), Edvinsson and Sullivan [9] put forward a navigator model, which focus on customer, finance, innovation and development, human resource and process, and built up a complete system of theory of knowledge capital and a index system consisting of 30 index, including financial and non-financial ones. They are used to evaluate and manage the knowledge capital [10]. The MARK Award, with most authorities in the field of knowledge governance in the world, evaluate the performance of knowledge governance from aspects of the quality of integrated knowledge planning, the support from the leaders for the knowledge governance, the contribution of the technology innovation, the measurement of promoting the knowledge capital to a large extent, the effect of knowledge share, the culture acceptance after sustaining study, the contribution degree to the stockholder's benefit when creating customers' loyalty to the value [11].

The importance of the evaluation has been noticed and researched on with lots of achievement coming out [13]. To evaluate the performance of knowledge governance, there are visible performance measurement and invisible measurement of knowledge capital. The integrated evaluation method and technique based on the theory of governance entropy is what we need to make up the disadvantage [14]. It can reveal and solve the problem in a general complete and dynamic way. Therefore, what this research does, analyzing the entropy mechanism of OKG, is also the first step of evaluating the performance of knowledge governance [15].

80.2 The Structural Model of OKG

In general, the structure matches up to the mechanism. So, we'd better figure out the structural model of OKG. From the perspective of the systems theory, OKG is a system and there is a Structure in it. Reviewing researches on OKG home and abroad, we can find that there are steps to knowledge collection, organization, transferring, sharing, innovation, and application in the process of OKG [16]. Organization knowledge and its business process have an inner relationship with each other. Organization knowledge exists in every business process as knowledge fragments. We should closely relate organization knowledge to concrete business processes, and manage knowledge in a systematic way, thus to realize the sharing and application of knowledge, so as to improve organizational performance. Hence, the OKG system model constituted in this paper is as follows (see Fig. 80.1).

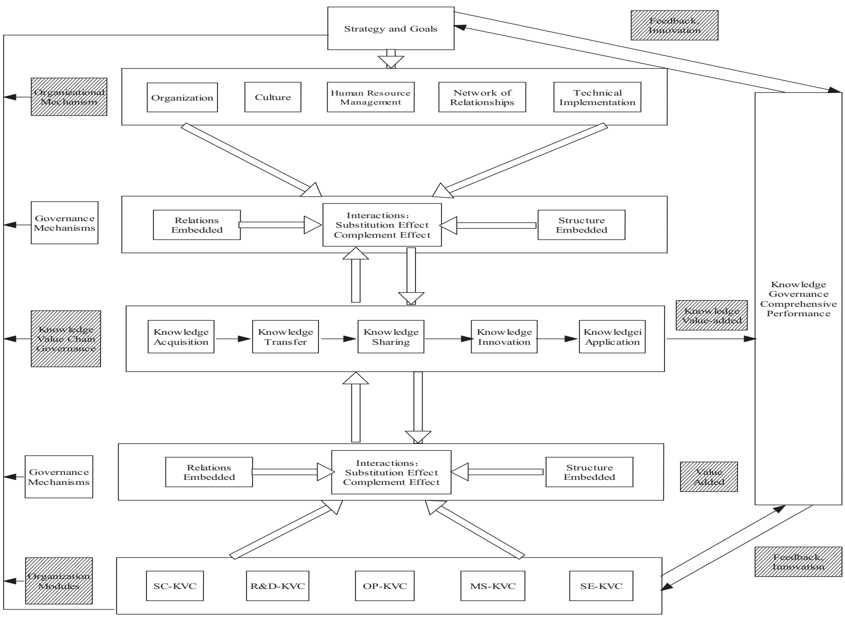


Fig. 80.1 OKG system model based on value chain (Note: KVC stands for Knowledge Value Chain)

OKG system has a dissipative structure. It is also an open, dissipative system, with a character of being far from a state of equilibrium and acts in phases. Since a knowledge governance system is multi-level, involving many factors, far from being in a state of equilibrium, is open and complex, its elements must have a non-linear effect.

Stability and structural instability: the evolution of OKG system has the mechanism of inducing and fluctuation. Fluctuation has induced the evolution of the OKG, which is not only influenced by its internal fluctuation but also by its external fluctuation because of the system's openness. In other words, the system has an internal fluctuation and external fluctuation. Meanwhile, the evolution of the OKG system has a bifurcation mechanism [18].

The OKG system has a non-linear dynamic mechanism. Hyper cycle organization is the carrier and performance method of the non-linear effect of the system. It is reflected in the formation, development, deconstruction and reorganization of every hyper cycle organization.

80.3 The Mathematical Model of the OKG Entropy

Using the mathematical model of governance entropy by professor Ren as a reference, this paper deduces a mathematical model of governance entropy according to the Boltzmann formula and the information entropy formula by Shannon [19].

Model hypothesis: firstly, the OKG system is a relatively closed and separate system. Exchange of information, energy and substance with the external environment is infrequent. Secondly, it is in a state of imbalance because there are energy differences within the organization knowledge system [20].

Mathematical model formula:

$$S_1 = \sum_{i=1}^{n} K_i S_i. \tag{80.1}$$

In the Equation (80.1), i is the element that affects the entropy value of the knowledge governance system that is relatively closed, i.e. knowledge governance basic value activity, knowledge governance supportive value activities. K_1 is the weight of every element in a specific industry and period. S_1 is the entropy value produced by the influence various kinds of elements.

$$S_i = -K_B \sum_{j=1}^{n} P_{ij} \ln P_{ij}, \tag{80.2}$$

where K_B is the coefficient of the knowledge governance entropy. Here, it is defined as: if the organization is in a specific performance, i.e. P_i is the probability of the knowledge governance entropy value change. P_j agrees $\sum P_j = 1$.

From the Equations (80.1) and (80.2), we have S_1, the OKG internal entropy value. The knowledge governance system's internal entropy value represents the degree of disorder of the OKG. An increase of the entropy value is the process of knowledge governance evolution from an orderly to disorderly state [21].

Since an increase of system entropy will cause a decrease of governance efficiency, the process of entropy increases inside a knowledge governance system and can be symbolized by the formula of decreasing organization efficiency [17].

$$Y = Re^{-x}, \tag{80.3}$$

$$x = f(a_1x_1, a_2x_2, \cdots, a_nx_n) = \sum_{i=1}^{n} a_ix_i, \tag{80.4}$$

where Y is the knowledge governance efficiency. R represents the constant knowledge governance structure. X_i is the function that affects the knowledge governance efficiency's elements. a_i is the weight number that affects every factor.

80.3.1 The Effect and Influence Made by Positive Entropy Change of the OKG

This paper believes the effects and influences made by positive entropy change of the knowledge governance entropy on the development of OKG as follows.

The so-called positive entropy change of knowledge governance entropy refers to that in the evolution and developing process of the OKG system, the coordination among the various elements inside the OKG is blocked, or an inappropriate exchange of substance, energy and information between the OKG and the environment, so as to cause a functional disorder of the OKG in some sense that orderliness decreases and disorderliness increases [22]. This state of OKG system is called the increasing entropy effect of the OKG, which can finally change the entropy value of OKG and will gradually appear in a state of a positive value, thus leading to a disorderliness effect on the OKG.

Positive entropy change blocks the development of the OKG system. It disturbs the developmental goals of the OKG system, weakens developmental forces, and even destroys the basic structure and future prospects. Positive entropy change destroys the relation of the knowledge governance system. The positive entropy change destroys the vitality of knowledge governance system [23]. The positive entropy stems from the balanced operation mechanism inside the OKG system, which writes off the various differences in it, and tries its best to draw the components of the OKG system and the OKG system elements giving out largest energy back to the balance state, so that the components and factors can be in symmetry in the time and space and movement mode [24]. In this way, the strongest functional components in the OKG and the potential factors must lose their strong ability and opportunity and environment where there should have been. There will be great inner dissipation in the equilibrium state, making the OKG system lose all its vitality and to becoming inert.

80.3.2 The Emergence of Negative Entropy of OKG

The dissipative structure was a theory put forward by physicist Prigogine, which is used to research development trends and the relevant condition of an open system. By constant exchange of substance and energy with the external environment, an open system far from equilibrium (physical, chemical, biologic, even the social system) may be transformed to an orderly state in time, space or function, from a disorderly state when variety reaches the holding value. This new system, which is far from balanced, is called dissipative structure. Ren [17] introduces the dissipative structure into organization governance and gives the concept of dissipative governance and dissipative governance structure.

The so-called negative entropy of OKG means that OKG system, in its evolution and development process, due to the internal contradictions of OKG system being resolved and weakened, or because of the reasonable exchange of substance, energy and information between OKG systems and the external environment, its entropy value decreases continuously and eventually, changes gradually or rapidly and finally becomes less than zero reaching a negative state, resulting in OKG system producing effects of order. OKG and external environmental exchanging of material, energy, and information is only a necessary condition for an orderly OKG system [25].

The emergence and expansion of Knowledge governance negative entropy means that the disorder factors of OKG system will be reeducated and offset. The order factors of OKG system will be created and strengthened.

In general, the higher the value of the knowledge governance negative entropy, the faster the decay speed of OKG system's entropy. Then the resulting effect of the order will be stronger, that is, the order degree of OKG system will be higher.

Negative entropy of knowledge governance continuously reduces the total entropy value of knowledge governance organization system, while constantly enhancing the functions of OKG system as a whole, so that OKG system is full of vitality. The reflection of negative entropy of knowledge governance in the evolution of OKG system are mainly as follows: within the system, negative entropy of the knowledge governance promotes various elements of OKG system to be interlinked with each other; various relationships to in harmony with each other; OKG system structure and system functions coordinate with each other; in external of OKG system, negative entropy is conducive for OKG system and system environment to adapt to and interact with each other, contributing to each other, the overall effect of OKG system is continuously improved, the records of development are constantly refreshed. In short, once the negative entropy of knowledge governance system plays a dominant role, the development speed and efficiency of OKG system will have a reliable guarantee [26].

80.3.3 The Dissipation and Interpretation for the Mathematical Model of OKG

According to the connotation of the knowledge governance dissipation, this research concluded the mathematics mode of knowledge governance dissipation:

The precondition of the knowledge governance dissipation mathematical model: (1) OKG is an open system far from a state of equilibrium. (2) OKG that produces a dissipative structure contains a system of many primitive and even multi level components. The elements inside the system have a non-linear correlation between each other. (3) The changing external environment conditions reach a certain threshold value. (4) The internal system consistently exchanges knowledge and information with the external environment so as to make the total entropy value negative.

The formula of knowledge governance dissipation. Firstly, the formula of negative entropy is as follows:

$$S_e = \sum_{j=1}^{n} k_j S_j, \tag{80.5}$$

where j is the factor that engenders negative entropy, such as new knowledge governance methods, new effective policy, a new effective incentive, a constraint mechanism and new effective personnel quality structure and so on. K_j is the weight of the influencing factors among the negative entropy input by the knowledge governance system. S_j is the negative entropy value of these influencing factors.

$$S_j = K_B \sum_{i=1}^{n} P_{ij} \ln P_{ij}, \tag{80.6}$$

where K_B is the coefficient of the OKG entropy. Here, it is defined as: if the organization is within a specific performance parameter, i.e. j represents all sub-factors that affect the OKG entropy. P_i is the probability of change of the OKG entropy value. P_i agrees $\sum P_j = 1$.

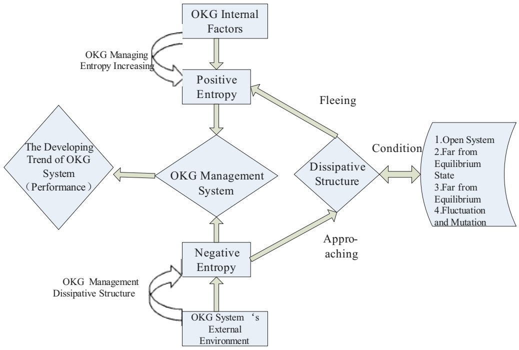
From Equations (80.5) and (80.6), we can have S_1, the OKG governance inner entropy value. The OKG governance system's inner entropy value represents the degree of disorder of the OKG governance. The increase of the entropy value is a process of OKG evolution from an orderly state to a disorderly state.

80.3.4 Analysis of the Total Entropy of OKG

The structure of the OKG system can be seen according to the identification and analysis of knowledge governance entropy and the theory of knowledge dissipation structure in the chart below (see Fig. 80.2).

Therefore, the total entropy of the OKG system can be calculated according to the above-mentioned positive entropy and negative entropy of OKG. The total entropy of an open OKG system can be expressed as follows:

Fig. 80.2 OKG System Dissipation Structure and Relationship Chart



$$S_t = S_i + S_e. \tag{80.7}$$

In Equation (80.7), S_t is total entropy of the whole OKG system; S_i is positive entropy of the OKG system; S_e is negative entropy Se of the OKG system.

It can be seen from the Equation (80.7) that only when $S_t < 0$, the dissipation structure can be formed, thus arises the condition for the forming of the knowledge governance dissipation structure: $|S_i| < |S_e|$.

Positive entropy and negative entropy are both opposed to and unified with each other. The two 'entropy' of different natures constantly affect the OKG system at the same time. They also follow through the whole process of the development of the OKG system. Because S_1 is always greater than 0, while S_e can be either positive or negative, there are three possible situations for the value of S_t:

First, when $S_t > 0$, two situations exist. One is when $S_e < 0$ and $|S_e| < S_i$, the intensity of the positive entropy produced within the OKG system is greater than the negative entropy introduced into the system, then the disorderly effect produced by the positive entropy is greater than the orderly effect produced by the negative entropy, so in total, the OKG system is developing in a disorderly direction. Here negative entropy only plays a passive role of reducing the degree of the disorderliness of the OKG system or of slowing down the pace of the system to develop into disorderliness, while the positive entropy plays a dominant role. The other situation is, when $S_e > 0$, i.e. the negative entropy being introduced does not counteract the positive entropy within the system; on the contrary, it strengthens the positive entropy. As a result, the total entropy of the OKG system increases instead of reduces. This situation can be called the weak converse effect of the negative entropy in OKG. This is a worse situation because the total entropy within the OKG system will increase drastically and when the total entropy reaches a certain degree, the OKG system will irreversibly develop into disorderliness.

Second, when $S_t < 0$. i. e. $S_e < 0$ and $|S_e| > S_i$, the intensity of the negative entropy introduced into the OKG system exceeds that of the positive entropy of knowledge governance within the system, then the negative entropy of knowledge governance flowing into the OKG system completely counteracts the knowledge governance entropy increase within the system and it makes the total knowledge governance entropy decrease negative, and the trend of orderliness of knowledge governance in the OKG system is greater than that of the disorderliness, then in total, OKG develops in a disorderly direction and a dissipation structure is formed.

Knowledge governance entropy only plays a passive role of decreasing the degree of orderliness of the OKG system or slows the pace of the system in developing into orderliness while the negative entropy of knowledge governance plays a dominant role. In fact, a lot of problems come up when the OKG enters the maturity stage of its development. At this point, being promoted by the external environment of knowledge governance system, the dilemma among the sub-systems of OKG and the elements making up those systems intensify, minor ups and downs become major ones and the degree of imbalance among the development of various elements in OKG system exceeds the critical threshold value for the stable development of the OKG system, and then the system loses its stability.

Under this circumstance, the organization adjusts its policies to improve the result of knowledge governance, enhances knowledge sharing, further improves support of information technology and organizational culture, strengthens the transformation and utilization of visible as well as invisible knowledge and solves the problem of the inefficient flow of knowledge, etc. These are all ways to introduce negative entropy of knowledge governance from the external environment into the OKG system. As long as the negative entropy of knowledge governance exceeds the increase of knowledge governance entropy within the OKG system, the OKG system will reach a new stable and orderly state and form a vital and orderly structure. At this time, the new advanced orderly OKG system has a strong anti-interference ability and a strong ability to take over and merge and to metabolize, thus the OKG will be successful.

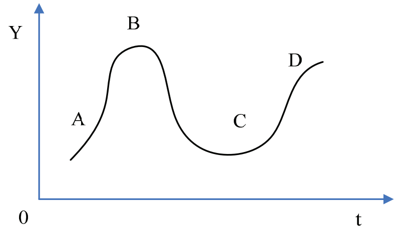
Third, when $S_t = 0$, i. e. $S_e < 0$ and $|S_e| = S_i$. At this time, the intensity of the negative entropy of knowledge governance introduced into the OKG system equals that of the increase of knowledge governance entropy within the system, then the tendency of becoming orderly and that of becoming disorderly of the OKG system are balanced; the orderliness and disorderliness of the system integrate and counteract with each other, so the total knowledge governance entropy is zero and the OKG system is in a temporarily stable and balanced critical state. However, this state does not last long. It will eventually end as the two interact with each other and the various elements making up the system and the external environment change, and either develops into orderliness or disorderliness.

Correspondingly, as the knowledge governance entropy and the negative entropy of knowledge governance change, the knowledge governance efficiency of the OKG presents a 'waveform', as shown in the chart below. It presents three different situations under different circumstances.

First, the AB segment. The corresponding condition is when $S_t < 0$, then the efficiency within the OKG system is less than the external efficiency, so the efficiency of the OKG is greater than zero, and it shows that the efficiency of the OKG increases continuously.

In Fig. 80.3, Vertical Axis Y stands for Efficiency, Horizontal Axis t stands for Time.

Fig. 80.3 OKG Efficiency Chart



Second, the BC segment. The corresponding condition is $S_t > 0$, at this point the efficiency within the OKG system is greater than the external efficiency, so the efficiency of the OKG system is less than zero which means that the efficiency of the OKG system will decrease continuously.

Third, points B and C. The corresponding condition is $S_t = 0$, at this point the efficiency within the OKG system equals the external knowledge governance efficiency, then the knowledge governance efficiency of the OKG system reaches its maximum, and in the chart point B is the maximum knowledge governance efficiency and point C is the minimum, certain measures must be taken at this moment.

At point B, one should be cautious of the potential risks. On the one hand, the problems in the sustainable development of the OKG system should be ascertained and efforts made to reduce and control the knowledge governance entropy. On the other hand, a large amount of knowledge governance negative entropy should be introduced from the external environment to ensure that the OKG system operates efficiently and to reduce various potential risks. For example, introducing highly qualified personnel and strengthening cooperation with related colleges and research institutes so as to sustain knowledge governance efficiency of OKG for longer.

At point C, if the OKG continues to stay in closeness, fails to innovate all systems in OKG timeously and fails to adopt exchanges with the external environment in materials, energy, information and personnel, etc. OKG will certainly fail and the OKG system will inevitably face further recession or even die out. If the OKG could introduce a large quantity of the materials, energy, information and personnel and innovate the systems, mechanisms, etc. within the system so as to reduce or eliminate the internal increase of knowledge governance entropy, then the deadlocked and balanced critical state within the OKG system will end so that the knowledge governance efficiency increases, then the OKG will again be successful.

In fact, the knowledge governance positive entropy and the knowledge governance negative entropy are two sides of one question. In the process of OKG, there is a non-linear complex and contradictory relationship between the two as they rely on and limit each other and if one falls when the other rises under the influence of the external environment, together with the complexity and the nonlinearity of the OKG system as well as the complexity and unpredictability of the external environment, makes the knowledge governance entropy process of the OKG chaotic, complex and uncertain. Knowledge governance entropy reveals the trend of developing from orderliness to disorderliness in the process of OKG describes the law of the decrease in knowledge governance efficiency and theoretically demonstrates that knowledge governance entropy is the reason for the inefficiency or failure of OKG. Knowledge governance negative entropy is the opposite. It describes the law of the increase in knowledge governance efficiency and the tendency of the OKG to develop from low orderliness to high orderliness, from disorderliness to orderliness under certain conditions and theoretically demonstrates that knowledge governance negative entropy is the guarantee for the OKG system to improve the efficiency of knowledge governance or the success of knowledge governance.

From the above-mentioned mathematical models about the positive and negative entropy of OKG, the models on the positive entropy and negative entropy as well as total entropy provide a basis of a series of theoretical support for solving the problems in OKG and new thoughts and ways to control the inefficiency or failure in OKG so as to ensure a success: slowing down or decreasing positive entropy increase and strengthening as well controlling the inflow of negative entropy; close attention should be given to the main elements affecting changes in increases in positive entropy and the inflow of negative entropy of the OKG system.

80.4 Conclusion and the Future Studies

The OKG that based on entropy provides us a new prospect for organization governance. By studying on how positive entropy, negative entropy and the related issues in the OKG, the organization can acquire various elements to build up its core ability. The organization achieve knowledge increment by knowledge integrating, thus to gain a sustainable competitive advantage by improving the knowledge governance performance.

- Researcher should construct mathematical model of OKG performance evaluation based on entropy theory.
- In the further research, a scientific method should be established to analyze OKG performance quantificationally.

Actually, our research team has established some evaluation factors, and we are going to do demonstration research.

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Chapter 81
Trade-offs among Lean, Agile, Resilient and Green Paradigms in Supply Chain Management: A Case Study Approach

Helena Carvalho, Susana Azevedo and Virgílio Cruz-Machado

Abstract Lean, Agile, Resilient and Green (LARG) management paradigms may help companies and supply chains to become more competitive and sustainable. However, the deployment of those management paradigms could lead to opposite results. This paper intends to identify and the necessary understanding of those paradigms trade-offs. An exploratory case study approach is used to identify the trade-offs in the automotive supply chain context. The case study findings show that not all the companies belonging to the same supply chain need to have a higher implementation level for all LARG practices. Some companies can be more Resilient than others, and the same happens with the Lean paradigm: not all companies in supply chain need to be totally Lean. Because of the differences in the LARG practices implementation level among supply chain echelons, two separate sequences of capabilities were found. For the automaker "quality" should be developed first, then "flexibility", "environmental protection" in addition to "cost", and finally "delivery". In the first-tier supplier echelon "quality" should be developed first, subsequently "flexibility", "delivery", and ultimately "cost" and "environmental protection".

Keywords Lean · Agile · Resilience · Green · Supply chain · Trade-offs Capabilities · Automotive industry · Case study

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81.1 Introduction

A supply chain (SC) can be described as a network that links various agents, from the customer to the supplier, through manufacturing and services so that the flow of materials, money and information can be effectively managed to meet the business requirements [1]. The management of the activities and flows among companies belonging to these networks is a strategic factor for increasing the organizational effectiveness of companies and achieving goals such as enhanced competitiveness, better customer service and increased profitability [2]. Among the various supply chain management (SCM) paradigms the following ones are considered critical to the SC competitiveness and success: Lean, Agile, Resilient, and Green paradigm [3–5]. The acronym LARG is used to refer to the simultaneous deployment of those paradigms: i) the Lean paradigm focus on waste and non-value added activities elimination to achieve higher levels of efficiency, profitability and flexibility; ii) the Agile paradigm is related to market sensitiveness, it confers the companies the ability to reading and responding to real demand; iii) the Resilient paradigm focuses on the SC ability to recover to a desired state after a disruption occurrence; and the Green paradigm is concerned with the reduction environmental risks and negative impacts.

The literature shows that almost researches have been focused on the study of individual paradigms or on the integration of only a couple of paradigms in SCM, e.g. [6–10]. As an extension of these studies Carvalho et al [5] propose an innovative approach to a simultaneous deployment of the Lean, Agile, Resilient, and Green paradigms in SCM. This conceptual study also stresses that important synergies and divergences arise when the four paradigms are deployed simultaneously in the SC context. However, there are not empirical studies covering the LARG deployment in SCs and respective companies.

The automotive SC provides a rich context to explore this issue. Companies belonging to the automotive SCs are implementing Lean solutions to reduce the SC cost [11]; but they also are looking for Agile manufacturing systems, because of the potential for equipment reuse and equipment investment cost reductions over time [12]. However, there are evidences that the tendencies of many automotive companies to seek out low-cost solutions may have led to leaner SCs but also too more vulnerable to disruptions [13]. The automotive SC is also pressured to become more sustainable and more environmentally friendly at the same time that are expected economic benefits of greening the SC [14].

Despite the LARG paradigms relevancy in SC context, there is a lack of models that cover the simultaneous paradigms deployment in a SC context. This work intends to fulfil the research gap that exists about this topic and to improve the knowledge as regards the simultaneous influence of LARG practices on SC performance. The identification of these relationships is critical to a better understanding of trade-offs that arise from the integration of LARG practices.

The paper is organized as follows. Following the introduction, a literature review on the Lean, Agile, Resilient and Green SCM paradigms is presented, being proposed a set of LARG SC cumulative capabilities; in addition provides a review on the trade-off theory. Next, a case study related to the automotive SC is presented and main findings discussed. Finally, some conclusions are drawn.

81.2 Background

81.2.1 Supply Chain Management LARG Practices

In the "Third International Conference on Management Science and Engineering Management", a paper named "Lean, Agile, Resilient and Green SC: a review" proposed an innovative approach to SCM: instead of considering each management paradigm individually, managers should integrate the four paradigms in their SCs and respective companies [3]. This new approach is relevant because of the paradigms complementarities and synergistic effects on SCs competitiveness. A SC that can be at the same time Lean, Agile, Green and Resilient means that: i) it reduces all kinds of wastes (waste associated with a lack of product quality, waste of time, waste of costs, and so on); ii) it improves the company's ability to respond rapidly and cost effectively to unpredictable changes in the markets; iii) it employs automatic mechanisms to react instantaneously to unexpected events; iv) it reduces processes environmental negative impacts and it is more concerned with raw materials and components used and also with production outputs.

These characteristics represent a new SC behaviour more adjusted to a threaten competitive market. Table 81.1 contains some of the main practices present in the literature that reflect the interaction among Lean, Agile, Resilient and Green paradigms with SC performance.

There are some synergies among the different paradigms. In literature the synergies among Lean and Agile paradigms are highly discussed. In their seminar work, Naylor et al [15] propose the integration of the Lean and Agile manufacturing paradigms in SC. They coined the term "leagility" to describe this new behaviour: the Lean paradigm is used in the SC companies that have a stable demand and the agility is used by the companies that need to satisfy a fluctuating demand.

Another synergy commonly discussed is among Lean and Green paradigms which are often seen as compatible because of their joint focus on waste reduction [16]. The removal of non-value adding activities, suggested by Lean paradigm can provide substantial energy savings and reduce the environmental impact, fitting with this way the main concerns of the Green paradigm [17]. Also, waste management has been expanded from the traditional 3R's (reduce, reuse, recycle) to a hierarchy which adds components such as energy recovery and disposal. This list has been modified to include: eliminate, reduce, reuse, recycle, convert waste into energy, and dispose [18]. Since Lean initiatives enable only demanded volumes to flow through the SC, a reduced amount of inventory needs to be sourced, produced, transported, packaged and handled, which also minimizes the SC negative environmental impacts. The literature also suggests another synergy between the Agile and the Resilient paradigms [19] [10]. SC agility supports the development of a more Resilient SC, since the SC response and velocity is improved [10]. Both management paradigms promote collaboration among SC partners and rely on flexible suppliers while seeking lead-time reduction.

Table 81.1 LARG management practices

Paradigm	Practice	Clarification and impact on SC performance
Lean	Just-in-time production	A production scheduling concept that calls for all raw materials, work in process, and finished goods to be available precisely when needed. It promotes the use of minimal of inventories of raw materials, work in process and finished goods [20].
	Geographic concentration with suppliers	It is related to the development of supplier parks in an area nearer the plant supporting the production of small batches and frequent deliveries [21].It also promotes trust among companies and can improve SC performance in terms of volume and variety, inventory levels and lead time [22].
Agile	Multi-product production systems	It is related to the development of product modularity and commonality, where product variants share the same resources and assets [23]. It results in simplified planning and scheduling, lower setup and holding costs, lower safety stock, and reduction of vendor lead-time uncertainty [23].
	Synchronizing transportation with production	In order to counter market forces and reduce the time to market, many companies deploy this practice to support the timely supply and delivery of parts and components for their products [24].
Resilient	Strategic stock	It is used as buffers between demand fluctuating and/or product variety and smooth production output [25]. It allows to overcome material and capacity shortages provoked by unexpected events in SC, reducing the stock-out ratio and improving service level [25].
	Flexible transportation	It comprises the rapid change of transport mode, multimodal transportation or use multiple routes. It ensures a continuous flow of materials and sustains SC performance in case of disruptions [26], [27].
Green	ISO 14001 certification	It is used as a systematic approach to reduce companies' environmental impacts. It can act indirectly to influence all partners to adopt more environmentally friendly practices [28]. It promotes the reduction of resource usage and waste, and contributes to quality improvement [29].
	Environmentally friendly packaging	The term is used in the broader sense to include reusable, returnable, degradable or easy to recycle packing materials (boxes, bags, pallets, racks, containers, among others). It is expected to reduce environmental costs and business waste [30] while improving customer satisfaction [31].

However also trade-offs appear when some of the LARG paradigms are deployed simultaneously in the SC context. For instance Lean strategies that employ just-in-time (JIT) delivery of small lot sizes can require increased transportation, packaging, and handling which can contradict a Green approach. By recognizing this conflict, companies may be able to identify trade-offs or develop solutions that mitigate undesirable consequences. For example, companies may consider reusable packaging and containers or adapt the lot-size to optimize cube utilization during transportation as a means to achieve both Lean and Green objectives [32]. With the rapid increase of long-distance trade, SCs are increasingly covering larger distances, consuming significantly more fossil-fuel energy for transportation and emitting much more CO_2 than a few decades ago [33]. Lean SCs typically have lower emissions due to reduced inventory being held internally for each company, but the frequent replenishment generally tends to increase emissions. As distances increase, it is quite possible for Lean and Green to be in conflict, which may require additional modifications to the SC (perhaps moving it away from the ideal Lean configuration) if emissions are to be minimized [33].

Other apparent divergence appears when the Resilience paradigm is considered simultaneously with Lean and Green paradigms. The presence of inventory may hide the causes of a bad SC performance and generate material obsolescence; for that reason, the Lean and Green paradigms prescribe the minimization of inventory levels. Even so, if the inventory of critical materials is maintained at low levels, the SC will be more vulnerable to unexpected events. The utilization of flexible transportation enables SCs to be more responsive to disruptions overcoming by this way the interruptions in material flows and speeding up the delivery of materials in the network [27]. However, the utilization of alternative or urgent transportations in some circumstances can lead to an increase in CO_2 emissions and to higher transportation costs.

81.2.2 LARG Supply Chain Cumulative Capabilities

SCM practices are enablers to achieve SC capabilities or core competences. Winter [34] defines capabilities as learned routines that companies use to convert inputs to outputs, typically combining both tangible and intangible resources. Morash et al [35] define SC capabilities or distinctive competencies as those attributes, abilities, organizational processes, knowledge, and skills that allow a company to achieve superior performance and sustained competitive advantage over competitors. SC capabilities are the building blocks for SC strategy and a source of competitive advantage for company success. The SC management practices, through the constitution of capabilities, have a direct effect on SC performance; this is the “bottom line” for strategies and their enabling capabilities; supply capabilities eventually evolve into supply performance [35].

Flynn and Flynn [36] observed that the capability concept is described by authors using different terminology and analysis level. In what is concerned with the LARG paradigms authors propose different attributes, characteristics or capabilities for each individual paradigm. Vitasek et al [37] identified six Lean SC capabilities: i) demand management capability - the product should be ‘pulled’ by actual customer demand and not ‘pushed’ into the market; ii) waste and cost reduction -waste can be time, inventory, process redundancy, or even digital waste; iii) process and product standardization -standardization across both processes and products; iv) industry standards adoption - standardization also needs to extend beyond a company's particular SC to the industry overall; v) cultural change competency - the resistance from the people who will be asked to embrace and implement the change; vi) cross-enterprise collaboration - through collaborative practices and processes, SC partners must work to maximize the value stream to the customer.

Hoek et al [38] propose four SC Agile capabilities: i) customer sensitivity - emphasize customers and markets; ii) virtual integration - instantaneous demand capture, interpretation and response; iii) process integration - focus on operator self - management to maximize autonomy and immediate response; iv) network integration - emphasize fluid clusters of network associates, while Lean policies focus on a more fixed set of long-term stable partnerships.

Carvalho et al [10] propose the following SC Resilience capabilities: i) redundancy - number of possible states a SC can take and the number of changes it is able to cope with; ii) flexibility - it ensures that changes caused by the disruption can be absorbed by the SC through effective responses; iii) visibility - prevents over-reactions, unnecessary interventions and ineffective decisions in a risk event situation; iv) responsiveness/velocity - processes' ability to be responsive to an unexpected event, i.e. to shift, stabilise and re-synchronization in a reasonable time frame; v) collaboration - it is related to the predisposition of the parties to align forces in the case of a disturbance event.

Parmigiani et al [39] consider four types of social/environmental capabilities: i) process improvement - to improve quality and better utilize materials, labour, energy, and capital (it includes pollution prevention, carbon footprint reduction and ISO 14001, safer manufacturing methods); ii) monitoring - it includes developing social and environmental metrics, auditing and tracking; iii) product improvement - designing low-impact products in a socially and ecologically conscious perspective removing hazardous materials, material substitution and designing for "cradle-to-cradle" and "servicizing"; iv) collaboration - exchange knowledge to promote flexibility and innovation, it includes forging effective partnerships, developing compliance plans and convening educational conferences.

As observed it is difficult to find out a common perspective on what is concerned with the definition of LARG SC capabilities. Moreover the definition of specific capabilities and respective operationalization is still a work to be done. Since the SC is composed by a network of companies, each one looking to improve its performance through the development of cumulative capabilities, this paper considers the perspective of the individual company. The cumulative capabilities proposed by Flynn and Flynn [36] are used to evaluate the impact of the trade-offs emerging from the LARG practices deployment at the company level. Table 81.2 provides an explanation of the LARG capabilities considered in this study. The proposed capabilities are in line with cumulative manufacturing capabilities proposed by the "sand cone" model; this is quality, delivery, cost, and flexibility. However, it was necessary to add an extra capability to assess the environment negative impact of the LARG practices on the company's performance [40]. It was added the capability related to environmental protection measured by percentage of CO_2 emissions.

Table 81.2 Companies' LARG capabilities definition

LARG capabilities	Capability measure	Indicator
Quality	Process-based quality	Percent of internal scrap and rework.
Delivery	On-time delivery	Percent of orders shipped on time.
	Fast delivery	Average lead time, from receipt of an order until it is shipped (days).
Flexibility	Product flexibility	Change in master production schedule from month to month, in aggregate.
Cost	Manufacturing cost	Manufacturing cost/sales value of production.
Environmental protection	Process-based environmental impact	Percent of CO_2 emissions.

81.2.3 The Trade-off Theory

To study the trade-offs among LARG paradigms a proper theoretical lens needs to be used. The trade-offs concept indicates that improving one aspect of the performance in one capability will imply a reduction in some other aspect. That is, a company cannot simultaneously provide the highest levels among all the competitors factors such as the product quality, the flexibility, the delivery, and also at the manufactured cost. The sand "cone model" [42] proposes that the sequence that the law of cumulative capabilities is most comfortable with is the following one: first quality, then delivery and cost, and finally flexibility improvements. This means that first companies should improve quality to enable the development of other manufacturing capabilities (e.g. flexibility). However, considering the theory of performance frontiers developed by Schmenner and Swink [43], the maximum performance that can be achieved by a company is specified and shaped by the aggregate set of policies used in choosing the plant design and in the choices management practices; this is the company's performance is stabilised by the set of management practices used to manage companies and to achieve the strategic goals.

According to the law of trade-offs, no single company can provide superior performance in all dimensions simultaneous. This law is valid if all competitors use similar technologies and are operating near the asset frontier. If all companies are far from the asset frontier, one company can simultaneously provide higher levels of product quality, flexibility, and delivery at a lower manufactured cost if, through betterment, its management approaches create an operating frontier which is superior to its competitors' [43].

Rosenzweig and Easton [44] stress that the discussion of trade-offs also should cover the companies' strategic choices and associated initiatives. They conclude that companies experience trade-offs not at the competitive dimensions of quality, delivery, flexibility and cost, but in the selection of strategic choices and respective initiatives or policies. One example that these authors provide is when a company may have a choice between implementing total preventive maintenance and organizing manufacturing into cells, since this choice could lead to improved performance among multiple dimensions.

Seuring [45] transfers the trade-offs theories from operations management to the SC context. He suggests that the performance frontier of a SC is given as the “sum” of the performance of all partners in the SC; therefore performance frontier of the SC will depend on the SC’s weakest link. In this line Rosenzweig and Easton [44] suggest that studying trade-offs in SC may require collecting data from multiple informants across the SC, essentially extending the unit of analysis of the firm-level to the dyad-chain, or even network-level.

The leagile SC [15] provides an example where Lean and Agile SCM paradigms are considered in a SC context in a cumulative perspective. The need for agility and leanness depends on the overall SC strategy; moreover a branch of the network of companies can follow a Lean paradigm and the companies subject to market variability should follow an Agile behaviour. Therefore the relationship between SC capabilities is an important element in the management of a network of companies. The focus of this paper is on those SC capabilities that are cumulative, this is, they could exist simultaneously reinforcing each others.

81.3 Case Study

The main objective of this research is to explore and understand the trade-offs among LARG management practices in a SC context. Because of restricted empirical evidence on this topic it is too early to develop testable hypotheses. Thus, this research is exploratory in nature. This research design fits well with qualitative research [46] as the researchers wanted to study in-depth trade-offs among LARG management practices. In this exploratory research, a single SC research design concerned to the Portuguese automotive SC was chosen.

In this research the level of analysis is the SC. However, to capture the variables related to the trade-offs among LARG management practices, the unit of analysis is the individual companies that belong to the same SC. Therefore we asked the focal company, the automaker, to designate a set of companies to make part of the study. The selection criteria to choose the companies for the case study were: i) relevance to understand of LARG practices: all of them are just in sequence suppliers, meaning that if a component or part is not delivered on time the automaker’s production line stops; ii) the companies should belong to large corporate groups and supply different plants in diverse countries; iii) willingness to take part in the study; and iv) geographical proximity to ensure the right conditions for the research team.

The case study is related to the automotive SC and it comprises two SC echelons: one automaker and three first-tier suppliers. Table 81.3 summarises the companies’ profiles according to the product lines, position in the SC and the company size.

Company A is a leading automaker responsible for the production of four different customized vehicle models. Their operations are managed according to a Lean paradigm, in a virtually zero-stock environment, producing the customized vehi-

Table 81.3 Company profile

Company label (j)	Product lines	Position in the supply chain	Company size (employees)
A	Vehicles	Automaker	More than 1000
X	Plastic parts	First-tier supplier	200-500
Y	Front rear	First-tier supplier	50-100
Z	Exhaust systems	First-tier supplier	50-100

cles in response to customer orders. In addition the assembly line was designed to support a high product mix, and the four models can be assembled in the same line.

The automaker developed long term relationships with about more than 600 suppliers to assure high reliability of components and parts deliveries. The automaker is located in an industrial park and it rents space for first-tier suppliers that supply materials and components in a just-in-sequence policy directly to the automaker's assembly line. The studied companies using a JIT production philosophy, produce components according to the automaker's daily requirements, although some subassemblies are produced in batches following a make-to-order policy. The transport of final products to the automaker is performed using specific reusable containers or racks adapted to each product type. These reusable containers or racks will directly supply the assembly line and act as a Kanban; that is, they return to the suppliers will act as a signal that more components are needed.

The data collection was carried out through semi-structured interviews. Using the literature review about LARG management practices (Table 81.1) and SC capabilities (Table 81.2) a set of semi-structured interview questions were developed. Table 81.4 provides the implementation level of the practices in each company under study.

From Table 81.4 is possible to observe that the Agile and Green practices have similar implementation levels along the different SC echelons. However there are some divergence in the LARG practice implementations along the two SC echelons (Fig. 81.1): i) the manufacturer implements the practice "strategic stock" with a moderate level because it relies on his supplier's strategic stock. This is, the manufacturer achieves its resilience by using his first-tier suppliers like "buffers"; ii) the manufacturer presents a higher level of Lean practices implementation, since in addition to deploy the practice "just-in-time production" it is located near to their just in sequence suppliers (practice "geographic concentration with suppliers"). However, to enable this geographic proximity with the manufacturer, the first-tiers suppliers are located far-away from their suppliers located in distant locations like Asia or México.

In addition to the implementation level of each practice, the perception concerning the influence of each practice LARG on the company capabilities was collected. The managers were asked to give a perception about the influence of each practice on the indicators present in Table 81.2. Different perceptions were reported with respect to each relationship between the implementation of a practice and the indi-

Table 81.4 LARG practices implementation level in the studied companies

Paradigm	LARG practice	Practices implementation level				
			Upstream level			
		Manufacturer	First-tier suppliers			
		A	X	Y	Z	Average
Lean	Just-in-time production	5	5	5	5	5
	Geographic concentration with suppliers	5	1	1	1	1
Agile	Multi-product production systems	5	4	5	4	4.33
	Synchronizing transportation with production	4	4	5	5	4.67
Resilient	Strategic stock	3	5	5	5	5
	Flexible transportation	4	4	3	5	4
Green	ISO 14001 certification	5	5	5	5	5
	Environmentally friendly packaging	5	5	5	5	5

Legend: 1- not implemented implementation; 3 - moderate level of implementation; 5 - totally implemented

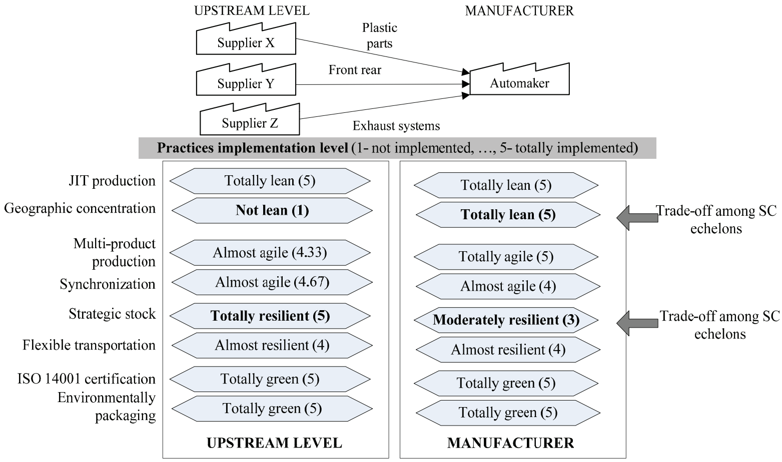

Fig. 81.1 LARG practices implementation level along the two SC echelons

cator. To find out the most significant relationships we follow the methodology proposed by Azevedo et al [14]. In a cross case analysis only the relationships pointed out simultaneously by more than 3 managers were considered as significant. Table 81.5 provides the significant relationships compilation.

According to the managers' responses the LARG capability more affected by the LARG practices is "cost". This is the capability with a high number of significant relationships: five significant relationships identified in Table 81.5. The "delivery capability" and "environmental protection" present four significant relationships with

LARG practices. The capabilities with a lower number of significant relationships are “flexibility” and “quality”.

Table 81.5 Relationships among LARG capabilities and LARG practices

LARG practices		LARG capability measures					
		Process based quality	Delivery capability		Product flexibility	Cost	Environmental protection
		A	B	C	D	E	F
Lean	I					↓	
	II			↓		↓	↓
Agile	III			↓	↑	↓	
	IV			↓		↓	↓
Resilient	V		↑			↑	
	VI		↑	↓			
Green	VII	↓					↓
	VIII	↓					↓

Legend: ↑ - increase; ↓ - decrease; A - Percent internal scrap and rework; B - Percent orders shipped on time; C - Average lead time; D - Change in master production schedule; E - Manufacturing cost/sales value; F - Percent CO_2 emissions; I - Just-in-time production; II - Geographic concentration with suppliers; III - Multi-product production systems; IV - Synchronizing transportation with production; V - Strategic stock; VI - Flexible transportation; VII - ISO 14001 certification; VIII - Environmentally friendly packaging.

One trade-off arises in the “cost” capability. The practices “just-in-time production”, “geographic concentration with suppliers”, “multi-product production systems” and “synchronizing transportation with production” contribute to reduce the “cost”. But the practice “strategic stock” contributes to increase the cost; this means that if the main competitive advantage of the companies and corresponding SC is to be a cost leader the companies should present a lower level of implementation of this practice. But as shown before there is a trade-off among SC echelons in what is concerned with the implementation level of “strategic stock” practice: the automaker present a lower level of implementation of this practice because it relies on the higher level of implementation of this practice by its suppliers.

The significant relationships between capabilities and practices in addition to the information about the practice implementation level could give an indication of how the LARG capabilities were developed in the SC. Companies implemented totally the practices “just-in-time production” with the purpose of reducing “cost”. As stated by Kannan and Tan [20] the JIT production contributes to a significant reduction in the inventory of raw materials, work in process and finished goods. Therefore, it is expected to reduce the inventory levels, quality and throughput levels. Furthermore, the companies also implemented totally the practices “ISO 14001 certification” and “environmentally friendly packaging” with the purpose of improving “quality” and “environmental protection”. The findings are in line with Nawrocka et al [29] since according to them the “ISO 14001 certification” contributes to a reduction in resource usage and waste and also to quality improvement. Moreover, it is expected that the application of environmentally friendly packaging initiatives will reduce environmental costs and business waste [30]. In addition “quality” is a key success factor in this industry [47]. The companies also have to comply with strict environmental regulations [14], therefore the “environmental protection” capability is fundamental to the reduction of CO_2 emissions.

These three capabilities, “cost”, “quality” and “environmental protection”, are the first ones to be developed in the companies belonging to the automotive SC. However the trade-offs that arise from the practices implementation levels among SC echelons indicate that companies deploy different implementation levels of the practices “geographic concentration with suppliers” and “strategic stock”, which affects the companies “delivery”, “cost” and “environmental protection” capabilities. This means that in a SC context, companies in a particular echelon could sacrifice these capabilities to beneficiate the overall SC behaviour.

The companies implemented in a large extent the practices: “multi-product production systems”, “synchronizing transportation with production” and “flexible transportation” with the purpose of increasing “delivery” and “flexibility” capabilities, in addition to “cost” and “environmental protection”. This is in line with the results of [23, 24, 26, 27].

In conclusion, all companies under study employed practices with the intention of improving “quality” and “flexibility” capabilities. The “delivery”, “cost” and “environmental protection” capabilities have been developed in different directions according to the SC echelons: the automaker intents increase these capabilities at the expenses of the first-tier suppliers behaviour. Since the automaker is located close to their first-tier suppliers his level of CO_2 emissions is reduced and his delivery capability and cost are improved. However, the automaker, develop the capability “cost” by reducing its strategic stock, and therefore reducing his capability of “delivery”. For the automaker the sequence of capabilities that arise from the case study is: first “quality” should be developed, then “flexibility”, “environmental protection” in addition to “cost” and finally “delivery”.

The first-tier suppliers also implemented practices to improve “quality” and “flexibility” capabilities, but they are located far away from their suppliers reducing the “delivery”, “cost” and “environmental protection” capabilities. Also they are required to constitute a strategic stock of materials, which increases their ability to deliver on time and also increases the cost. In the first-tier suppliers the sequence of capabilities that arise from the case study is: first “quality” should be developed, then “flexibility”, “delivery”, and finally “cost” and “environmental protection”. Fig. 81.2 provides an overview of the pattern of cumulative capabilities development in the two SC echelons.

Automaker	Quality	→	Flexibility	→	Cost and Environmental protection	→	Delivery
First-tier supplier	Quality	→	Flexibility	→	Delivery	→	Cost and Environmental protection

Fig. 81.2 Sequence of LARG capabilities development in the SC echelons

81.4 Conclusions

The main purpose of this work is to identify and provide a deeper understanding on the trade-offs that exist among Lean, Agile, Resilient and Green (LARG) SCM paradigms. A set of SCM practices associated to each paradigm was chosen as follows: i) Lean: "just-in-time production" and "geographic concentration with suppliers"; ii) Agile: "multi-product production systems" and "synchronizing transportation with production"; Resilient: "strategic stock" and "flexible transportation"; Green: "ISO 14001 certification" and "environmentally friendly packaging". As regards the SC capabilities, in this study the following ones were studied: "quality", "delivery", "flexibility", "cost", and "environmental protection". Considering the rationale behind the trade-off theory the relationships among LARG SCM practices and SC capabilities were explored considering the positive and negative impacts by the firsts over the SC capabilities.

A case study with four companies from the Portuguese automotive SC was performed. Among the studied companies the LARG practices with the highest level of implementation are: "just-in-time", "strategic stock", "ISO 14001 certification", and "environmentally friendly packaging".

The "cost" seems to be the capability more influenced by the researched LARG practices. However it is important to highlight that there is a trade-off between this capability and the Resilient practice "strategic stock". Being in mind this statement and depending on the strategy delineated by the companies this practice should have low levels of implementation if they want to be a cost leader. After exploring the levels of implementation for this practice it was observed that only the automaker company presents a moderate level of implementation contrary to the suppliers which have high levels of implementation. This reflects the higher power of the automaker which transfers the strategic stock holding cost to the suppliers. Therefore it is suggested that in the SC, not all companies need to have a higher implementation score for all LARG practices. Some companies can be more Resilient than others, and the same happens with the Lean paradigm: not all companies in SC need to be totally Lean.

Because of the differences in the LARG practices implementation level among SC echelons two separate sequences of cumulative capabilities were found: i) for the automaker: "quality", "flexibility", "environmental protection" in addition to "cost", and "delivery"; ii) for the first-tier suppliers: "quality", "flexibility", "delivery", and finally "cost" and "environmental protection".

The trade-off analysis between the LARG practices and the SC capabilities represents an important tool for supporting strategic decisions on which LARG SCM practices should be implemented in order to not influence negatively the SC capabilities. Despite the important contribution of this paper limitations of the study should be noted. Both, the researched LARG practices and SC capabilities are limited. It is necessary to conduct further research concerning the trade-off analysis among the LARG practices and the SC capabilities in a quantitative way using for example the Structural Equation Modelling (SEM).

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Part VI
Project Management

Chapter 82
Net Zero: Rational Performance Targets for High Performance Buildings

Charles J. Kibert and Ravi Srinivasan

Abstract Sustainability suggests that society should live within the limits of nature and the resources that are locally available. However, the ecological footprint of society, particularly developed countries has been enormous, necessitating the import of enormous quantities of energy, materials, and water and the export and disposal of equally enormous quantities of waste. A relatively new concept known as Net Zero, proposes that the built environment and, by extension, building users and owners, be powered and resourced from the local environment, and preferably from the building site. The most advanced of these concepts, Net Zero Energy, has resulted in actual building projects where the facility annually generates as much energy from renewable sources as it consumes. Similarly a Net Zero Water building must be designed to match water consumption with local rainfall, wastewater recycling, and water storage strategies. In the same spirit, the net zero strategy is being extended to materials, emissions, and carbon. This paper will address how this new strategy is affecting the design and construction of high-performance buildings in the US and how national and local governments have begun to incorporate net zero into building regulations. Several recent projects are discussed as case studies to illustrate the direction.

Keywords Net Zero Energy · Net Zero Water · Net Zero Materials · Net Zero Emissions Net · Zero Carbon

82.1 Introduction

Buildings consume about one-third of global energy. In the U.S., buildings consume 40 percent of primary energy, while the industrial sector consumes 32 percent

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and transportation accounts for 28 percent. According to [1], commercial and residential buildings use almost 40 percent of the primary energy and approximately 70 percent of the electricity in the United States. The power required to heat and cool buildings causes about 40 percent of greenhouse gas emissions, and if current trends continue, buildings will be the major energy consumers by 2025, using as much energy as industry and transportation combined. The challenge is to develop radically new, holistic strategies that can reverse this trend and reduce both energy and GHG emissions. One of the hopeful new strategies is the development of Net Zero Energy (nZE) buildings which, over the course of a year, produce as much energy from renewable sources as they consume, the result being buildings that are energy self-sufficient. According to [2], "the U.S. Department of Energy and the National Renewable Energy Laboratory (NREL) in a June 2006 conference paper titled Assessment of the Technical Potential for Achieving Zero-Energy Commercial Buildings, 22 percent of buildings today have the potential to be ZEBs Through advancements in technology, an estimated 64 percent of buildings could be ZEBs by 2025 [3]." This statement embodies the ideal that although Net Zero Energy building is not a brand new concept, it is still in its infancy. With the tremendous amount of money that the current U.S. administration has allocated for research and development in the building sector, the idea of net zero energy building is growing in popularity and implementation. However, setting performance targets for green buildings that are in keeping with the sustainability paradigm has been a continuing challenge for both designers and owners. Building energy targets include Net Energy, Zero Energy, nZE, and others. Net Energy is a technique for evaluation which compares the amount of energy delivered to society by a technology to the total energy required to find, extract, process, deliver, and otherwise upgrade that energy to a socially useful form [4]. Thus, Net Energy is the true value of energy to society [5]. The difficulty with Net Energy is the definition of the boundary, particularly, the non-inclusion of energy related to material formation. However, several terms have been developed to capture the essence of the larger Net Energy concept such as energy payback, energy return on investment [6], energy yield ratio, and others. The Zero Energy metric is applied to balancing the energy delivered to the grid and energy used. This balance is maintained on an annual basis and specifically includes the life cycle energy associated with delivering the building and its components in addition to building operation. This is the significant difference with the nZE metric.

Net Zero Energy (nZE) metric is applied to balancing the energy delivered to the grid and energy used. This balance is maintained on an annual basis and specifically includes the life cycle energy associated with delivering the building and its components in addition to building operation. This is the significant difference with the nZE metric. Likewise, a Net Zero Water (nZW) building must be designed to match building water consumption with local rainfall, wastewater recycling, and water storage strategies. In the same spirit, the Net Zero strategy is being extended to materials (Net Zero Materials or nZM), emissions (Net Zero Emissions or nZEm), and carbon (Net Zero Carbon or nZC).

82.2 Net Zero Energy

Net Zero Energy buildings can be identified based on boundaries determined by energy-flow and renewable supply options. While energy flow based nZE buildings definitions are determined by means of segregating the boundaries of energy consumption and generation (site or source levels), and their quantification (energy quantity measured or energy costs), the renewable supply options based nZE buildings definitions are established by way of demand-side location of site renewables. The following are several variants of the definition of nZE buildings by the National Renewable Energy Laboratory [1, 7]:

- Zero Net Annual Site Energy: This is probably the most commonly understood definition for NZE buildings and the concept is that on an annual basis, an equal amount of energy is exported from the building footprint as is imported in the form of electricity and/or natural gas. The site generated energy is normally electricity and the accounting is done at the site boundary. Energy derived from wood on-site or methane generated onsite are not included in the accounting, only energy generated within the building footprint.
- Zero Net Annual Source Energy: The total energy used off-site to generate the energy imported to the building must be matched by on-site generated energy. In the U.S. for electrical energy, each unit of energy generated requires a factor of 3 units of fuel energy. For natural gas 1.1 units of fuel energy are required to deliver each unit of natural gas energy to the building. This definition tends to favor the use of fossil fuels over electricity as an energy source.
- Zero Net Annual Energy Cost: For a zero-net-annual energy cost building, the amount of money collected by the building owner from the utility for exporting on-site generated electricity is equal to the electric and natural gas utility bills. Because natural gas is cheaper, less site generated electricity can be used to offset the same amount of natural gas energy.
- Zero Net Annual Emissions: This definition is based on offsetting the emissions of the energy source used to power the building and generally refers to greenhouse gas emissions. As a result another name for a zero-net-annual emissions building is a climate neutral building. Offsets can be created by onsite generated photovoltaic (PV) electricity, or through the purchase of, for example Renewable Energy Certificates (REC) or Green Tags that support the generation of off-site renewable energy.

Another nZE definition is the Life Cycle Zero Energy Building [8]. In addition to the operational primary energy, this definition includes the embodied energy of the building's materials. Although nZE generally applies to individual buildings, it can also be applied to groups of buildings. For example, a recently completed research report into the feasibility of using PV energy at large scale by the Florida Department of Transportation concluded that it was possible to make large turnpike plazas self-sufficient for meeting their energy needs [9].

(1) Designing for Net Zero Energy

Achieving nZE is a challenging process because it is heavily dependent on several factors, all of which must be favorably addressed for a building to achieve this level of performance:

- The building must be designed to consume the minimum energy possible.
- The occupants must be willing to conserve energy in the operation of the building (system scheduling, setpoints, maintenance, recommissioning).
- A feedback and control system designed to inform occupants and assist in reducing energy consumption must be provided.
- Adequate site and building roof area must be available for installation of a renewable energy system, most often PV system.

These factors point to some significant constraints on PV powered nZE buildings. An average PV panel may generate about 110 kWh/m^2 annually which represents the energy consumption of a highly efficient commercial office building. A NREL study which monitored six relatively efficient office or academic buildings across the U.S. concluded that a single story office building could achieve nZE buildings performance but that a two story building could not [1]. If additional area is available over parking areas or other on-site locations, then there is potential for multi-story NZE buildings. If collecting wind energy is feasible, then much larger nZE buildings building, even high-rise buildings may have potential.

Solar insolation worldwide varies from about 1000 kWh/m^2/year to a maximum of about 2500 kWh/m^2/year. For an nZE building based on PV technology, the location, energy footprint of the building, and efficiency of the PV technology limit the number of floors in the building, assuming it were to be completely solar powered (Fig. 82.1).

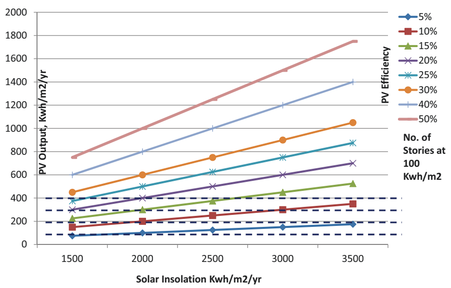

Fig. 82.1 The number of building stories feasible for a NZE building will be a function of its energy footprint, its location, and the type of technology being employed.

The U.S. has enormous potential for renewable energy for both solar and wind applications. Solar insolation ranges from about 8 kWh/m^2/day in some areas of the southwest to 6 in Hawaii to about 5.5 in Florida, 4 in the northeast, 3.5 KWh/m^2/day in portions of the Pacific Northwest, and to 3 kWh/m^2/day or less in Alaska. On the average it is in the 4 to 6 kWh/m^2/day range over most of the U.S. By some estimates, virtually all of the energy needs of the U.S. could be met by solar thermal or solar electric energy systems. At present the total grid connected solar PV is about 800 MW out of a total 1,000 GW of generating capacity in the U.S., about 0.1

percent of generating capacity. This compares to wind energy which now comprises 35,000 MW of generating capacity, a factor of more than 40 greater than solar PV.
(2) National and local government programs

Research and development of NZE commercial buildings became national policy in the U.S. by virtue of the Energy Security and Independence Act of 2007 [10] which established the Net-Zero Energy Commercial Buildings Initiative. The stated goal of this initiative is: To develop and disseminate technologies, practices, and policies for the development and establishment of nZE commercial buildings for: ① Any commercial building newly constructed in the U.S. by 2030; ② 50 percent of the commercial building stock of the U.S. by 2040; and ③ All commercial buildings in the U.S. by 2050 [11, 12]. In addition to national and state policy drivers behind the move to produce nZE commercial buildings, the launch of the Building Energy Quotient (Building EQ) program by the American Society of Heating, Refrigeration and Air-conditioning Engineers (ASHRAE) in December 2009 poses nZE buildings as the highest achievement level for commercial buildings (ASHRAE 2009). In fact, at present, there are just eight few non-residential buildings in the U.S. Zero Energy Buildings Database and most of these are relatively small buildings.

Of particular importance in reducing U.S. energy consumption are residential buildings, especially single family homes. Although most housing is comprised of the existing housing stock, an enormous number of new homes, estimated at 34 million, were forecast to be constructed between 2005 and 2030 [13]. Consequently rapidly raising the bar for new residential construction is crucial to reducing U.S. energy consumption and shifting to renewable energy resources.

Some jurisdictions are already making policy changes that would require NZEH and other buildings in the not too distant future. Every two years, the California Energy Commission (CEC) releases an Integrated Energy Policy Report in which it makes recommendations for energy policy in the state, including changes to Title 24, the energy efficiency portion of the building codes [14]. In its 2007 report, CEC recommended adjusting Title 24 to require net-zero-energy performance in residential buildings by 2020 and in commercial buildings by 2030. The CEC believes that new legislation to incorporate these goals is not needed and is already moving to put them in place. The goals set in California were inspired by the 2030 Challenge goals, in which the nonprofit organization, Architecture 2030, called for no fossil fuel use by buildings by 2030. California's goals are focused on net-zero-energy performance instead of fossil fuel use. CEC based its definition of net-zero-energy performance, and many of its recommendations, on a report by the California Public Utility Commission (CPUC), which states that a goal of "no net purchases from the electricity or gas grid" may be met with energy-efficient design and "onsite clean distributed generation."

On September 5, 2007, the City Council of Austin, Texas passed a resolution to establish the Zero Energy Capable Homes (ZECH) program which requires new single-family homes to be ZNE capable by 2015. These homes will be 65% more efficient than homes built to the Austin Energy Code in 2006, and it will be cost-effective to install renewable on-site generation and become zero energy homes. The program will be implemented in phases. The first of four planned local amendments to the International Energy Conservation Code (IECC) was approved by the City Council in October, 2007. Austin's program demonstrates that increasing energy efficiency and decreasing greenhouse gas emissions can both be cost-effective. When the increased cost of building the home is rolled into a 30-year mortgage, reduced energy costs are greater than increased mortgage payments. Historically, the main obstacle to adopting effective energy codes has been resistance from the home building industry and affordable housing advocates, due to cost concerns. Austin overcame this resistance by forming a task force that included representatives from these groups as well as industry trade associations, energy efficiency advocates, the Electric Utility Commission, Texas Gas Service, and City Staff. A positive and productive task force addressed the needs of stakeholder groups, increased buy-in from the community, enhanced participation in the program, and will help insure the long-term success of the project. These program's initial amendments increased the overall efficiency of homes by 11 percent and electric energy efficiency by 19 percent. For 2008, based on average annual construction of 6,400 new homes, this translates into an annual reduction of 9,367 metric tons of CO_2. The first amendments also reduced annual household energy consumption by 2515 kWh and 4 therms of gas. This decreases household energy costs by $227.68 per year, with an estimated payback of 5.2 years. And finally, the changes will reduce SO_2 emissions by 3.9 tons and NOx by 19.8 tons.

On July 14, 2009, General Electric (GE) unveiled plans for a "Net Zero Energy Home" (NZEH) project which combines GE's most efficient appliances and lighting, the company's new energy management systems, and GE power generating and storing technologies in new home construction [17]. When applied together, the system would enable a homeowner to achieve net zero energy costs by 2015. The Net Zero Energy Home project -and new smart grid consumer poll data from the U.S. and the U.K. - were introduced at GE's smart grid symposium at its Global Research Center in upstate New York. As part of the company's Ecomagination strategy, the GE Net Zero Energy Home offerings will be comprised of three major groups within the product portfolio: energy efficient products including appliance and lighting products that will reduce energy consumption in the home; energy management products that will enable consumers to manage their costs and energy consumption; and energy generation/storage products like solar PV, advanced energy storage and next generation thin film solar that will play an integral part in the net zero energy home. In 2010, GE will introduce the Home Energy Manager, their version of a central nervous system for the NZEH that will work in conjunction with all the other enabling technologies in the home to help homeowners optimize how they consume energy. GE will also introduce a line of smart thermostats in 2010 that, together with the Home Energy Manager, will inform consumers on their energy use and empower them to make smarter decisions on their energy.

Key to the NZEH strategy are radical improvements in the energy performance of homes, with reductions in typical home energy consumption on the order of 60 to 70 percent needed to bring NZEH to reality. This improvement in performance, coupled with advanced control technology and an optimized feedback system, and on-site generation of electricity from solar photovoltaic systems, provides a realistic and achievable pathway to NZEH's. Although NZEH's are rapidly becoming a reality, there are several gaps in technology that make the transition difficult. The advent of the smart grid will help close some of the key gaps needed to make the overall building stock shift to a NZE status. A smart grid uses digital technology to improve reliability, security, and efficiency (both economic and energy) of the electric system from large generation, through the delivery systems to electricity consumers and a growing number of distributed-generation and storage resources [18]. The information networks that are transforming our economy in other areas are also being applied to applications for dynamic optimization of electric system operations, maintenance, and planning. Resources and services that were separately managed are now being integrated and rebundled as society addresses traditional problems in new ways, adapts the system to tackle new challenges, and discovers new benefits that have transformational potential.

Although the smart grid provides some level of data that a homeowner can access to understand and respond to reduce their energy consumption, it does not provide adequate feedback for a NZEH owner to be immediately aware of the home's energy consumption profile and patterns. Additionally the owner must log into a utility website to view data that is not real time and not adequately fine-grained for response. Ultimately the control of a NZEH and the integration of feedback loops will be key to the successful implementation of this concept. An Advanced Controls System for Net Zero Energy Homes (AFCS-NZEH) will have two major components: i) an automatic control system that minimizes energy consumption based on inputs by the owner to the controller, and ii) a real-time feedback system that provides the homeowner with information on energy generation, consumption, and costs, and allows the NZEH owner to change strategies based on their response to the feedback.

The Living Building Challenge aggressive approach to building energy forces the building to rely only on current solar income. The entire energy needs of the project must be supplied by onsite renewable energy systems on a net annual basis, i.e., nZE, at a minimum.

82.3 Net Zero Water

Buildings account for about 12 percent of freshwater withdrawals. Among others, one of the critical components of a building is its hydrologic cycle. It is the flow and storage of all types of water on sites altered from their natural state for the purposes of building and infrastructure. They include potable water, rainwater, stormwater, graywater, blackwater, and reclaimed water that are used, processed, stored, and moved by employing a variety of technologies that may be coupled with natural systems [19]. It is also extended to the water used for irrigation. The built environment hydrologic cycle involves the handling and use of water both internal and external to buildings. Net Zero Water building balances its hydrologic cycle through optimal design of water, wastewater, and stormwater systems. In other words, an nZW strategy is based on one of the core ideas of sustainability; that is, resource use should be constrained to what nature provides. nZW follows a three-fold approach:

- Minimize the consumption of potable or drinking quality water from wells or the municipal wastewater system
- Minimize wastewater generation
- Maximize rainwater infiltration into the ground

82.3.1 Designing for Net Zero Water

Net Zero Water strategy for high-performance built environment hydrologic cycle comprises a series of logical steps [19]. These steps are targeted to minimize consumption of potable water and wastewater generation (steps 1 to 6), and maximize rainwater infiltration into the ground (steps 7 and 8):
Step 1. Select the appropriate water sources for each consumption purpose.
Step 2. For each purpose, employ the technologies that minimize water consumption.
Step 3. Evaluate the potential for a dual wastewater system.
Step 4. Analyze the potential for innovative wastewater treatment strategies.
Step 5. Apply life-cycle costing.
Step 6. Design landscaping to use minimal water for its maintenance and upkeep.
Step 7. Design parking, paving, roads, and landscaping to maximize the infiltration of stormwater.
Step 8. Incorporate green roofs.

To best evaluate water use, water use calculators may be used. These calculators compare projected water use with baseline models that incorporate EPAct 1992 data. These calculators use a three-step process to determine water savings potential: (1) estimation of daily potable water use - this involves occupant type (full-time equivalent, visitor, male/female), fixture type, and water use data; (2) number of workdays; and (3) EPAct 1992 data. An estimated water quantity for a conventional water system can then be used to estimate the quantity of wastewater quantity for the building.

Water (and wastewater) budget rules of thumb [19] include: for the low-flow fixture strategy, high-efficiency fixtures are aggressively used, and the results is about a 50 percent, or Factor 2, reduction in potable water consumption compared to code requirements. For a combination of low-flow fixtures and alternative water strategies, an 80 percent reduction in potable water consumption was achieved. Consequently, it is possible to develop water reduction strategies that are in excess of Factor 4 for an aggressive strategy that includes alternative water sources and low-flow fixtures and at least Factor 2 for a less aggressive strategy that uses a simple low-flow fixture strategy.

Similarly, constructed wetlands may be used to treat wastewater onsite. A well-known, proprietary approach is the Living Machine. These natural ecosystem setups can generate fuel, grow food, restore degraded environments, and even heat and cool buildings. For landscaping, the best known strategy is xeriscaping or the use of drought-tolerant native and adapted species of plants and turfgrass.

82.3.2 National and Local Government Programs

As discussed in Sustainable Construction: Green Building Design and Delivery [19], the U.S. Energy Policy Act of 1992 [20] is a landmark pieces of legislation concerning potable water consumption. EPAct 1992 requires all plumbing fixtures used in the U.S. to meet ambitious targets for reducing water consumption; as a result, building codes now mandate these dramatically lower levels of water consumption. Additional requirements for water efficiency for pre-rinse spray valves in commercial kitchens were set by the Energy Policy Act of 2005 [21].

Other regulations and programs include:

- WaterSense: In 2006, a voluntary labelling program emerged that certified fixtures that utilize 20 percent less water that requirement of EPAct 1992. The label is awarded based on third-party certification that the fixture meets EPA requirements.
- California: In 2007, California passed stringent requirements for toilets and urinals; from 1.6 gpf (gallons per flush) to 1.28 gpf for toilets; 1.0 gpf to 0.5 gpf.
- New York: In New York City, a widespread toilet replacement program for apartment buildings reduced and average 29 percent reduction in total water use for the buildings. In all, over 1.3 million toilets were replaced saving over 60 to 80 million gallons a day of freshwater.
- California, Florida, Arizona, Nevada, and Texas: In states that have chronic water problems such as listed above, there are programs to provide reclaimed water to the building's location. The water has been treated for non-potable purposes such as landscaping; golf course maintenance or agricultural irrigation; decorative features such as fountains; cooling tower makeup; boiler feed; once-through cooling; concreted mixing; snowmaking; and fire main water.

The Living Building Challenge calls for nZW that has to be met in order to gain the certification. If not all, some of the imperatives of this certification program are very demanding. The Water Petal comprises of two imperatives namely, 05 - Net Zero Water and 06 - Ecological Water Flow. The nZW mandates for 100 percent of the project's water needs that must be supplied by captured precipitation or other natural closed loop water systems that account for downstream ecosystem impacts, or by recycling used project water. Additionally, water use be appropriately purified without the use of chemicals. For the imperative 6 - Ecological Water Flow, that requires that 100 percent of stormwater and building water discharge be managed onsite to meet the project's internal water demands or released onto adjacent sites for management through acceptable time-scale surface flow, groundwater recharge, agricultural use, or adjacent building reuse.

82.4 Net Zero Materials

Net Zero Materials should close material loops using five cardinal rules [19]: (1) Buildings must be deconstructable, (2) Products must be disassemblable, (3) Materials must be recyclable, (4) Products/materials must be harmless in production and in use, (5) Materials dissipated from recycling must be harmless. The cardinal rules state that the complete dismantling of the building and all of its components is required so that materials input at the time of the building's construction can be recovered and returned to productive use at the end of the building's useful life. These rules also establish the ideal conditions for materials and products used in buildings. While rules 1 and 2 focus on whole-building and systems integration (for instance, the design of structural system for disassembly), rule 3 focuses on the recyclability of the product or materials used in the building. Rules 4 and 5 are significant owing to materials' impact on the environment.

Assessing the environmental impacts and material resource consumption associated with various approaches to the built environment is currently achieved using Life Cycle Assessments (LCA). LCA emerged as a defining concept during the last two decades, largely due to the increasing awareness of environmental issues associated with the manufacturing sector, along with the waste generated by manufacturing processes. LCA was formalized by the International Standards Organization (ISO) to examine industrial systems' performance, from the point of extraction of raw materials, through the manufacturing process and finally to the product disposal. According to the ISO14040, which refers to principals and framework for environmental management, LCA considers the entire life cycle of a product, in terms of energy and materials used in order to manufacture such product, as well as the end of life of that given product [22]. Many studies have demonstrated the usefulness of LCA in improving the manufacturing process, or in the assessment of environmental impacts for manufacturing processes [23–25]. The boundaries associated with the traditional LCA start from energy associated with the extraction of raw material, expand to the manufacturing end point of a product, and continue up until end of life of the product [26]. Other researchers have taken a more holistic approach by going beyond initial embodied energy of building materials, and including a more detailed accounting of energy expenditure and environmental impacts throughout the life cycle of the building. Such inclusions are energy used in construction of the building, as well as energy used in the operation of the building [27, 28].

Although great efforts have been made to quantify energy expenditures as well as environmental impacts within the built environment, few studies show the complete holistic LCA approach (manufacturing of building material through demolition of building) that quantifies energy use throughout the life of the building, along with the building's associated environmental impacts. One such study was conducted by Scheuer et al [29], where the authors determined the energy and mass needed for a 7300 m^2 six story building with a life span of 75 years. The study also measured environmental impacts caused by the production of primary energy used through the life cycle of the building (petroleum, coal, natural gas, and nuclear energy), and their contribution to global warming, ozone depletion, acidification and nitrification of soils and water, and solid waste generation. Ramesh et al [30] demonstrated, through a compilation of studies, that the most energy used throughout the life cycle of a typical building is through its operation. Nevertheless, there are several challenges in LCA of a building. One of the major challenges is consistency in the choice of system boundaries.

Designing for Net Zero Materials

Process-based and Economy Input-Output (EIO) are two major approaches to LCA. Detailed tracking of each of the diverse materials used in the manufacturing process is essential for process-based LCA approach. This is a cumbersome process that may lead to high cost, time, and issues related to data confidentiality and verifiability. A top-down approach such as EIO-LCA uses the whole economy as the boundary of analysis. Yet, there are several drawbacks associated with EIO-LCA such as (1) it uses aggregate data, and aggregate industry sectors may not provide information on the particular processes used in the manufacturing of the product under investigation; (2) the data for the 1997 Input-Output benchmark model is based on the 1997 US economy, thus adding uncertainty to results from different years, although correction coefficients exist to minimize industry data variation; and (3) data used in the EIO model is incomplete, with inherent uncertainties, thus underestimating results such as environmental impacts [31]. Henrickson et al [32] provides a detailed comparison of EIO-LCA with process-based models.

There are three readily available LCA tools (see below), all of which can be applied to North American projects:

- Athena EcoCalculator uses defined building assesmblies (structural systems such as columns, beams, floors, etc.) to estimate embodied fossil energy use and impacts.
- Athena Impact Estimator provides a cradle-to-grave life cycle inventory profile for a whole building.
- BIRDS is an extension to the Building for Environmental and Economic Sustainability (BEES).

All of the three LCA tools are process-based LCA tools. Other process-based LCA tools include SimaPro that utilizes EcoInvent database. On the other hand, a top-down approach such as EIO-LCA uses the whole economy as the boundary of analysis [33]. Although robust and easy-to-use, EIO-LCA approach uses aggregate data and may not be subjective to a particular process in the manufacturing of the product under investigation. Hendrickson et al [32] provides detail comparison of EIO-LCA with process-based models. It is to be noted that LCA has limitations in that it does not adequately address closed-loop materials cycle.

Another approach to maximize material reuse is crucial for replacement of virgin building materials is discussed in Srinivasan et al [34]. In this approach, emergy (spelled with an “m”) calculation is conducted to balance reuse materials to attain maximum Renewable Emergy Potential. National and Local Government Programs.

The emergence of Environmental Product Declarations (EPD) and Environmental Building Declarations (EBD) to determine environmental efficacy of materials and products used in construction is the first step toward nZM. While EPD can be used to compare products used for the same purpose (e.g., steel versus concrete structural systems), EBD can be used for whole-building declarations to allow trade-offs between systems with an end goal of minimizing total impact (e.g., impacts of triple-glazing to the effects of reducing system sizing). The EPD presents quantified environmental data for products and systems based on information from an LCA that was conducted using a standard approach as defined by ISO. An EPD based on the output of an LCA, and its format is governed by ISO 14025, Environmental Labels and Declarations-Type III Environmental Declarations - Principles and Procedures. Basically, an EPD is a statement of product ingredients and environmental impacts that occur during the life cycle of a product (similar to a nutrition label of food product). Two other applicable standards in relation to EPD in the U.S. include the ASTM WK23356 - New Specification for Product Category Rules for Building Products and Systems, and US Part 260 Guidelines for Use of Environmental Market Claims.

Managed by U.S. Environmental Protection Agency and the U.S. Department of Energy, ENERGY STAR is a popular program that labels products based on their manufacture and operative energy data. The Deutsche Gesellschaft fur Nachhaltiges Bauen (DGNB) is a German certification program requires whole-building impact assessment as part of the scoring system for the certification.

The Living Building Challenge has stringent measures for materials, particularly with the "red list" (a list of chemicals that should stay from building materials) and embodied carbon footprint. Primarily, the project should account for all the construction-related embodied carbon. Currently, simple LCA tools are used for this calculation and offset, potentially using RECs.

82.5 Net Zero Emissions

Among others, one of the critical issues is the environmental emissions such as carbon dioxide (CO_2), Sulfur Dioxide (SO_2), Volatile Organic Compounds (VOC), particulate matter (PM10), carbon monoxide (CO), and nitrous oxides (NO_x) emitted to the atmosphere. These are harmful to human health and biodiversity. nZEm is not the same as Zero Net Annual Emissions where the later refers to the offsetting the emissions (carbon-dio-oxide equivalent or CO2E) of the energy source used to power the building. Traditionally, building life cycle starts from the energy associated with the extraction of raw material, and expands through the manufacturing of the product, and continues up until the end of the product's life. Other researchers have taken a more holistic approach by going beyond the initial embodied energy of building materials and including a more detailed accounting of energy expenditure and environmental impacts throughout the life cycle of the building. Typically, a building's entire life cycle includes four phases and it is imperative that all environmental emissions related to all these four phases are taken into consideration:

- Material resource: This phase denotes all the energy used in the extraction, manufacture, and transportation of the material. Additionally, all the energy used up to produce the mineral ore can be estimated using emergy concepts.
- Material placement: This includes the energy used to construct the building.
- Operations and maintenance: Energy used in the operation of the building including its maintenance. Energy used in the replacement of building components are also included in this phase.
- Decommissioning: This phase comprises of recycling/reuse, deconstruction, demolition, and landfill, and includes all energy used in transportation, etc.

Net Zero Emissions strategy calls for significant reduction in environmental emissions through conscious decision-making during the entire life cyle of a building.

82.5.1 Designing for Net Zero Emissions

Several tools exist to determine emissions related to building construction, i.e., EIO-LCA, Athena, etc. In addition to typical emissions evaluation, some tools aid in determining human toxicity as well. Recently, the Rinker Hall building at the University of Florida campus was assessed for embodied energy and emissions [35]. Rinker Hall is home to the University of Florida's School of Building Construction. This 4,394 m^2 three-story building has a footprint of about 1,622 m^2 and consists primarily of classrooms, construction and teaching laboratories on the first two floors, and offices on the third floor. The building was designed to maximize natural light by using skylights and louvers. It has lighting controls in the form of motion sensors to increase energy efficiency. Furthermore, water use is reduced by the use of low-flow plumbing fixtures, waterless urinals, and a rainwater harvesting system. Rinker Hall's building materials consist of reused bricks from demolition, recycled cellulose insulation material, local and regional assembly of parts, certified wood, and renewable flooring material. Cooling and heating for the building is supplied by chilled water and steam, from a centralized plant.

To give an example, the transportation energy was calculated in detail. In order to calculate the energy use and related emissions due to the transportation materials from the manufacturing site to the construction site, the monetary cost of diesel fuel was estimated based on material quantities used, truck capacity and type, and distance traveled from the manufacturing to the construction site. The distances from manufacturer to the building site for most of the structural components and facades, as well as some interior components were obtained from the Leadership in Energy and Environmental Design (LEED) report. Transportation energy used in construction and construction waste disposal was also estimated based on local recycling and landfill facilities, as well as material quantities designated for reuse, recycling or the landfill. Traveled distances for electrical, plumbing, and mechanical equipment were not available; therefore, they were not included in the calculations.

82.6 Net Zero Carbon

Net Zero Carbon is the rebalance of carbon emissions into the atmosphere by greatly reducing the carbon associated with building construction and operation and with the distribution of buildings in communities. The latter point addresses the problem of how buildings and their location drive energy consumption and carbon emissions and transportation systems. The carbon emissions related to built environment has four major components:

- The output of carbon due to building operation (operation energy).
- The carbon invested in the materials and products of construction (embodied energy).
- The carbon emissions from transportation energy.
- The output of carbon associated with processing and moving water, wastewater, and stormwater.

Reducing atmospheric carbon will require a concerted effort on the part of all stakeholders to the built environment to shift building design onto a course that focuses on long-term strategies to rebalance carbon. Doubling the lifetime of a building from 50 to 100 years in effect cuts the embodied carbon emissions into half. Good planning with a long time horizon will ensure that frequent redesign of urban areas that requires removal of large numbers of buildings is unnecessary. Although many technical fixes have been proposed to reduce and absorb carbon in the atmosphere, thus far, no technical fix has been proven to work at large-scale to remove the enormous quantities of carbon that would be required to stabilize the atmosphere [19].

82.6.1 Designing for Net Zero Carbon

Several strategies may be employed to reduce the built environmental carbon emissions [19]:

- Dramatically reducing energy consumption;
- Shifting to renewable energy sources;
- Emphasizing compact forms of development;
- Shifting to mass transportation;
- Designing buildings for durability and adaptability;
- Restoring natural systems;
- Designing low-energy building environment hydrologic systems;
- Designing buildings for deconstruction and material reuse;
- Selecting materials for their recycling properties.

Additionally, tools and strategies discussed for any of the above Net Zero techniques would be effective in reducing carbon emissions in order to rebalance.

82.7 Conclusions

The built environment is a major consumer of resources, both in its construction and operation. Buildings consume about one-third of global energy, and the built environment continues to grow as population, affluence, and urbanization increase. This paper addressed how net zero strategy is affecting the design and construction of high-performance buildings in the US and how national and local governments have begun to incorporate net zero into building regulations. Five components of net zero concept namely, nZE (energy), nZW (water), nZM (materials), nZEm (emissions), and nZC (carbon). Strategies and technologies to create Net Zero buildings is a response to rapidly rising energy prices, overdependence on foreign energy sources, and the imperative to take action regarding climate change. In all of these components, one of the major take home messages is that built environment (and the society) should live within the limits of nature and within the resources that are available. Several recent projects were provided as case studies to illustrate the direction.

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Chapter 83
A Framework to Explore Energy Saving Measures During Construction Phase

Abdol R. Chini and Sandeep Shrivastava

Abstract There has been a significant increase in interest and research in energy efficient buildings in recent years. In the construction phase of a building's life cycle, contractors provide resources and select the means and methods of construction. To make the construction phase less energy intensive, the contractor has to purchase the required resources from the jobsite proximity and select less energy-intensive resources to minimize the energy consumption. Sometimes, it might not be possible to analyze and practice energy-saving measures for the whole project due to time and budget constraints. Therefore, it would be helpful for a contractor to focus on the most energy-consuming activities and deploy energy-efficient procurement to reduce energy consumption of a particular project. This requires a tool to estimate energy required for procurement and installation of the building elements and to identify the most energy-intensive activities. This research focuses on developing a spreadsheet-based tool to estimate energy consumption during construction of a project. The proposed framework uses the project's bill of quantity, data related to materials transportation, and energy data for the required resources to estimate the probable energy consumption during construction. A case study was performed to demonstrate the application of the tool

Keywords Energy efficiency · Energy information system · Embodied energy · Materials transportation

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83.1 Introduction

Building construction projects impose loads on the environment in various forms, namely depletion of resources and contamination of air, soil, and water. These loads are generated while various demands, such as materials and energy are met to construct the building. The construction industry uses more materials by weight than any other industry in the United States [1]. Moreover, the environmental impacts of building construction, partly caused by large consumption of energy, are imposed during the whole life cycle of a building [2, 3]. Energy consumed during the life cycle of a building may be divided into operational energy, embodied energy, and decommissioning energy [4–6]. Operational energy is required for heating, cooling, ventilation, lighting, equipment and appliances. Embodied energy is non-renewable energy required to initially produce a building and maintain it during its useful life. It includes energy used to acquire, process, manufacture the building materials, including any transportation related to these activities (indirect energy); energy used to transport building products to the site and construct the building (direct energy); and energy consumed to maintain, repair, restore, refurbish or replace materials, components or systems during the life of the building (recurring energy). Embodied energy is measured as a quantity of non-renewable energy per unit of building material, component or system. The embodied energy makes about 15-20% of the total energy consumption during building life cycle. However, the share of the embodied energy will become more significant when buildings become more energy efficient, as shown in Fig. 83.1 [5, 7].

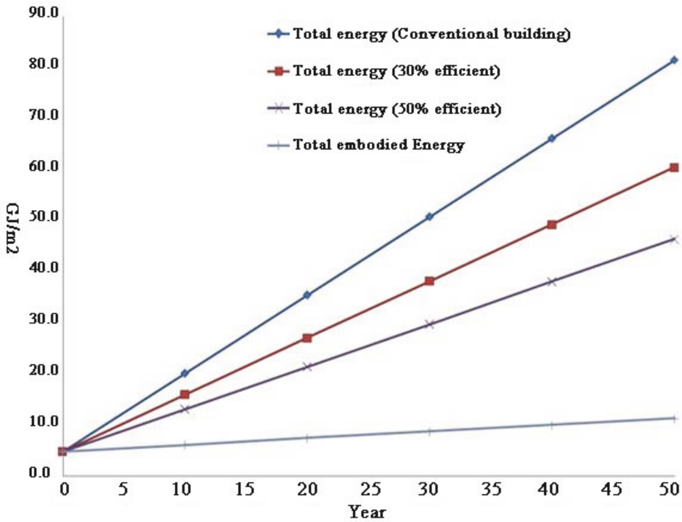

Fig. 83.1 Energy use in buildings - the changing relationship between embodied and operational energy

Among various phases of embodied energy, energy consumption during construction phase is less explored [8]. In the construction phase, contractors provide resources and select the means and methods of construction. To make the construction phase less energy intensive, the contractor has to purchase the required resources from the jobsite proximity and select less energy-intensive resources. This is possible if the contractor has access to an energy-profile of the project to identify which material procurement and/or installation consumes maximum energy. The contractor may then seek less energy -intensive alternatives that are available. This research focuses on developing a spreadsheet tool to estimate energy consumption during construction activities of a project.

83.2 Energy Estimation Tool

The construction phase of a building life cycle involves numerous activities such as construction of temporary structures, transportation and installation of building materials and components, site work, etc. These activities consume energy and affect the environment. When a construction project is started, the general contractor prepares a detailed estimate for the required materials, labor, and equipment. A bill of quantities (BOQ) that includes a list of materials as well as tasks required for the execution of the project is prepared. The framework for the proposed tool uses a project's bill of quantity and energy data related to transportation and assembly of building components to estimate energy consumption during construction. Resources required (materials, equipment, labor, etc.); their transportation modes, and their distances from the project site are assigned to each project activity (Fig. 83.2).

Fig. 83.2 Energy consuming tasks within jurisdiction of a contractor

For example, an estimation of the amount of energy consumed in transporting a material depends on the mode of transportation, energy consumption to transport one kg of material to one km distance, quantity of material required to finish the activity, and the distance of material manufacturing unit to the project site. In a construction process, an activity might include different materials transported from different distances using different transporting modes. The total sum of these energy requirements will be the energy required to transport the materials for that activity. The system calculates total energy required and arranges the activities of BOQ in a descending order to identify energy-intensive activities.

At the end of the estimation process, a report containing information about energy consumption of each activity and high energy-demanding activities is generated. This report can be utilized by the contractor to consider alternative solutions for energy-intensive resources and procurements for the project (Fig. 83.3).

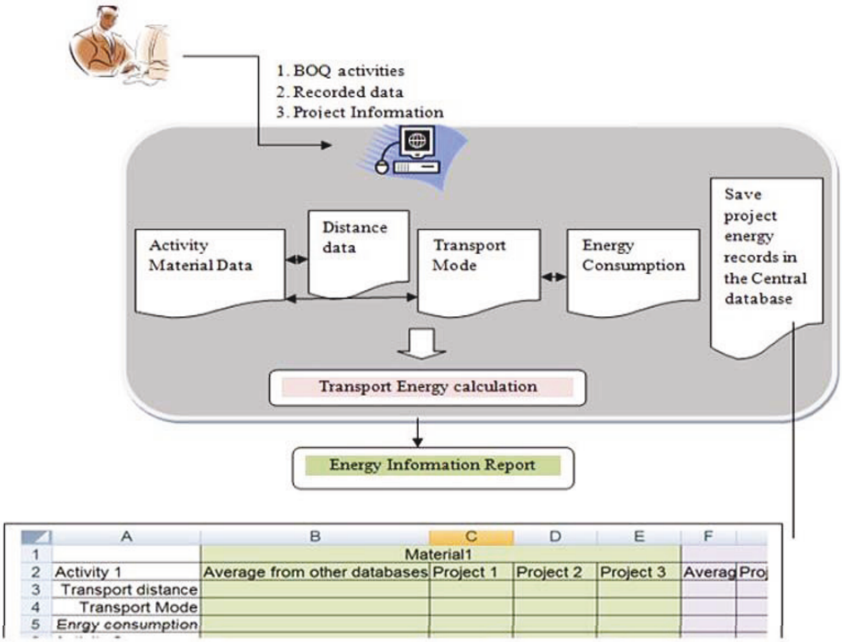

Fig. 83.3 The framework to estimate and record energy for material transportation

Many researchers have mentioned the lack of project-related energy and environment data to accurately assess energy consumption and environmental impacts [8, 9]. Currently, most of the work at this phase is performed by researchers using LCA application packages, which might use data on a national average. These data might be effective in getting an overall picture of the energy consumption, but may be less meaningful if a contractor wants to improve the supply chain at local level and for a specific project. In order to do so, the contractor needs a system that can estimate and record the relevant data to improve energy estimation for future projects.

The suggested framework can be extended to record the related data by adding one more sheet that saves energy data for construction activities of various projects. Fig. 83.3 shows the framework with a snippet of spreadsheet to record energy data.

The framework can be used to estimate energy consumption using reliable and local data for any activity. If such data is not available, national average data collected from various databases and available literature can be used. Once the required data is recorded for a few projects, energy consumption for a similar project could be estimated based on the recorded data.

83.3 Energy Information System Framework

An Energy Information System (EIS) framework was developed to assist contractors in estimating the energy demands of a project before it begins, and to record data to update the framework's databases.

The proposed framework utilizes the building project's Bill of Quantities (BOQ) sheet to estimate energy consumption during the construction. Project data needed are the building type, size, and duration of the project. In addition, the management set-up data, such as information about trailers, service vehicles, generators, and security lights are needed.

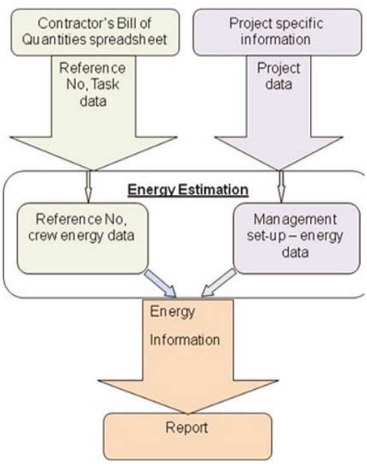

Fig. 83.4 Energy information system — internal divisions

Before a building construction project begins, the contractor or construction manager prepares a detailed estimate for materials, labor, and equipment required to finish the project. Almost all construction companies prepare a BOQ in a more or less similar format. Each row in a BOQ sheet contains a reference number (Construction Specification Institute master format number), task description, quantity, unit, cost per unit, and total cost of the task.

Fig. 83.4 shows the internal divisions of the framework. The framework is divided into two parts. One part handles data related to the building's dimensions and management set-up, and the other part handles the building's BOQ. The required energy for the management set-up and BOQ are estimated separately. The final report provides information about both of these estimates and the total energy consumption.

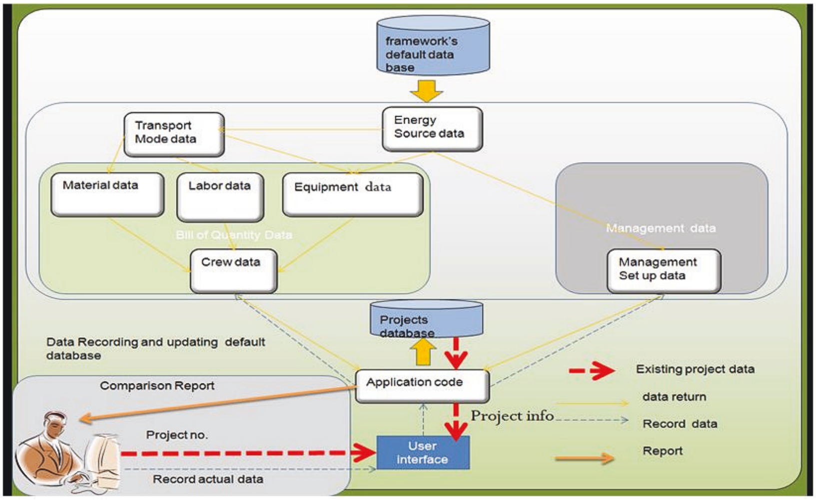

Fig. 83.5 Energy information system framework - estimation process

Fig. 83.5 shows a detailed diagram of the EIS framework used to estimate a project's energy consumption. The figure illustrates the relationships between various databases, and the processes that the framework follows to estimate energy consumption. The framework contains four main components:

- **User interface.** The user interface interacts with the user and asks for input to run the energy estimation process. The user provides a unique project number, project information, building information, management set-up data and the BOQ sheet. This information is saved into a project database against the unique project number.
- **Application code.** The application code interacts with the framework's internal databases. It takes information from the user and sends queries to the databases for data required to run the estimation process. The code makes a series of calculations and saves the results in the project's database against the project number.
- **Databases.** The required databases are shown in Fig. 83.5. Initially, these databases are developed based on the available information, but they are continuously updated based on the values recorded during the actual construction process.
- **Report.** Providing the project's unique number, a user can generate a report. The report contains information about the project's energy consumption and energy

use to provide insight into the energy demand of the project. It identifies the most energy intensive activities of a project so that the contractor can target those activities for reducing energy consumption.

It is important to note that the EIS framework can also be used to record the project's energy consumption. Fig. 83.5 illustrates the relationships between various databases and the processes that the framework follows to record data during the construction process.

83.4 Case Study

A three-story building case study was performed to demonstrate the use of the EIS tool. The goals of the case study were to demonstrate the use of the tool, address the challenges one may encounter in applying the tool, and check the accuracy of the model by comparing outcomes from estimated and recorded values.

The building was a steel-framed 4,514 sq m structure, with brick, metal panel, and exterior curtain wall. Construction started in July 2010 and finished in October 2011. The facility was planned to serve as a business incubator for new companies and products with an estimated cost of $10 million.

The contractor prepared a BOQ sheet, estimated the project cost, hired specialty contractors and subcontractors, and developed a project schedule. The EIS tool was used to estimate the building's probable energy consumption during construction. In addition, on-site energy consumption data for several activities were recorded. The energy consumption based on the recorded energy data was then compared to the estimated data.

83.4.1 Scope of the Study

Scope of the study was confined to the construction of structural components and included concrete, masonry, and structural steel activities. The activities under these divisions were further limited to those that were completed for the period of the study from November 2010 to July 2011. Table 83.1 shows the detailed descriptions of the activities and their quantities. Table 83.2 shows the total costs of the activities and those that were considered within the scope.

83.4.2 Energy Consumption Data

Since it was the first run of the EIS tool, the internal databases did not have the necessary data to estimate the project's energy consumption. Thus, the data for var-

Table 83.1 Activities within the scope of the study

Reference No	Descriptions	Quantity	Unit
33053404260	Building: tie beams	53.13	cu m
33053401220	Building: tie columns	70.26	cu m
33053403250	Building: slab on deck	3,034.4	sq m
33053404200	Building: walls	9.86	cu m
33053405001	Building: 100 mm slab on grade	1,572.5	sq m
33053405010	Building: 150 mm slab on grade	82.5	sq m
33053405020	Building: 200 mm slab on grade	20.8	sq m
33053407000	Building: metal pan stair fill	114.0	sq m
33105704260	Building: walls-elevator pit	11.85	cu m
35216160250	Lightweight insulating concrete at main roof	1,918.4	sq m
40516300250	Cell fill concrete	126.76	cu m
40519260060	Rebar	10.6	MT
42113133050	Brick veneer	1,420.8	sq m
42210141150	200 mm CMU	1,808.1	sq m
42210141250	300 mm CMU	103.7	sq m
51223770800	Structural steel construction area	4,927.9	sq m
53112352950	Roof deck	1,990.3	sq m
53113503450	Floor deck	3,034.4	sq m
54213300200	Steel tube beams at facade	44.81	m
55213500020	Aluminum railings	54.56	m
55213500500	Steel railings	51.21	m
55213500940	Metal pan stairs railings steel pipe	39.62	m

Table 83.2 Cost of the activities within the scope of the study

Division	BOQ cost	Cost under the scope
Concrete	$ 635,557	$ 323,844
Masonry	$ 312,920	$ 311,306
Metal	$ 866,480	$ 787,304

ious databases were entered into the EIS tool. This data was collected through R.S. Means Construction Cost Data, equipment manuals, and available literature.

The activities within the scope of the study were also observed on-site to collect data for verification of the EIS tool, and to update the databases. The project's contractor, subcontractors, equipment providers, equipment operators, fabricators, and material suppliers were approached for data collection. If any data could not be collected through these means, online resources were used to fill in the missing data.

83.4.3 Energy Consumption Data

Table 83.3 compares the energy consumption estimated by the EIS tool with those recorded on-site. The EIS tool estimated the total energy consumption for the targeted activities as 5,366 GJ, with an energy intensity of 1.18 GJ/sq m. A major portion of the type of energy consumed was in the form of fuels, such as diesel and gasoline. Only 9% of the consumed energy was from electricity. However, the use of electric and battery-operated equipment can increase a project's electricity demand.

Table 83.3 Output of the estimated and recorded energy consumption

Descriptions	Estimated values	Recorded values
Building construction energy intensity (GJ/sq m)	1.18	1.35
Total energy consumption (GJ)	5,366.62	6,081.28
Total BOQ energy (GJ)	4,867.79	5,654.86
Total Management setup energy (GJ)	497.84	426.42
Energy due to electricity demand (%)	9.28	5.03
Energy due to other fuel demand (%)	90.72	94.97

The total recorded energy consumption was 6081 GJ with an energy intensity of 1.35 GJ/sq m. The total recorded value increased by approximately 14% in comparison to the estimated value. The reasons behind this variation are changes in material transportation distances, equipment use, labor productivity, labor transportation distances, and equipment fuel consumption. It should be noted that as a whole this variation seems moderate, but at the activity level there might be activities with high variation (Table 83.4). The range of variation will improve if more data is collected on-site and recorded into the EIS tool. This supports the need for recording on-site data to create a more realistic database. As stated earlier, this was the first run of the EIS tool, and the data for the estimation was collected from various sources and a moderate variation was expected. Now, with the use of collected data in the EIS tool, a more accurate estimation can be made for a similar project in the future.

83.4.4 Recommendations to Improve Energy Efficiency

Table 83.5 and Fig. 83.6 present a comparative summary of the energy intensive activities within the scope of this study. They indicate that brick veneer construction was the most energy intensive activity because of high energy consumption in transportation of labor and material to the project site. The structural steel activity was the most energy-intensive activity in terms of equipment operation.

The recorded energy consumption in material transportation (3309 GJ) had the largest portion (72%) of the total energy consumption (4574 GJ). The bricks rec-

Table 83.4 Comparison of estimated and recorded energy consumption by activities (in GJ)

Specification	Software estimation	Recorded value	% change
Building: walls- elevator pit	6.39	7.20	13
Building: walls	4.83	4.66	4
Building: 100 mm slab	53.66	58.62	9
Building: 150 mm slab	3.91	3.95	1
300 mm CMU	50.84	43.30	15
200 mm CMU	615.33	565.30	8
Brick veneer	1,923.19	2,374.19	23
Cell fill concrete	88.31	102.37	16
Structural steel	1,304.14	1,634.64	25
Floor deck	239.44	205.40	14
Roof deck	155.13	126.78	18

Table 83.5 Estimated and recorded energy intensive items in the BOQ

Energy consumption	Office buiding-estimated BOQ items/activities	Total energy (GJ)	Office building-recorded BOQ items/activities	Total energy (GJ)
Labor transportation	Brick veneer	118	Brick veneer	192
	Structural steel	76	Structural steel	116
	200 mm CMU	55	200 mm CMU	49
Material transportation	Brick veneer	1,805	Brick veneer	1,925
	Structural steel	999	Structural steel	999
	200 mm CMU	560	200 mm CMU	385
Equipment operation	Structural steel	228	Structural steel	484
	Cell fill concrete	42	Brick veneer	258
	Building: slab on deck	15	200 mm CMU	132
Total Energy consumption	Brick veneer	1,924	Brick veneer	2,374
	Structural steel	1,304	Structural steel	1,635
	200 mm CMU	615	200 mm CMU	565

ommended by the architect were produced by a manufacturer 1,610 km away and transported to the site by trucks. One approach to reduce the transportation energy was to ask the architect to allow use of an alternative brick with similar performance that was available at a closer distance.

The second largest source of energy consumption was transportation of structural steel to the job site. The steel was purchased from two different locations, 652 km and 1,549 km away from the site. Nearly 44 Metric Tonnes (MT) of steel were ordered from the closer and the rest (131 MT) from the distant manufacturer. The cost of steel purchased from the closer manufacturer was 10% higher than that of the distant location. Fig. 83.7 shows the energy and cost distribution for the structural steel materials. It shows that additional costs may be incurred if energy reduction is desired. The structural steel cost (material and transportation) would have been $315,000 and energy consumption 1,170 GJ if all the steel were purchased from the distant location (1,549 km). However, the cost would have increased to $350,000 and energy consumption decreased to 503 GJ for purchase from the closer location

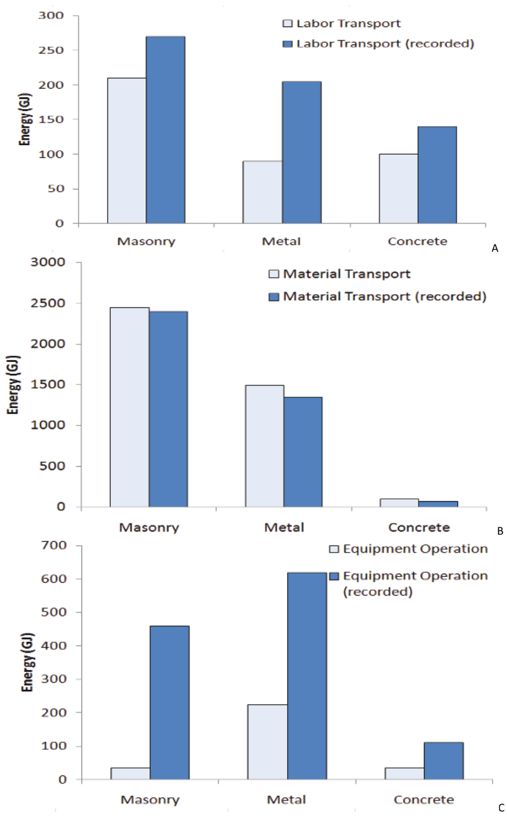

Fig. 83.6 Energy consumption comparison. A) Labor transport. B) Material transport. C) Equipment operation

(652 km). In this project, 25% of materials were purchased from the closer location and 75% from the distant location. This resulted in $328,000 material and transportation cost and energy consumption of 999 GJ.

When purchasing materials, contractors are looking for the least expensive option and may not be motivated to reduce energy consumption. However, the project owner may specify a maximum distance for material purchase or provide some incentive for purchasing materials from local vendors. The U.S. Green Building Council LEED rating system provides credit for materials that are purchased within an 800 km radius. At times, a lower cost might not be the only reason in the selection of manufacturers. Factors such as availability of material, production rate of a manufacturing unit, and specialty in manufacturing a particular item, and relations between parties may play a role in the selection process. In general, energy efficiency in procurement of resources should be given priority and required contractually.

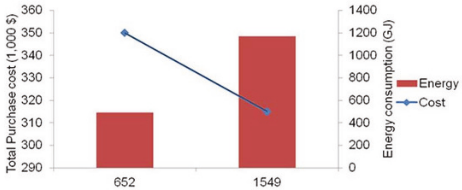

Fig. 83.7 Cost and energy distribution for the structural steel purchase

The construction of brick veneer was observed on-site and its energy consumption was recorded. A total of 192 GJ energy was consumed for transporting labor to and from the job site. The masons and their helpers were using their pick-up trucks for transportation, and the average distance from their homes to the job site was approximately 80 km. Moreover, most were coming from similar locations. One approach to reduce transportation energy for mason crew was to provide pooled transportation for them and forbid use of personal trucks in commuting to the project site.

83.5 Summary and Conclusion

In summary, contractors can play a major role in development of energy efficient means and methods to reduce energy consumption, i.e., carbon footprint, during the construction phase of a project. A spreadsheet-based framework was developed to estimate energy consumption of project activities during the construction phase. The proposed framework allows contractors to identify energy-intensive activities before construction starts and deploy energy-efficient procurement and installation methods to reduce energy consumption of a particular project. A case study was presented to demonstrate application of the framework for a building construction. Based on the energy consumption data, several recommendations were made for reducing energy consumption. The framework may also be used for collecting energy consumption data during construction for continuous update of the database and to increase its accuracy in estimating energy consumption for future projects.

The framework will be enhanced if it is integrated with a decision support system (DSS). The DSS should compare various energy-saving alternatives and their associated costs to identify a least expensive energy-saving measure on a project.

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Chapter 84
Conflict Types and Innovative Work Behavior: Exploring a New Path

Rabia Imran, Arshad Zaheer, Afsheen Fatima and Muhammad Asif Khan

Abstract The research was aimed at conceptualizing and empirically testing a path to highlight the interrelationships of conflict types and innovative work behavior. A random sample of 320 managers of telecommunication sector of Pakistan was selected for the study. The conceptual model was empirically tested using Structural Equation Modeling (SEM). The findings reveal positive and significant impact of task conflict on innovative work behavior. Further, it shows the significant positive impact of innovative work behavior on process conflict. There is also a significant and positive impact of process conflict on relationship conflict. This study presents a role model for the strategic managers and practitioners as a guideline to stimulate innovative work behavior through better conflict management.

Keywords Innovative work behavior · Task conflict · Process conflict · Relationship conflict

84.1 Introduction

Conflict is the observable fact of daily work life of every type of organization and a necessary element of the human activity [1, 2]. It occurs when there is an incongruity between concerns of two or more persons [3]. It is a process with visible incongruity, disparity in or among social units like individuals, groups or organizations [4].

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In the modern age, organizations need to innovate in order to stay competitive [5]. This scenario stimulated the research team to examine and understand innovation process, which leads to innovation within organizations. Innovation begins with creativity that relates to the development of new ideas, useful product or service [6]. It is the implementation of the creative ideas into reality. Employee's innovative behavior is considered very important to maintain the competitive edge. Innovative work behavior is the deliberate effort to initiate, produce and implement new ideas for the betterment of the organization [7].

Present research aims to focus on a critical process within the organizations, i.e. conflict, and investigates the contribution of conflict to the innovative work behavior of the employees. Past researches in this area examined the relationship between conflict types and creativity and innovation. This study aims to explore this relationship in a relatively different manner.

The study conceptualizes and empirically tests a relatively new model. The objective is to examine the role played by task conflict in fostering idea generation, idea promotion and idea realization components of innovative work behavior. Further, it also investigates the way innovative work behavior is expected to lead to process conflict and then the way process conflict is expected to lead to relationship conflict.

84.2 Literature Review

84.2.1 Conflict

Conflict was considered to be an undesirable event until 1940s. The traditional perspective of conflict was that of avoidance. Conflict was thought to have adverse effects like ineffectiveness and unproductiveness, so it should be removed or reduced as much as possible [8]. The behavioral perspective, on the other hand, was of management. Conflict was assumed to be a necessary component of the workplace as one could not maintain a conflict free organization. Thus, instead of trying to eliminate it, one should try to decrease or resolve the conflict [9]. The contemporary perspective of conflict considers it as something useful for the organizations. It is used to identify problems, bring unity and invigorate the organization [9]. Now it is not considered as something awful. It can open up new possibilities in future and can facilitate employee development if managed properly [10].

Conflicts are unavoidable in the organizational settings as people disagree upon different issues like workload distribution, communication patterns, desires, requirements, aims and choices. These issues create tension when individuals interact with each other within the organization [3].

Literature reveals three different kinds of conflict namely task conflict, process conflict and relationship conflict Task conflict involves different point of views, beliefs and thoughts relating to disagreement about the decisions like distribution of resources, procedures adopted and explanation of facts [11]. Process conflict concerns with disagreements during task accomplishment like the logistic, transportation and delegation issues, in particular, who is going to do what [12]. Relationship conflict relates to personal disagreements like differences of values, norms, tastes, etc. This type of conflict occurs when individuals are incompatible in interpersonal dealings [13].

84.2.2 Innovative Work Behavior

Individual behavior gained attention in recent years. The future oriented and self initiated behaviors are intended to transform and develop one's existing condition [14]. These behaviors include voice, taking charge, proactive work behavior and innovative work behavior [7, 15]. Innovative work behavior is expected from the employees in order to maintain a competitive edge. These are the behaviors intended to instigate and deliberately introduce novel ideas, procedures or products [16].

Innovative behavior has three stages. First, Idea generation, in which the individuals recognize the problem. Resultantly, new solutions and ideas are thought of. Apparent problems and upcoming developments related to the work often initiate generation of new ideas [17]. Secondly idea promotion helps in identifying the ways to promote these solutions. The ideas are looked for and the individuals try to prove the authenticity of their ideas within and outside the organization. Third, Idea realization, which is the realization of the solution and development of the model of the innovation to be used in the organizational setting [18].

A number of factors affect innovative behaviors such as organizational characteristics, group level factors and characteristics of personality. Personality characteristics are one of the important ones. These characteristics include the mental capacity and characteristics of the job performed. These factors vary as everyone has different qualities, different thinking pattern and different job requirements which play an important role in their innovative output [16]. Task conflict enhances the innovative work behavior of employees in the work settings [19].

Researchers comprehend a long time ago that it is impossible to innovate in isolation. In fact, the people working around the employee affect innovative abilities of the employees [20]. Interaction with people is important to carry out and support innovation [18]. According to Scott and Bruce [21], it is vital to find out what stimulates innovative behavior as it is the foundation of the high performing organizations. They developed a model of innovative work behavior. According to them innovative behavior is influenced by leadership, problem resolving approaches of people and relationship within the work group.

Conflict gives rise to diverse point of views, brings flexibility, and develops a source of information, which leads to creativity [22, 23]. Conflict is found to have a positive impact on employee creativity [7]. Amabile [24] also found the influence of social processes like conflict on creative cognitive steps.

There are number of research studies that have examined the association among conflict types and personal and organizational outcomes. West and Anderson [25] found task conflict to have positive relation to the quality of ideas and innovation. Task conflict was also found to be related to constructive debate within the group [26], the emotional acceptance of group decisions [27] and avoidance of group think [28]. On the other hand, relationship conflict was found to be negatively associated with the above mentioned factors. However, it affects climate and decreases efficiency of the team [29].

Previous researches established relationship between conflict types and innovation but the current study conceptualizes the concept differently. We also included a logical path of task conflict leading to innovative work behavior, which further leads to process conflict. Furthermore, it aims to analyze at whether process conflict results in relationship or not. On the basis of available literature and understanding following hypotheses are developed:

H1: Task Conflict significantly leads to Innovative Work Behavior if there is Task Conflict then there would be Innovative Work Behavior.

H2: Innovative Work Behavior significantly leads to Process Conflict.

H3: Process Conflict significantly leads to Relationship conflict.

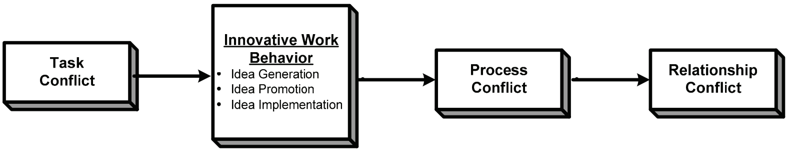

Fig. 84.1 Conceptual framework

84.3 METHODOLOGY

84.3.1 Subject

The subjects of this study comprised a random sample of 320 respondents from telecom sector of Pakistan.

84.3.2 Instrumentation

The research team used a 3-item scale developed by Jehn [13] to measure Task Conflict. Five point Likert scale was used ranging from 1 (Strongly Disagree) to 5 (Strongly Agree). Relationship conflict was also measured by a 3-item scale developed by Jehn [13]. Process conflict was measured by using 3-item scale developed by Shah and Jehn [30] These two scales were rated on five point Likert scale ranging from 1 (Not at All) to 5 (A great deal). Innovative Work Behavior was measured by the instrument developed by Zaman [31] which consisted of 25 items. These items measured the facets of Innovative Work Behavior such as Idea Generation, Idea Promotion and Idea Implementation. The instrument was anchored at five point Likert scales ranging from 1 (Strongly Disagree) to 5 (Strongly Agree).

84.4 Analysis and Result

Hypotheses and Model Testing

The research team tested the conceptual model using Amos 16.0. This study used Structural Equation Modeling (SEM) method for model testing. There are four error terms viz. e1, e2, e3 and e4 associated with variables of the hypothesized model viz. Task Conflict, Innovative Work Behavior, Process Conflict and Relationship Conflict respectively. SEM uses Common factor analysis and general linear model techniques for data analysis [32]. Fig. 84.2 reveals the measurement model of this study.

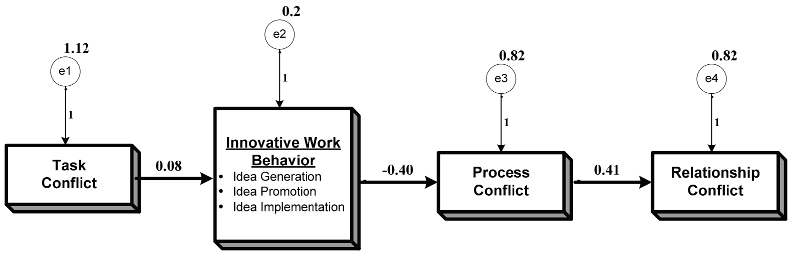

Fig. 84.2 Measurement model

The estimates of variances of errors are 1.12, 0.2, 0.82 and 0.82.

Table 84.1 Model fit indices

Chi Square	df	Sig.	GFI	AGFI	CFI	NFI
11.153*	3	0.011	0.983	0.944	0.896	0.868

Table 84.1 reveals the model fit indices of this study. The value of chi square (11.153) is insignificant ($\rho > 0.01$) which signifies the model acceptance [33]. Model fitness indices such as GFI, AGFI, CFI) and NFI are either greater or close

to the threshold value of 0.9 [34–36] which substantiates the goodness of the model fit.

Table 84.2 Model testing result based on regression weights

Hypothetical relationships	Regression estimate (β)	S.E.	Critical ratio	Result
TC-IWB	0.08*	0.024	3.317	Accept H_1
IWB-PC	−0.4*	0.112	−3.567	Accept H_2
PC-RC	0.41*	0.055	7.372	Accept H_3

$^*\rho < 0.001$

In TC-IWB hypothesized relationship of the model, the value of regression estimate ($\beta = 0.08$) is highly significant ($\rho < 0.001$). There is a significant effect of Task Conflict (TC) on Innovative Work Behavior (IWB) and hypothesis *H1* is therefore supported.

In IWB-PC hypothesized relationship of the model, the value of regression estimate ($\beta = -0.40$) is highly significant ($\rho < 0.001$). There is a significant effect of Innovative Work Behavior (IWB) on Process Conflict (PC) and hypothesis H_2 is therefore supported.

In PC-RC hypothesized relationship of the model, the value of regression estimate ($\beta = 0.41$) is highly significant ($\rho < 0.001$). There is a significant effect of Process Conflict (PC) on Relationship Conflict and hypothesis H_3 is therefore supported.

84.5 Discussion

The study was aimed at conceptualizing and empirically examining a path model. Conflict is found to be related employee creativity [7, 24]. According to West and Anderson [25] task conflict is positively related to quality of ideas and innovation. When the employee is suffering from task conflict this situation fosters the innovative work behavior of the employee. As the disagreement of ideas creates a need to find innovative solutions, which tempt the employees to exhibit innovative work behavior. Then employees search new ideas, attempt to get agreement for their exhibition and find ways to implement them. This helps the organizations to improve their performance and become competitive. Thus, task conflict is the driving force for the employees to become innovative.

The impact of innovative work behavior on process conflict and the impact of process conflict on relationship conflict were also established. This is relatively a new concept. There is a lack of literature related to this concept. However, there emerges a logical path. Previous literature only focuses on the effect of the conflict types on innovation and creativity but the current study tries to find their effects differently. The individuals exhibiting innovative work behavior can again experience process conflict at the implementation phase, i.e. what is to be done by whom? The process conflict is further resulted into relationship conflict as when employees are unclear about the situation they might start fighting, delay the work, indulge in politics and unable to get along with each other.

The current study provides basis for future investigation of the interrelationships between conflict types and innovative work behavior. It provides guideline to the practitioners to handle conflicts in a manner that boost innovative work behavior. Secondly, not to forget the effect of innovative work behavior that might result in another type of conflict which might affect the performance of the organization.

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Chapter 85
The Exact Solutions to Analytical Model of Tsunami Generation by Sub-Marine Landslides

Zehra Pınar, Ekin Deliktaş and Turgut Öziş

Abstract Nonlinear differential equations and its systems are used to describe various processes in physics, biology, economics etc. There are a lot of methods to look for exact solutions of nonlinear differential equations: the inverse scattering transform, Hirota method, the Backlund transform, the truncated Painleve expansion. It is well known that different types of exact solutions of an auxiliary equation produce new types of exact travelling wave solutions to nonlinear equations. In this paper, by means of symbolic computation, the new solutions of original auxiliary equation of first-order nonlinear ordinary differential equation with a sixth-degree nonlinear term are presented to obtain novel exact solutions of the analytical model of Tsunami generation by sub-marine landslides.

Keywords The auxiliary equation technique · The analytical model of Tsunami generation by sub-marine landslides · Wave solutions

85.1 Introduction

In spite of extensive progress and applications of numerical methods in real physical systems and applied mathematics, in particular, the analytical methods preserve entirely their significance. What is more, exact analytical solutions cannot be found for most nonlinear differential models which come up in particular conditions in real physical systems. In broad, by an exact analytical solution, we indicate one that is given in terms of functions whose properties are known or tabulated. Even such

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a solution be present, such solution may not be particularly useful, however, from either a computational or analytical point of view.

Hence, over the past decades, a number of approximate methods based on perturbation approach for finding travelling wave solutions to nonlinear evolution equations have been proposed/or developed and furthermore modified. There are a lot of methods to look for exact solutions of nonlinear differential equations: the inverse scattering transform, Hirota method, the Backlund transform, the truncated Painleve expansion etc. Among these methods, one of the current methods is so called auxiliary equation method [23–27]. The technique of this method consists of the solutions of the nonlinear evolution equations such that the target solutions of the nonlinear evolution equations can be expressed as a polynomial in an elementary function which satisfies a particular ordinary differential equation along with is named as auxiliary equation in general. Recently, to determine the solutions of nonlinear evolution equations, many exact solutions of various auxiliary equations have been utilized [3, 28–31, 34, 35].

A concise observation shows that novel exact solutions of the auxiliary equations may fabricate original exact travelling wave solutions of nonlinear evolution equations. Therefore, it is very important to find novel exact solutions of the distinct auxiliary equations.

In this paper, we will examine the consequences of the choice of the auxiliary equation for determining the solutions of the nonlinear evolution equation in consideration and more we search for additional forms of new exact solutions of nonlinear differential equations which satisfying a first-order nonlinear ordinary differential equation with a sixth-degree nonlinear term.

85.2 Auxiliary Equation Technique and Some Remarks

We assume that the given nonlinear partial differential equation for $u(x,t)$ to be in the form:

$$P(u, u_x, u_t, u_{xx}, u_{xt}, u_{tt}, \cdots) = 0, \tag{85.1}$$

where P is a polynomial in its arguments, which includes nonlinear terms and the highest order derivatives. Then, using the transformation $u(x,t) = u(\xi)$, $\xi = (x - ct)$ one can reduce Equation (85.1) to the ordinary differential equation:

$$Q(u, u_\xi, u_{\xi\xi}, u_{\xi\xi\xi}, \cdots) = 0. \tag{85.2}$$

Now, we seek the exact travelling wave solutions of Equation (85.2) by means of auxiliary equation method. As it is well known, most exact travelling wave solutions of nonlinear evolution equations were obtained on the assumption that the exact solution can be expressed as a finite expansion of linearly independent elementary functions. One common way of obtaining linearly independent elementary functions is that to assume them as a solution of appropriate algebraic or differential equations which are exactly solvable.

Hence, for the solution of Equation (85.2), let us assume that the exact solution can be expressed as simple expansion in the form of:

$$u(\xi) = \sum_{i=0}^{N} g_i z^i(\xi), \tag{85.3}$$

where $g_i,\ (i = 0, 1, \cdots, N)$ are constants which will be determined later and function $z(\xi)$ is an appropriate function that yields new travelling wave solutions and defined by the solution of the auxiliary equation considered.

Now, let us remember the process for finding the unknown coefficients $g_i,\ (i = 0, 1, \cdots, N)$ where $u(\xi) = \Sigma_{i=0}^{N} g_i z^i(\xi)$. Substituting the auxiliary equation into the given nonlinear equation and equating each coefficient of a power of $z(\xi)$ to zero yields an algebraic system. Hence, all coefficients g_i can be determined by solving the algebraic system and the parameter N is a positive integer and can be determined by balancing the highest order derivative terms and the highest power nonlinear terms in Equation (85.3) in general.

In this paper, we seek for the solution of Equation (85.2) in terms of ansatz (85.3) with $z(\xi)$ satisfying the following new auxiliary equation with a sixth-degree non-linear term i.e.

$$\frac{dz}{d\xi}^2 = a_0 + a_2 z^2(\xi) + a_4 z^4(\xi) + a_6 z^6(\xi), \tag{85.4}$$

where $a_i,\ (i = 0, 2, 4, 6)$ are real constants. The new solutions of the auxiliary Equation (85.4) under 8 distinct cases which include solutions including Bessel function and Lambert function and one can use these new solutions to seek exact travelling wave solutions for nonlinear equations [34].

As it is noticeable, by choosing the particular values of $a_i,\ (i = 0, 2, 4, 6)$, Equation (85.5) provides numerous types of special solutions. Hence, in ansatz (85.4), the parameter N is a positive integer and can determined by balancing the higher order derivative term and highest power nonlinear terms in Equation (85.2). The highest degree of $\frac{\partial^p u}{\partial \xi^p}$ can be calculated by:

$$\begin{cases} O\left[\frac{\partial^p u}{\partial \xi^p}\right] = N + p, & p = 0, 1, 2, \cdots \\ O\left[u^q \frac{\partial^p u}{\partial \xi^p}\right] = qN + p, & q, p = 0, 1, 2, \cdots \end{cases} \tag{85.5}$$

Consequently substituting Equations (85.3) and (85.4) into Equation (85.2) and equating the coefficients of all powers of $z(\xi)$ and

$$z^j(\xi)\sqrt{a_0 + a_2 z^2(\xi) + a_4 z^4(\xi) + a_6 z^6(\xi)},\ (j = 0, 1, 2, \cdots)$$

to zero in the resulting equation, several algebraic equations will be obtained. Then solving these algebraic equations by the symbolic computation system Maple, and combining Equation (85.3) and the auxiliary equation (85.4), we can get the exact solutions for Equation (85.1).

85.3 Exact Travelling Wave Solutions

In this section, we are going to combine the auxiliary equation method with the new solutions of original auxiliary equation (85.4) with a six-degree nonlinear term to consider the an analytical model of Tsunami generation by sub-marine landslides which is proposed by Pelinovsky [11].

$$u_t + auu_x + bu_{xxx} + cu_x = -\frac{c}{2} f_x(x,t), \tag{85.6}$$

where $a = 3c/2h$, $b = (ch^2)/6$ and $u = u(x,t)$ is the elevation of the free water surface, $f = f(x,t)$ represents the solid bottom, h is assumed to be the constant mean water depth and $c = \sqrt{gh}$ is the long wave speed with g being the gravity acceleration.

To find the travelling wave solutions for Equation (85.6), we use the wave variable $\xi = u(x - mt)$, where $m \neq 0$ and $u \neq 0$. The wave variable ξ carries Equation (85.6) into the ordinary differential equation:

$$mu' + am\mu^2 uu' + b\mu^3 u''' + c\mu u' = -\frac{c}{2}\mu f', \tag{85.7}$$

From Equation (85.5), and using Equation (85.7), we have $N = 3$. Therefore, the ansatz yields:

$$u(\xi) = g_0 + g_1 z(\xi) + g_2 z^2(\xi) + g_3 z^3(\xi), \tag{85.8}$$

where $z(\xi)$ may be determined by the auxiliary equation.

Now, for convenience, we give the calculation of typical two cases only for the practical purposes and the rest can be determined in a similar manner.

We first consider, the auxiliary equation with six-degree nonlinearity, i.e.

$$\frac{dz}{d\xi}^2 = a_2 z^2(\xi) + a_6 z^6(\xi). \tag{85.9}$$

The solution of Equation (85.9):

$$z(\xi)=\frac{e^{(\sqrt{a_2}(-\xi+c_1))}2^{1/4}}{\left(\frac{a_6e^{(4\sqrt{a_2}(-\xi+c_1))}}{a_2\text{LambertW}\left(-\frac{a_6e^{(4\sqrt{a_2}(-\xi+c_1))}}{2a_2}\right)}\right)^{1/4}}, \tag{85.10}$$

we believe, a new solution in the literature.

Hence, substituting Equations (85.8) and (85.9) into Equation (85.7) and letting each coefficient of $z^i(\xi)\sqrt{a_2z^2(\xi)+a_6z^6(\xi)}$, $(0\le i\le 8)$ to be zero, we obtain:

$$\begin{aligned}
&15g_1a_6+165g_3a_4=0,\\
&3\gamma g_3a_6+3c\mu g_3a_6+60b\mu^3g_3a_4^2+21b\mu^3g_1a_6a_4=0,\\
&2\gamma a_6+2c\mu a_6+24b\mu^3a_4^2=0,\\
&\gamma g_1a_6+c\mu g_1a_6+6b\mu^3g_1a_4^2+3\gamma g_3a_4+3c\mu g_3a_4=0,\\
&3\gamma+3\mu c=0.
\end{aligned} \tag{85.11}$$

Solving the system (85.11) by the aid of Maple 13, we can determine the coefficients:

$$\begin{aligned}
c&=\frac{\begin{array}{c}-(3267\gamma+198\gamma a_6-1020\gamma a_6^2+200\gamma a_6^3+175446b\mu^3a_6^2+283176b\mu^3a_6^2\\+114264b\mu^3a_6^4)\end{array}}{\mu(2a_6+3)(-33+10a_6)^2},\\
a_4&=\frac{3a_6(57+46a_6)}{2(-33+10a_6)},\\
g_1&=\frac{3a_6(57+46a_6)}{2(-33+10a_6)}.
\end{aligned}$$

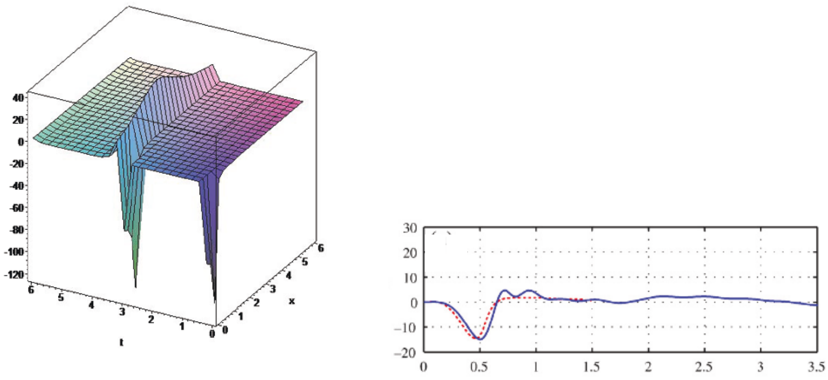
Substituting the above coefficients into ansatz (85.8) with the solution (85.10) of auxiliary equation, we obtain one of new solution of the leading-order evolution equation:

$$\begin{aligned}
u(x,t)=\;&g_0-\frac{33}{4}g_3(57+46a_6)\sqrt{3}\sqrt{2}\Bigg(\Bigg(-a_6+\frac{9}{4}a_6^2(57+46a_6)^2\mu^2(x-\\
&(3267\gamma+198\gamma a_6-1020\gamma a_6^2+200\gamma a_6^3+175446b\mu^3a_6^2+283176b\mu^3a_6^3\\
&+114264b\mu^3a_6^4)t/(\mu(3+2a_6)(-33+10a_6)^2))^2/(-33+10a_6)^2\\
&-\frac{9}{2}_C1a_6^2(57+46a_6)^2\mu(x-(3267\gamma+198\gamma a_6-1020\gamma a_6^2+200\gamma a_6^3\\
&+175446b\mu^3a_6^2+283176b\mu^3a_6^3+114264b\mu^3a_6^4)t/(\mu(3+2a_6)(-33\\
&+10a_6)^2))/(-33+10a_6)^2+\frac{9a_6^2(57+46a_6)2_C1^2}{4(-33+10a_6)^2}\Bigg)a_6(57+46a_6)/\\
&(-33+10a_6)\Bigg)^{(1/2)}\Bigg/\Bigg((-33+10a_6)\Bigg(-a_6+\frac{9}{4}a_6^2(57+46a_6)^2\mu^2
\end{aligned}$$

$$(x-(3267\gamma+198\gamma a_6-1020\gamma a_6^2+200\gamma a_6^3+175446b\mu^3a_6^2+283176$$
$$b\mu^3a_6^3+114264b\mu^3a_6^4)t/(\mu(3+2a_6)(-33+10)^2)^2/(-33+10a_6)^2$$
$$-\frac{9}{2}\_C1a_6^2(57+46a_6)^2\mu(x-(3267\gamma+198\gamma a_6\gamma a_6+200\gamma a_6^3+175446$$
$$b\mu^3a_6^2+283176b\mu^3a_6^3+114264b\mu^3a_6^4)t/(\mu(3+2a_6)(-33+10a_6)^2))/$$
$$(-33+10a_6)^2+\frac{9a_6^2(57+46a_6)2\_C1^2}{4(-33+10a_6)^2}\Bigg)\Bigg)+\frac{3}{2}g_2a_6(57+46a_6)\Bigg/$$
$$\Bigg(\Bigg(-a_6+\frac{9}{4}a_6^2(57+46a_6)^2\mu^2(x-(3267\gamma+198\gamma a_6-1020\gamma a_6^2+200$$
$$\gamma a_6^3+175446b\mu^3a_6^2+283176b\mu^3a_6^3+114264b\mu^3a_6^4)t/(\mu(3+2a_6)(-33$$
$$+10)^2)^2/(-33+10a_6)^2-\frac{9}{2}\_C1a_6^2(57+46a_6)^2\mu(x-(3267\gamma+198$$
$$\gamma a_6\gamma a_6+200\gamma a_6^3+175446b\mu^3a_6^2+283176b\mu^3a_6^3+114264b\mu^3a_6^4)t/$$
$$(\mu(3+2a_6)(-33+10a_6)^2))/(-33+10a_6)^2+\frac{9a_6^2(57+46a_6)2\_C1^2}{4(-33+10a_6)^2}\Bigg)\Bigg)$$
$$+\frac{3}{4}g_3\sqrt{3}\sqrt{2}\Bigg(\Bigg(-a_6+\frac{9}{4}a_6^2(57+46a_6)^2\mu^2(x-(3267\gamma+198\gamma a_6$$
$$-1020\gamma a_6^2+200\gamma a_6^3+175446b\mu^3a_6^2+283176b\mu^3a_6^3+114264b\mu^3a_6^4)t$$
$$(\mu(3+2a_6)(-33+10a_6)^2))^2/(-33+10a_6)^2-\frac{9}{2}\_C1a_6^2(57+46a_6)^2\mu(x$$
$$-(3267\gamma+198\gamma a_6\gamma a_6+200\gamma a_6^3+175446b\mu^3a_6^2+283176b\mu^3a_6^3$$
$$+114264b\mu^3a_6^4)t/(\mu(3+2a_6)(-33+10a_6)^2))/(-33+10a_6)^2$$
$$+\frac{9a_6^2(57+46a_6)2\_C1^2}{4(-33+10a_6)^2}\Bigg)a_6(57+46a_6)/(-33+10a_6)\Bigg)^{(3/2)}\Bigg/\Bigg(-a_6$$
$$+\frac{9}{4}a_6^2(57+46a_6)^2\mu^2(x-(3267\gamma+198\gamma a_6-1020\gamma a_6^2+200\gamma a_6^3$$
$$+175446b\mu^3a_6^2+283176b\mu^3a_6^3+114264b\mu^3a_6^4)t/(\mu(3+2a_6)(-33$$
$$+10)^2)^2/(-33+10a_6)^2-\frac{9}{2}\_C1a_6^2(57+46a_6)^2\mu(x-(3267\gamma$$
$$+198\gamma a_6\gamma a_6+200\gamma a_6^3+175446b\mu^3a_6^2+283176b\mu^3a_6^3$$
$$+114264b\mu^3a_6^4)t/(\mu(3+2a_6)(-33+10a_6)^2))/(-33+10a_6)^2$$
$$+\frac{9a_6^2(57+46a_6)2\_C1^2}{4(-33+10a_6)^2}\Bigg)^3. \tag{85.12}$$

The graph of the Equation (85.12) is illustrated for selected values of coefficients given in Fig. 85.1.

As it is seen in Fig. 85.1, the solution is obtained by the extended auxiliary equation method is more stable than the solution which is obtained by Boussinesq-type approach method in [35].



(a) (b)

Fig. 85.1 Graph of Equation (85.12), (a) is the extended auxiliary solutions for the values $\gamma = 1.85, a_6 = sint, \mu = 1$, (b) is for the same values obtained by Fuhrman and Madsen [35]

85.4 Conclusion

As is seen, the key idea of obtaining new travelling wave solutions for the nonlinear equations is constructing different types of solutions of the given auxiliary equation. In this letter, the exact solutions of the auxiliary equation with six -degree nonlinearity (Equation (85.5)):

$$\left(\frac{dz}{d\xi}\right)^2 = a_0 + a_2 z^2(\xi) + a_4 z^4(\xi) + a_6 z^6(\xi),$$

where $a_i,\ (i = 0,2,4,6)$ are real constants, is used to construct the solutions of the leading-order evolution equation. Using these solutions, we have successfully obtained some new exact periodic solutions of the leading-order evolution equation. In this letter, we have obtained exact solutions of the auxiliary equation with sixth-degree nonlinearity (85.5) for distinct cases. Therefore, our approach give additional new solutions beside the solutions obtained via fourth order auxiliary equation and theoretically, some of our solutions may coincide with the solutions of Wu [20], Sirendaoreji [21], Jang [22], Lv [23] and some cases of Yomba [24] for certain choice of the parameters which we have left as an exercise. However, it is well known that different types of auxiliary equations produce new travelling wave solutions for many nonlinear problems. Hence this also is our future work. The presented method could lead to finding new exact travelling wave solutions for other nonlinear problems.

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Chapter 86
Impact of Work-life Balance on Employees Productivity and Job Satisfaction in Private Sector Universities of Pakistan

Asif Kamran, Shuana Zafar and Syed Nayyer Ali

Abstract The objective of this research paper is to discuss the nature of work and family policies in Pakistan's environment particularly in Education Sector. There are 133 universities in Pakistan, of which 73 are Public sector universities and Private universities are 63 which are functioning under Higher Education Commission of Pakistan. This study will further assess that how different Educational sectors in Pakistan have approached the work life balance agenda and examines the actual outcomes for both the employees and the employers. Employees can achieve a healthy balance between work and family life through flexible working arrangements. Results of this study will be beneficial for organizations to better choose the policies to formulate, therefore helping organization to increase the effectiveness and productivity. There is a positive moderate relationship between job satisfaction and work-life balance; which suggests that universities should focus their efforts on formulating and implementing work-life balance policies. the questionnaire to tell partakers the rationale of this study, which is to evaluate employees work related approach on family friendly/work-life balance policies execution among different universities of Pakistan Chi-square test and regression analysis was conducted to examine the strength of relationship between work-life balance policies and employees job satisfaction.

Keywords Degree Awarded Institute (DAI) · Higher Education Commission (HEC)

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86.1 Introduction

Balancing work and family life has become a great challenge for almost every organization. Work-life concerns have tremendously become important for both employers and employees, and these issues are a universal worldwide phenomenon. Research implies that the necessity for work and family policies is being driven by demographical changes in societies. The work and family life issues are growing intricate due to a range of factors including increased participation of women and mothers into work places [15], and the escalation of couples in dual career [9].

In 2004 a survey of work-life balance was conducted by Community Business which reported that out of 1,000 respondents around 75% were going through pressure and complained about their unhealthy balance between work and personal lives [5]. Growing level of stress can swiftly result in poor productivity, low employee morale and decline in job satisfaction. Increasing number of employees is putting across considerable emphasis over work time and the pressure resulting from workload [3, 8]. Former studies confirmed that the benefits of executing family friendly policies in organizations can considerably address better productivity, increased employee morale and job satisfaction [14]. Also providing work-life balance policies can influence employees attachment to their work and they may contribute with better loyalty and improved morale [7].

Different researchers suggest different definitions for “work and family” or “family-friendly workplaces” escorted by a number of different policies including leave for maternity, sickness, emergencies, career breaks and extended leaves [12]. While according to Johns [13], family friendly policies includes flexible working arrangements, career break schedules, job sharing, part-time work, family leaves, and assistance with elder care and child care responsibilities.

During 21st century’s initial era, stronger outlook of economy and hastened growth in various sectors have been resulted by reforms in Pakistan’s wide economy. Pakistan has been exposed by improved living standards due to economic investments. Pakistan being a communal country has always shared the values and traditions of male breadwinner-female homemaker model but now these traditions are changing due to many factors like women entering in workforce, more broken homes, both parents working etc which results in a greater need to integrate both work and family life.

In Pakistan the higher education system is comprised of two main sectors; one is the sector of affiliated colleges and the other is the sector of university/Degree Awarding Institutes (DAI). The Higher Education Commission is an apex independent body responsible for giving out public funds to DAIs and universities from the federal government and also accrediting their degree programs. In recent years, the higher education commission in Pakistan has undergone a revival after almost about two decades of serious ignorance. The condition started to overturn itself in the early 2000s, with the government presenting a clear dedication towards improving higher education.

There are total of almost 133 universities in Pakistan, out of which 73 are Public sector universities and Private universities are 63 which are functioning under

Higher Education Commission of Pakistan (HEC). In 1947-1948 there were only 2 Public sector universities and none of the private sector. In 1950 it goes to 4 but in private sector still remains to zero 0. In 1982-1983 the first private sector university was opened and then very slowly and gradually increased by small numbers and goes to 10 in 1999 but then after 2000 till 2010 there was a drastic increase in number of private sector universities which grows up to 42 showing that the number increased by 4 times in a 10 years' time period. This above data shows that higher education has been promoted at a very fast pace after 2000. This drastic and gigantic increase in the number of universities means increase in the size of workforce. When the employees increases in number, both the work related and personal problems tend to burgeon resulting in a negative effect on productivity and motivation and hence balancing work and family life and surviving with transition becomes a great challenge for almost everyone and every organization either public or private.

In actual, there are many states where the family friendly policies have been taken up in greater number by organizations in order to reach a healthy balance between work and family life [20, 21]. Organizations that espoused these work-life balance policies most benefit from improving productivity and reducing absenteeism [4]. Few studies also confirmed that employees who have access to these policies are less likely to leave their organizations and show greater commitment [11].

86.1.1 Statement of Problem

In recent years, the trend for executing work and family life policies in organizations has gained tremendous importance. The policies such as reduced work hours, compressed working weeks, flexible starting time, leave for family related issues, and employee assistance programs help to improve the morale of employees and their productivity by reducing turnover rate and absenteeism. In order to effectively cultivate work-life balance in higher education sector, it is essential to promote comprehensive policies in universities. For example, reduced work hours are believed to be an initiative that would assist employees in attaining a healthy work-life balance. There is a need of conducting a comprehensive study on the impact of entire work-life balance policies in gaining an improved understanding for the implementation of these policies in future.

86.1.2 Purpose of the Study

The purpose of this study is to discuss the nature of work and family policies in Pakistan's environment particularly in Education Sector. The aim of writing this paper is to discuss and explore the desired and preferred work hour choices by employees in educational sector. The purpose is to make the readers understand the benefits of flexible work arrangements. This study will further assess that how different Educational sectors in Pakistan have approached the work-life balance agenda and examines the actual outcomes for both the employees and the employers. This study will look at the impact of work-life balance policies on employees' job satisfaction and their productivity. Results of this study will be beneficial for organizations to better choose the policies to formulate, therefore helping organization to increase the effectiveness and productivity.

86.1.3 Hypothesis to be Tested

H_0: Work-life balance policies and employees job satisfaction are negatively interrelated.
H_1: Work-life balance policies and employees job satisfaction are positively interrelated.

86.2 Research Methodology

The participants of the study were consisted of employees of 3 different Private Universities operating in Pakistan. The participants were asked to fill in the work-life balance questionnaire and their responses were used to measure the impact of family friendly/work-life balance policies on employee productivity and job satisfaction. Cover letter was also attached with the questionnaire to tell partakers the rationale of this study, which is to evaluate employees work related approach on family friendly/work-life balance policies execution among different universities of Pakistan. Participants were willing and were assured of the austere confidentiality of the responses and information that they provided. The questionnaires administered personally. 45 questionnaires were distributed and 30 were returned, that yield a response rate of 66.67%. Participants of the study were also asked to specify their age, gender, marital status and presence of dependent children for the demographic factors. After collecting the data, Chi-square test and regression analysis was conducted to examine the strength of relationship between work-life balance policies and employees job satisfaction.

86.3 Literature Review

Family friendly or work-life balance policies is defined as any working environment or benefits that an organization provides to its employees for a healthy balance between their work and personal life [16]. Literatures exposed family friendly policies that are in place to help employees achieve a fair work life. Work-life balance can be helpful tool in supporting higher productivity, greater job satisfaction and better employee retention [20]. Some researchers explained the impact of family friendly policies on employee's intention to leave their organization. Employees with an access to such policies demonstrate greater commitment to the organization [11]. Likewise, social justices predict that employees if treated fairly will have more positive attitudes toward their organizations [10]. Family friendly policies include reduced working hours, Flexible starting time, time off for family emergencies or events, compressed working weeks. Numerous studies have proved that the implementation of policies does not promise their actual operation because culture of the company, and particularly supervisors and colleagues may not be accommodating at all [1].

86.3.1 Compressed Working Weeks

In compressed work week standard number of hours are worked by the employees in one or two week time period, but these hours are compressed in lesser work days thus longer hours are worked at workplaces [6]. Various researches suggest that if employees do not want to deal with incoming task on daily basis then compressed workweeks are suitable for them. Different studies revealed that organization can reduce employee absenteeism, turnover and stress and can increase employee productivity and morale through compressed working weeks.

86.3.2 Flexible Starting Time

There are number of forms for flexible working arrangements that may includes flexibility in working time arrangement or the number of hours worked. Now days organizations espouse various policies for flexitime such as job sharing, teleworking, part time working, flexible schedule programs etc at workplace. Prior research on the same confirmed that employees job satisfaction improves with flexible programs [17, 19]. Employees can achieve a healthy balance between work and family life through flexible working arrangements. The positive results of such policies were also demonstrated in one of Australia's banks with reduced absenteeism and turnover [18].

86.3.3 Time Off for Family Emergencies or Events

Employees are allowed to be away from their workplaces in order to tackle with family obligation under family leave policies [2]. In some organizations, few particular policies like child care or elder care responsibilities and maternity leave are at the discretion of employer. In Pakistan only the maternity leave is compelled by law for which the maximum time period is three months while all other leaves are different from employer to employer. Like all other family friendly policies, family leaves policies help employees achieving a healthy balance between their work and life.

86.3.4 Reduced Working Hours

Employees work less in a day in reduced working hours. In Pakistan, usually the official timings are 9 to 5, however, under reduced working hour's policy employees can leave earlier. Reduced working hours demonstrates that if working patterns are reformed then it will have a positive impact on work-life balance while working longer hours results in fatigue which may affect employees performance and can increase absenteeism.

86.4 Data Analysis

Frequency Table:

Table 86.1 Demographics data of gender

		Frequency	Percent	Valid percent	Cumulative percent
Valid	Female	20	66.7	66.7	66.7
	Male	10	33.3	33.3	100.0
	Total	30	100.0	100.0	

Table 86.1 shows the demographic of respondents of the observed sample, where male group comprises 33.3% and female 66.7%.

Table 86.2 WLB2

		Frequency	Percent	Valid percent	Cumulative percent
Valid	No	21	70.0	70.0	70.0
	Yes	9	30.0	30.0	100.0
	Total	30	100.0	100.0	

The data in Table 86.2 shows that 70% respondents feel that they are not able to balance their work and family life, while 30% are able to maintain a balance.

Table 86.3 WLB3

		Frequency	Percent	Valid percent	Cumulative percent
Valid	Never	3	10.0	10.0	10.0
	Often	11	36.7	36.7	46.7
	Sometimes	9	30.0	30.0	76.7
	Rarely	7	23.3	23.3	100.0
	Total	30	100.0	100.0	

From Table 86.3, 36.7% respondents said that they often miss out quality time with their family and friends because of pressure of work and 10% said that they never missed out that quality time.

Table 86.4 WLB4

		Frequency	Percent	Valid percent	Cumulative percent
Valid	Often	7	23.3	23.3	23.3
	Sometimes	12	40.0	40.0	63.3
	Rarely	3	10.0	10.0	73.3
	Always	8	26.7	26.7	100.0
	Total	30	100.0	100.0	

It can be shown from Table 86.4 that 40% respondents said that they sometimes feel tired because of work load, 26.7% always feel tired and 10% said that they rarely feel tired because of work load.

(1) Work-life balance policies that help balancing work and family commitment

From Tables 86.5 $\sim$ 86.8, we know that among different work-life related policies; 70% respondents said that flexible starting time helps in balancing work and family commitment, 93.3% supported time off for family events, 96.7% said reduced work hours are helpful and 70% said that compressed working weeks can also help in balancing work-life commitments.

Table 86.5 WLB6A: flexible starting time

		Frequency	Percent	Valid percent	Cumulative percent
Valid	No	9	30.0	30.0	30.0
	Yes	21	70.0	70.0	100.0
	Total	30	100.0	100.0	

(2) Working patterns that hinder you in balancing work and family life commitment

It can be known from Tables 86.9 and 86.10 that all 30 respondents said that long working hours hinder employees in balancing work-life commitments. 76.6%

Table 86.6 WLB6B: time off for family events/emergencies

		Frequency	Percent	Valid percent	Cumulative percent
Valid	No	2	6.7	6.7	6.7
	Yes	28	93.3	93.3	100.0
	Total	30	100.0	100.0	

Table 86.7 WLB6C: reduced work hours

		Frequency	Percent	Valid percent	Cumulative percent
Valid	No	1	3.3	3.3	3.3
	Yes	29	96.7	96.7	100.0
	Total	30	100.0	100.0	

Table 86.8 WLB6D: compressed working week

		Frequency	Percent	Valid percent	Cumulative percent
Valid	No	9	30.0	30.0	30.0
	Yes	21	70.0	70.0	100.0
	Total	30	100.0	100.0	

respond that weekend classes hinder them, and only 33.3% respondents said that training are hindering them in balancing work and family life commitments.

Table 86.9 WLB7A: long working hours

		Frequency	Percent	Valid percent	Cumulative percent
Valid	Yes	30.0	100.0	100.0	100.0

Table 86.10 WLB7D: trainings

		Frequency	Percent	Valid percent	Cumulative percent
Valid	No	20	66.7	66.7	66.7
	Yes	10	33.3	33.3	100.0
	Total	30	100.0	100.0	

Table 86.11 shows that 43.3% participants respond that they are unhappy with the amount of time they spend at work, 26.7% were very unhappy and only 3.3% were happy about the amount of time they spend at their work.

From Table 86.12, we know that 73.3% respondents agree that work-life balance enable people to work better.

Here from Table 86.13, 56.7% participants said that their boss or colleagues do not provide any kind of support to fulfill their work and family commitments, and 43.3% accounts that their boss/colleagues provide them support.

Table 86.11 JS1

		Frequency	Percent	Valid percent	Cumulative percent
Valid	Very unhappy	8	26.7	26.7	26.7
	Unhappy	13	43.3	43.3	70.0
	Indifferent	8	26.7	26.7	96.7
	Happy	1	3.3	3.3	100.0
	Total	30	100.0	100.0	

Table 86.12 WLB9c

		Frequency	Percent	Valid percent	Cumulative percent
Valid	Strongly disagree	1	3.3	3.3	3.3
	Indifferent	7	23.3	23.3	26.7
	Agree	22	73.3	73.3	100.0
	Total	30	100.0	100.0	

Table 86.13 JS3

		Frequency	Percent	Valid percent	Cumulative percent
Valid	No	17	56.7	56.7	56.7
	Yes	13	43.3	43.3	100.0
	Total	30	100.0	100.0	

Table 86.14 Correlation analysis

		JS1	WLB2
JS1	Pearson Correlation	1	.483**
	Sig. (2-tailed)		.007
	N	30	30
WLB2	Pearson Correlation	.483**	1
	Sig. (2-tailed)	.007	
	N	30	30

*. Correlation is significant at the 0.01 level (2-tailed).

It can be seen from Table 86.14 that there is a positive moderate relationship between job satisfaction and work life balance; which suggests that universities should focus their efforts on formulating and implementing work-life balance policies because there is an appreciable effect on employee's job satisfaction and their performance.

From Table 86.15, in this case significance value is low as .009, which means that the two variables i.e. job satisfaction and work-life balance are related to each other, so the null hypothesis is rejected and support the alternative one, which is that there is a positive relationship between work-life balance policies and job satisfaction.

Table 86.15 Chi-square test

Chi-square tests			
	Value	df	Asymp. Sig. (2-sided)
Pearson chi-square	21.892[a]	9	.009
Likelihood ratio	17.801	9	.038
Linear-by-linear association	.736	1	.391
N of valid cases	30		

a. 16 cells (100.0%) have expected count less than 5. The minimum expected count is .10.

86.5 Practical Implications

The findings of this research study have practical implications for universities which are interested in implementing work life balance policies in the near future. Given the literature confirmed the desirable outcomes associated with job satisfaction of the employees. Work-life balance policies such as reduced working hours and flexible starting time have a significant impact on employees' higher productivity and job satisfaction. The benefits that organizations particularly universities gain by espousing work-life balance policies are clear. A productive and healthy workforce is essential to compete and become a differentiator as a university of choice. Meanwhile, the finding of this study supports the Higher Education Commission to nurture a family friendly workplace for the employees of different universities. It also convinces organizations to take a positive role for developing more caring environment on the execution of policies. It is expected that these findings will persuade further exploration and application of work-life balance policies in other organizations.

86.6 Conclusion

This research investigated the considerable impact of work-life balance policies on employee's productivity and their job satisfaction. Since these work-life balance policies are not very common in Pakistan, many employees have little understanding about them and hence they do not recognize the purposes behind it. The result of this study verified that work life balance policies have a significant positive relation with job satisfaction and hence better productivity. The work-life balance policies are important because people generally do not want to miss out quality time with their families or friends due to work pressure. The results support and encourage more work-life balance policies in private universities of Pakistan. It serves as reference for organizations to suggest more effective and efficient policies in the future.

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Chapter 87
Research on Risk Control of Human Resources Outsourcing in Private Enterprise

Yihua Wang and Xiaosu Zheng

Abstract The private enterprises play important roles in China, promoting the urbanization construction, enhancing the regional competition ability and creating more jobs. In order to further enhance the market competition of enterprises, promote enterprise better and faster development, more and more enterprises choose human resource outsourcing. However, there are many sorts of risks in the process of outsourcing. This paper studies the risk identification and evaluation of private enterprise human resources outsourcing. Through constructing optimal contract model, this paper analyzes how the private enterprises construct optimal outsourcing contraction in the process of human resources outsourcing. And we believed that the risk in human resource outsourcing process is inevitable, so the private enterprise need unifies itself actual situation, outsourcing project characteristics, the comprehensive strength and special skills of the outsourcing service providers to make the most suitable enterprise outsourcing contract.

Keywords Risk · Human resources outsourcing · Private enterprise

87.1 Introduction

The risk of human resources outsourcing is one of the problems which specially attract by domestic and overseas scholars and enterprise. From domestic scholars' research, the risk of outsourcing mainly includes two aspects of the risks, and one is from the enterprise interior, mainly include the operating cost, risk cost and the

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cultural integration, the other is from external, mainly from contractors. This paper will also from inside and outside to study the risk of human resources outsourcing of private enterprises [1].

From the present study, scholars at home and abroad have conducted extensive research on human resources outsourcing, and has obtained some achievements. This laid a foundation for entrepreneurs, managers, scholars to understand human resources outsourcing. This paper in view of the private enterprise, exploring its risk of human resources outsourcing and how to take effective measures to control the risk [2]. On the one hand, it can rich the study of literature theory on risk of human resources outsourcing, on the other hand it provide private enterprise managers theoretical guidance of relevant human outsourcing risk control and evasion strategies [3].

The earliest introduced human resources outsourcing is foreign company, compared to them, most of the private enterprises has not been acquainted with the outsourcing which is a function of human resources management, but in some enterprise have started parts function of human resources management outsourcing[4]. Although the domestic enterprises have not established mature human resource management system, modern human resources management ideas and methods obtained fast development in China. Especially with deeply system reform, private enterprises urgent need flexible employment methods and become more and more fall for human resources outsourcing service [5]. Human resources outsourcing as a new change direction of the development of enterprise human resources management function get fast grow up. According to the authority statistics of the international data group, global outsourcing services spending breakthrough 150 billion dollars in 2003, and growth rate in China is 15.1% [6]. The surveys that show currently there are about 75% of local companies haven't implement human resources management information solutions in China. And human resources outsourcing this concept also has just been introduced before long, is just in the initial stage. At the same time, a number of multinational companies, local companies, and the relevant agencies have the expressed a keen interest and attention to the human resource outsourcing, we can say human resources outsourcing in China has a broad market prospect [7].

However, the private enterprises have many shortcomings in the human resources management outsourcing. First of all, the private enterprise to lack understanding of human resources outsourcing especially labor dispatching. Human resources outsourcing mostly only stay in primary aspects such as the employee files relations and social security personnel; the advantage labor dispatching in staff management has not been fully understand. Secondly, human resources outsourcing development level is low, most of the private enterprises have not prepared to adopt human resources outsourcing, and part of the enterprise also give up use because some problems. Thirdly, enterprise labor dispute risk is big, avoiding the risk of labor becomes one of the important reasons of private enterprise human resources outsourcing. At the same time, the quality of the outsourcing service providers and professional quality is enterprise's biggest concern and also the biggest risk factor, but the price and cost factors considered less; Outsourcing services of the service quality and professional quality should be improved. In addition, the will of the staff and interests didn't get enough attention in the human resource outsourcing, the service consciousness in the human resources work is still lacking [8]. So, despite the current human resources outsourcing have a good development, but whether it can keep firmly on a stable eventually in the domestic still depends on the the constraints above whether can be improved as soon as possible, and the problems existing in the human resource outsourcing whether can be solved as soon as possible.

Because the there are many problems in human resources outsourcing management of private enterprise, what followed is the risk control problems, therefore, if private enterprises want to get advantages in human resources outsourcing, they must learn to recognize the risks the enterprise will face, and develop the corresponding strategies to avoid [9]. This shows, the risk control of private enterprise human resources outsourcing is very important.

87.2 The Risk Model Analysis of Private Enterprise Human Resources Outsourcing

Human resources outsourcing is private enterprises contract with outsourcing service providers to determine the content of the human resource outsourcing and the related service requirements, assume by give all or part of the human resources management function of the original enterprise itself to the outsourcing service providers, through its operation, the original enterprise can reduce costs and improve core competitive ability of the enterprise. Principal-agent relationship is contract mechanism between both sides of the main body of the transaction, which enables outsourcing service providers (agent) in the implementation of the outsourcing of human resources, can not only realize itself utility maximization, but also work better for the interests of private enterprise. In the process of outsourcing contract formulation, except for the provisions of some necessary rights and obligations, still design effective incentive and restraint system according to cooperation performance of outsourcing service providers in the process of human resources outsourcing. This plays a decisive role of actively preventing service providers' moral hazard occurring in outsourcing processing.

87.2.1 Establishment of the Model

In principal-agent relationship, the private enterprises as a client can't directly observed what strategy the outsourcing service providers (agent) take, and can only observe some variables generated by some behavior of the outsourcing service providers and other factors, the private enterprise give rewards and punishments to outsourcing services providers according to the observed variables in order to realize the optimization of the outsourcing contracts. When the private enterprise do decision-making, it will face two constraint conditions from the outsourcing service providers: (1) In participation constraint, namely when the outsourcing service providers accepting the outsourcing contracts, the expected utility they can get should be more than the maximum expected utility when they not accepting. (2) Incentive compatibility constraint, that's to say, no matter whether the private enterprise can observe the strategy that outsourcing service providers take, in any kind of incentive contract, the outsourcing service providers will choose strategy which can make it be able to achieve the expected utility maximization. A contract mechanism which can be well implemented must not only meet the participation constraints but also compatibility constraint, and the private enterprise is to design a contract which can be well implemented and also reach the goal of expected utility maximization.

Model assumption: private enterprise give part of the human resources management function to the human resources outsourcing service, the outsourcing services have two kinds strategies: (1) G_1 represents hard working (2) G_2 represents the opportunism behavior produce when outsourcing service providers want to get their own interests, that is the moral risk. In this model, the $G = (G_1, G_2)$ is a two-dimensional variables of the hard working, among them, the G_1 and the G_2 is two continuous variables with a reverse relationship for replacement, considering outsourcing service providers is limited rationality, then set out a up line level $\overline{G}$, it is $\overline{G} = G_1 + G_2$.

Although the behavior of outsourcing service providers in the implementation of human resources can not be observed, but the effect after the outsourcing can been seen. Suppose that the gains of human resources outsourcing of the private enterprise decided by effort degree G_1 of outsourcing service providers and other external factors θ. In order to show the effect of human resources outsourcing has great uncertainty, the assumption is that the probability p of the private enterprise succeed in implementing of the human resources outsourcing, then outsourcing failure probability is $1-p$, and once the outsourcing fail, the private enterprise will get a loss, L is a known value representing a fixed loss. Set π $(\overline{\pi}, \underline{\pi}$ as final output value of outsourcing service providers, among them, $\overline{\pi} = G_1 + \theta$ is the profit function for successful implementation of the human resource outsourcing, $\underline{\pi} = G_1 + \theta - L$ is failure function of outsourcing (θ represents mean is 0, variance is random variable of normal distribution of σ^2, it means uncertainty of external factors).

Because the private enterprise human resources outsourcing itself has great uncertainty, that is, θ has a big influence on the gains of human resources outsourcing. Usually, the private enterprise as a client need to take a greater risk than outsourcing service providers. Therefore, the assumption is that the risk of private enterprise is neutral, outsourcing service providers is of risk aversion, the outsourcing contract expression proposed by enterprise is $S(\pi) = \alpha + \pi\beta$ $(0 \leq \beta \leq 1)$, among them, and α represents the fixed income that private enterprise pay to outsourcing service providers, β represents output share of outsourcing service providers, that is when output π increase each extra unit, the reward of outsourcing service providers will boost β units. When $\beta \to 1$, it means the revenue of outsourcing service providers increase, meanwhile the risk is getting higher by the outsourcing service providers; When $\beta = 0$, outsourcing service providers need not bear any risk of outsourcing;

When $\beta = 1$, outsourcing service providers will take all the risk for the outsourcing.

$$\begin{aligned} E[S(\pi)] &= E\{p[S(\underline{\pi})] + (1-p)S(\overline{\pi})]\} \\ &= E\{p[\alpha + \beta(G_1+\theta)] + (1-p)[\alpha + \beta(G_1+\theta-L)]\} \\ &= E\{\alpha + \beta[G_1+\theta - L(1-p)]\} = \alpha + \beta[G_1 - L(1-p)]. \end{aligned} \tag{87.1}$$

The strategy of human resources outsourcing service providers is a two-dimensional variables of the hard working, there are three parts of its revenue: (1) the fixed income α, (2) revenue sharing of voluntary risk for outsourcing, (3) get the immoral gains coming from the moral risk. The revenue has a correlation with G_2, set its immoral revenue function as $V(G_2) = mG_2$. Assume that the cost of outsourcing service providers pay only relating to their efforts level, the cost function can be expressed as $C(G_1, G_2) = 1/2m_1^{G_1^2} + 1/2m_2^{G_2^2}$ $(m_1 > 0, m_2 > 0)$, among them, the m_1 represents the efforts the outsourcing service providers made for the enterprise human resources management and m_2 represents the efforts made for itself interests. The bigger of the value of m_1 and m_2, the bigger the negative effects is though paying the same efforts.

87.2.2 Solving of the Model

As the risk of private enterprise is neutral, for a given $S(\pi) = +\beta\pi$, the expected utility of the private enterprise is equal to the expected revenue:

$$\begin{aligned} &ET1\{p[\overline{\pi} - S(\overline{\pi})] + (1-p)[\underline{\pi} - S(\underline{\pi})]\} \\ &\quad = E\{p[\overline{\pi} - S(\overline{\pi})] + (1-p)[\underline{\pi} - S(\underline{\pi})]\} \\ &\quad = E\{p[G_1+\theta-\alpha-\beta(G_1+\theta)] + (1-p)[G_1+\theta-\alpha-\beta(G_1+\theta-L)]\} \\ &\quad = -\alpha + E(1-\beta)[G_1+\theta-L(1-p)], \\ &ET1 = -\alpha + E(1-\beta)[G_1+\theta-L(1-p)]. \end{aligned} \tag{87.2}$$

Suppose the utility function of human resources outsourcing service providers is the same absolute risk aversion, then we can use a $T_2 = -e^{-\rho w}$ ($\rho = -T_2^{''}/T_2^{'}$ is for absolute risk measurement) to represent the utility function of outsourcing service providers, because of $T_2^{''} < 0$, $T_2^{'} > 0$, so $\rho > 0$, and the actual income use w to represent. So the real income of outsourcing service providers is:

$$\begin{aligned} w = \;& p[S(\overline{\pi}) - C(a)] + (1-p)[S(\underline{\pi}) - C(a)] + V(G_2) \\ = \;& p[\alpha + \beta(G_1+\theta) - \frac{1}{2}m_1G_1^2 - \frac{1}{2}m_2G_2^2] \\ & + (1-p)[\alpha + \beta(G_1+\theta-L) - \frac{1}{2}m_1G_1^2 - \frac{1}{2}m_2G_2^2] + mG_2 \\ = \;& \alpha + \beta(G_1+\theta) + mG_2 - \frac{1}{2}m_1G_1^2 - \frac{1}{2}m_2G_2^2 - \beta L(1-p). \end{aligned} \tag{87.3}$$

As we have assumed Outsourcing service providers is of risk aversion, so the certain equivalent income T_2 is the difference between expected revenue Ew and the risk cost of outsourcing service providers, so

$$\begin{aligned} T_2 = &\ Ew - \frac{1}{2}\rho\beta^2\alpha^2 = \alpha + \beta G_1 + mG_2 - \frac{1}{2}m_1G_1^2 - \frac{1}{2}m_2G_2^2\beta L(1-p) - \frac{1}{2}\rho\beta^2\alpha^2 \\ = &\ \alpha + \beta G_1 + m(\overline{G} - G_1 - \frac{1}{2}m_1G_1^2 - \frac{1}{2}m_2(\overline{G} - G_1)^2 - \beta L(1-p) - \frac{1}{2}\rho\beta^2\alpha^2. \end{aligned}$$

The bigger of the σ^2 value is, the bigger deviates from gains π of the human resources outsourcing, when $0 < \beta < 1$, the income of the outsourcing service providers will reduce, the cost of risk will increase, so the σ^2 positively is correlated with risk cost. But when $\beta = 0$, the risk cost of outsourcing service providers is 0. The maximized expected utility function of outsourcing service providers is $ET_2 = -Ee^{-\rho w}$ which is equivalent to the certain maximized value of equivalent income, and its reserved income level is $\overline{w}$, so the participation constraint of outsourcing service providers can be expressed as:

$$\alpha + \beta G_1 + m(\overline{G} - G_1) - \frac{1}{2}m_1G_1^2 - \frac{1}{2}m_2(\overline{G} - G_1)^2 - \beta L(1-p) - \frac{1}{2}\rho\beta^2\alpha^2 \geq \overline{w}.$$

If the certain equivalent income of outsourcing service providers is not more than $\overline{w}$, the outsourcing service providers will refuse the outsourcing contract.

The private enterprises want to design a practical outsourcing contract, not only need to meet in participation constraint, but also accord with the condition of incentive compatible constraint. So we have a class derivation of the certain equivalent income of outsourcing services as following

Let $\frac{\partial ET_2}{\partial G_1} = 0$, that is $\beta - m - m_1G_1 + m_2\overline{G} - m_2G_1 = 0$, we can get:

$$G_1 = \frac{\beta - m + m_2\overline{G}}{m_1 + m_2}. \tag{87.4}$$

This shows that outsourcing service providers choose strategy G_1, that's the condition of the hard work.

In the private enterprise human resources outsourcing process, the moral risk model is:

$$\max_{\alpha,\beta,G_1} ET_1 = -\alpha + (1-p)[G_1 - L(1-p)], \tag{87.5}$$

participation constraint is:

$$G_1 = \frac{\beta - m + m_2\overline{G}}{m_1 + m_2}, \tag{87.6}$$

incentive compatibility constraint is:

$$G_1 = \frac{\beta - m + m_2\overline{G}}{m_1 + m_2}. \tag{87.7}$$

In this model, so long as satisfying the outsourcing service providers acceptable minimum income, that's participation constraint can meet equal sign, then outsourcing service providers would accept human resources outsourcing contract. Take α into Equation (87.5), we can get:

$$\begin{aligned}\max_{\alpha,\beta} ET_1 = {} & \beta G_1 + m(\overline{G}-G_1) - \frac{1}{2}m_1G_1^2 - \frac{1}{2}m_2(\overline{G}-G_1)^2 \\ & -\beta L(1-p) - \frac{1}{2}\rho\beta^2\alpha^2 - \overline{w} + (1-p)[G_1 - L(1-p)] \\ = {} & G_1 + m(\overline{G}-G_1) - \frac{1}{2}m_1G_1^2 - \frac{1}{2}m_2(\overline{G}-G_1)^2 \\ & -\frac{1}{2}\rho\beta^2\alpha^2 - \overline{w} - L(1-p). \end{aligned} \tag{87.8}$$

Then take Equation (87.7) into the Equation (87.8), and calculate optimized first order.

Let $\frac{\partial ET_1}{\partial\beta} = 0$, then $1-\beta[1+\beta\sigma^2(m_1+m_2)] = 0$, we can get:

$$\beta = \frac{1}{1+\rho\sigma^2(m_1+m_2)}. \tag{87.9}$$

Take the α into Equation (87.1), we can get:

$$\begin{aligned} E[S(\pi)] = {} & \beta[G_1 - L(1-p)] + \overline{w} - \beta G_1 - m(\overline{G}-G_1) \\ & + \frac{1}{2}m_1G_1^2 + \frac{1}{2}m_2(\overline{G}-G_1)^2 + \beta L(1-p)\frac{1}{2}\rho\beta^2\alpha^2 \\ = {} & \overline{w} - m(\overline{G}-G_1) + \frac{1}{2}m_1G_1^2 + \frac{1}{2}m_2(\overline{G}-G_1)^2\rho\beta^2\alpha^2. \end{aligned} \tag{87.10}$$

Finally, take β and G_1 generation into Equation (87.11), we can get the optimal contract model of both sides of the outsourcing activities:

$$\begin{aligned} E[S(\pi)] = {} & \frac{1}{2(m_1+m_2)+2\rho\sigma^2(m_1+m_2)^2} - \frac{m_2G-m}{2(m_1+m_2)} + \frac{m^2\overline{G}^2}{2} - m\overline{G} + \overline{w}, \\ \because s(\pi) = {} & ES(\pi) + \beta\theta, \\ \therefore S(\pi) = {} & \frac{1+2\theta(m_1+m_2)}{2(m_1+m_2)+2\rho\sigma^2(m_1+m_2)^2} - \frac{m_2G-m}{2(m_1+m_2)} + \frac{m^2\overline{G}^2}{2} \\ & -m\overline{G} + \overline{w}. \end{aligned} \tag{87.11}$$

87.2.3 Analysis of the Parameters of the Model

Because $\beta = \frac{1}{1+\rho\sigma^2(m_1+m_2)}$, and $\rho\sigma^2(m_1+m_2) \geq 0$, so $0 < \beta \leq 1$, this shows that in the process of private enterprise human resources outsourcing, outsourcing service providers will undertake part of the risk, and the private enterprise must give a part of the income to the outsourcing service providers to inspire the enthusiasm of outsourcing service providers. Obviously, β is decided by ρ, σ^2, m_1, m_2, and these variables is reducing function.

β is decreasing function of ρ, reflecting the more the outsourcing service providers want to avoid risk (that's the greater the absolute risk evasion ρ is), then the share of outsourcing income will less (that's the β is smaller). When the risk of outsourcing service providers is neutral (i.e. $\rho = 0$), it will undertake all the risk, but according to the principal-agent theory about the part of the discussion of best effort level we can know that, in this case, $G_2 = 0, \overline{G} = G_1$ which means that there is no moral hazard of outsourcing service providers. But, in reality of the outsourcing process, the risk of moral hazard is inevitable, namely the $\beta \neq 1$, therefore, the private enterprise need to actively take measures to prevent and reduce the moral risk. When the private enterprise enter into a outsourcing contract, not only explain clear account to pay the fixed income to outsourcing services, but also make clear how to share the risk of each side of the outsourcing, so we can design a reasonable income distribution proportion.

The β is decreasing function of σ^2, which illustrate that the bigger the uncertainty of the desired effect of private enterprise human resources outsourcing, the smaller the outsourcing service providers are willing to take the risk and the shares from the outsourcing. It is the same in the outsourcing of practical operation process, when encountered some not easily be executed human resources management function, the response of the outsourcing service providers is to avoid the risk. When the private enterprise choose of human resources outsourcing service providers, not only to explore their comprehensive strength, more important is to consider their special skill, through this way the enterprise can find more matching outsourcing service providers, and in this way we can reduce the uncertainty of outsourcing in maximization. In addition, the private enterprise need to identify risks, and do outsourcing of evaluation and supervision work in the process of outsourcing.

β is a decreasing function of the m_1, which can be understood that the bigger the cost the outsourcing service providers paid when they work hard, the more worried about the risk they should undertake and the small income shares they could get. β is a decreasing function of m_2, it can be expressed as the more the cost the outsourcing service providers spend on the opportunism behavior, the more likely they are to avoid risk. The private enterprise outsourcing service providers strengthened the supervision and punishment of the outsourcing service providers, refused the next cooperation with outsourcing service providers and loss of its reputation and other various factors may result in outsourcing service providers to pay the large cost of the generation of moral hazard, but might also promote outsourcing service providers to work hard, and too much effort may increase their cost, then choose risk aversion. The cost coefficient of m_1 and m_2 is different, which made the influence of m_2 on β have a difference, $m_1 - m_2 < 0$, the influence degree m_2 on β is more than the degree when $m_1 - m_2 > 0$. The private enterprise can achieve optimal value by the ways that add supervision, incentive and some other measures in the contract, to adjust m_1 and m_2.

87.2.4 Summary

Based on the study of the related literatures human resources outsourcing at home and abroad, combined with the transaction cost theory, principal-agent theory and Core cost theory, etc., and combining with the state of the human resource management of private enterprise, the paper do the study on the risk of outsourcing and mainly draw some conclusions as following:

- The private enterprises adopt human resources outsourcing contributing to enterprises to concentrate on the development of core business, integration of advantageous resources, establishment of the competitive advantage. Although human resources outsourcing has many advantages such as cost reduction, there are also many potential risks in the decision-making and implementation of the outsourcing of the enterprise. So, doing the research on the risk of private enterprise human resources outsourcing has great significance.
- The main risks of private enterprise human resources outsourcing are the imperfection of human resources management outsourcing market not perfect in the current, information asymmetry in the two sides of outsourcing and the limitation of the enterprise itself. Before the human resources outsourcing, it is necessary to do identification and evaluation of the outsourcing risks, then take effective measures to prevent risks, so as to make the outsourcing achieve the desired effect, realize the strategic goals of the enterprise.
- This paper through constructing optimal contract model, analyzes how the private enterprises construct optimal outsourcing contraction in the process of human resources outsourcing. And we believed that the risk in human resource outsourcing process is inevitable, so the private enterprise need unifies itself actual situation, outsourcing project characteristics, the comprehensive strength and special skills of the outsourcing service providers to make the most suitable enterprise outsourcing contract.

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Chapter 88
The Information Efficiency of Stock Index Futures in China

Qianwei Ying and Ziying Liang

Abstract This paper investigates whether the recent introduction of Index Futures in China has reduced volatility in the underlying spot market, and whether the index futures market effectively serves the price discovery function in both the short run and the long run. Applying GARCH model, we find that the volatility on CSI 300 Index was alleviated due to the emergence of the index futures. Moreover, the Granger Causality test figured out that in the short run, futures index market and the underlying stock market have reciprocal causation relationshipbut the causation effect from futures index market to spot market is relatively weaker. Johanson Cointegration test and VECM Model further revealed that the index futures market and the spot stock market are cointegrated while the index futures market responds more swiftly to new information than the spot stock market. The results of this paper verify that the index futures market in China does play the role of price discovery and information transfer, although it needs further improvement.

Keywords Stock index futures · Volatility · Price discovery · Information efficiency

88.1 Introduction

On 6th April, 2010, CSI 300 Futures Index began trading in China, symbolizing that Chinese financial market marched to the era of availability of short sales. Since then, there has been great concern about the impact of stock index futures on the underlying spot market, and on the market volatility and the information efficiency

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both in the short and the long run. However, scholars have not reached an agreement on this topic.

Some researches argued that volatility in the spot stock market had decreased since the advent of stock index futures. Bessembinder and Seguin [4] studied the impact of futures trading in S&P 500 Index and found that stock index futures alleviated fluctuations of prices in the underlying spot market. Lee and Ohk [12] who analyzed the Heng Seng Index Futures during the period from 1984 to 1988, and Antoniou et al [2] who studied FT-SE100 Index have also obtained similar conclusions. Nevertheless, more researches argue that there is little significant changes in volatility of the underlying spot prices caused by the introduction of stock index futures. Using the sample of S&P 500, Edwards [8, 9] found that although the introduction of stock index futures has a temporary effect in the fluctuation of the spot market, the effect disappeared soon. What is more, Brorsen [6], Baldauf and Santoni [3] showed consensus on the view of ineffectiveness of stock index futures on spot market volatility. Hodgson and Nicholls [10] also found that the common stock Index in Australia was not affected by the appearance of the stock index futures contracts. Some cross-country researches even support the opposite side, that the introduction of stock index futures magnified fluctuations in the spot market. For example, Antoniou and Holmes [1], utilizing GARCH model to investigate FT-SE 100 Index, found that the trading of stock index futures magnifies volatility in spot market, but also improved the speed and quality of the spot market's reaction to the new information.

Information efficiency, also known as function of price discovery, refers to the process through which information is truly reflected in the price and speed of converging from a deviated price to the long run equilibrium price. The index futures market may serve price discovery function in both short run and long run. In the short run, the price discovery function of the index futures market refers to its ability to temporarily change the price of the underlying assets through assimilating new information; While in the long run, the price discovery function of the index futures market refers to its ability to change the trend of the underlying asset price. According to Tse [14], the effectiveness of the index futures market's price discovery function depends on the level of market transparency, liquidity, government supervision or regulations, and constraints on short sales. A majority of studies support the point of view that the stock index futures market performs effective price discovery functions. Kawaller et al [11], using the data of S&P 500 from 1984 to 1985, reported that the S&P 500 Index Futures incorporate new information more quickly than the underlying spot index by 20-45 minutes. Moreover, when making use of 10-minute intraday data in S&P 500 and U.S.MMI, Stoll and Whaley [13] also verified that the stock index futures market digested information better than the spot stock market. In contrast, by digging into the 1-min intraday market data of Australia's AOI and SPI, West [16] proposed an opposite conclusion to the above researches, and argued that the spot market performs better than the index futures market in the term of price discovery. Some other studies using the data of emerging markets have also contributed to this field of research. For example, Zhong et al [15] studied Mexican stock index futures and found that although the offering of the stock index futures enlarged the volatility of the underlying spot market, it also contributed to the improvement of price discovery. Using the data of index futures market and spot stock market in India, Bose [5] found a co-integration relationship between the two markets, and also verified the long term price discovery function of the stock index futures through Vector Error Correction Model (VECM). These conclusions were also consistent with Christos and Dimitrios [7]'s study on stock index futures in Greek.

What is the impact of stock index futures trading on the fluctuation of underlying spot market, and what is the extent of informational efficiency of the stock index futures market in China? These are the main questions that we will focus on in this paper.

CSI 300 Index Futures is a brand new weathervane of information transference and pricing efficiency in Chinese capital market. While a considerable number of researches have studied the stock index futures in foreign countries such as U.S. and European countries, and a handful of studies have made multinational comparisons, only a few of them are related to the emerging markets. What is more, ever since the introduction of Chinese CSI 300 Index Futures, few empirical researches have been launched to focus on the price discovery function of stock index futures market and its impact on the volatility of the spot market. To fill this gap, this paper aims at investigating the changes in volatility of underlying spot index market after the advent of index futures contracts, as well as the interaction between the two markets when confronted with new information. This paper will deliver empirical evidence on the information transmission and pricing efficiency of the index futures market in China, and may also provide a basis for the future research in this field.

In the first place, this paper uses GARCH Model to examine whether the volatility of the spot market index spot market is alleviated after the introduction of stock index futures contracts, and thus to test the efficiency of information transmission in the index futures market in China. Secondly, the price discovery function of the stock index futures in the short run will be investigated through the Granger causation test, which is designed to verify the causation relationship between the stock index futures market and the underlying spot market. Last but not least, the long-term price discovery function of the stock index futures market will be checked by the co-integration tests and the Vector Error Correction Model (VECM).

88.2 Research Design

88.2.1 Data Source

Compared with the closing price, the settlement price will be less likely to be manipulated by investors. Therefore, statistics of CSI 300 Index Futures settlement price from 16th, April, 2010 to 18th, April,2011 is chosen in this paper. What is more, as the transaction is usually more active in the month right before the settlement month, we chose the index futures contracts with closest settlement month as our sample. There are a total of 242 stock index futures observations downloaded from CSMAR Database, a most popular database for financial research in China. At the same time, we chose 242 observations of the underlying spot market index before the introduction of stock index futures and and the same number of observations of spot market index right after it, with a total of 484 observations of spot market index, which is also obtained from the CSMAR Database.

Thus, the sample of the underlying spot market index is divided into two subgroups according to the time when the stock index futures contracts were initially offered. There are 242 samples in the first group and equally in the other. Furthermore, the return rate of stock index futures and spot market index can be calculated by taking the difference of the logarithm of the prices, i.e., $R_t = \ln(\frac{P_t}{P_{t-1}})$. After this procedure, we can get 242 stock index future returns and 484 spot market index returns.

88.2.2 Empirical Methodology

To investigate the impact of stock index futures on the information transition efficiency of underlying spot market, and the price discovery function in the stock index futures market, three questions should be answered: First, did the appearance of stock index futures contracts have positive, negative or no impact on the volatility of the spot market? Second, is there any temporary causation relationship between the two markets? Third, is there a long-term co-integration relationship between the two markets? And finally, Does the stock index futures market assimilate information faster than the spot stock market? If yes, it can be concluded that the stock index futures market performs the function of price discovery efficiently in the long run.

To answer the first question, we put a dummy variable, DV into the variance equation of the GARCH model on the daily returns of the CSI 300 Index. DV equals to zero for the sample of spot market index before the advent of stock index futures, and otherwise equals one. Denote the regression coefficient on the variable DV to be ω_1. The null hypothesis is $H_0 : \omega_1 = 0$. If the null hypothesis is rejected, it means that the introduction of stock index futures has little influence on the spot returns, and otherwise, it does have an impact to some extent.

To respond to the second concern, Granger Causality Test will be applied to examine the short-term price discovery function of the stock index futures market. Last but not least, Johansen test will be employed to test the long term co-integration relationship between the futures index and the underlying spot index. If the co-integration relationship holds, then VECM is applicable to test the correction speed of temporary divergence of the index prices in the two markets, which will provide a verification of the price discovery function of stock index futures market. If the result shows a larger coefficient on the error correction term in favor of stock index futures, then we can conclude that the error correction speed of the index futures market is larger than the spot market, and vice versa.

88.3 Empirical Results

88.3.1 Data Descriptions

The return of CSI 300 Index is shown in Fig. 88.1. The mean value of daily return approximates to zero. The standard deviation measuring the return risk is 2.1%. The Skewness is below-zero, implying left tailed, and the probability of Jarque-Bera is zero, both of which reject normal distribution. The Kurtosis is larger than 3, an implication of fat-tailed.

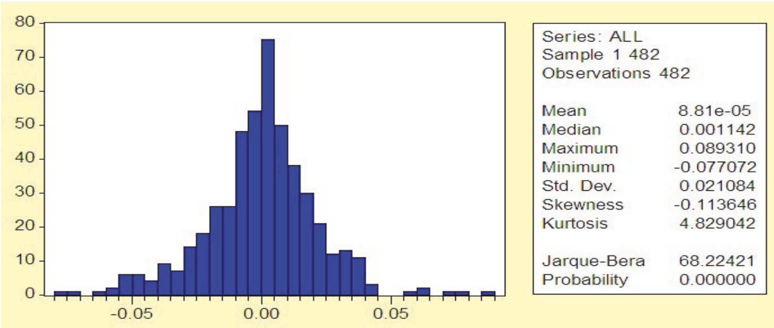

Fig. 88.1 Description of statistics on CSI 300 index returns

Fig. 88.2 shows the statistics on returns of CSI 300 index futures. The mean value of daily return also approximates zero. The standard deviation measuring the return risk is 1.7%. The Skewness is below-zero, implying left tailed, and the probability of Jarque-Bera is zero, both of which reject normal distribution. The Kurtosis is larger than 3, an implication of fat-tailed.

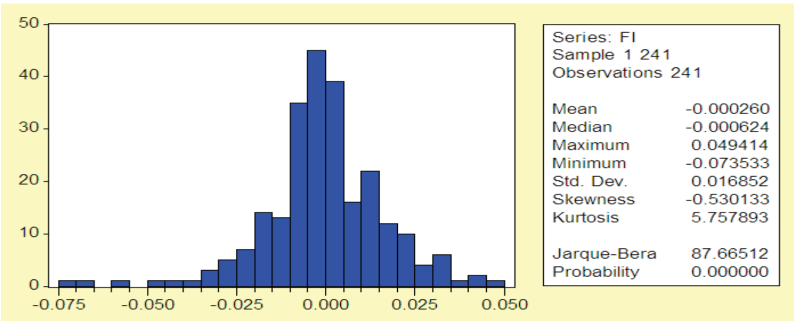

Fig. 88.2 Description of statistics on returns of CSI 300 index futures

Through ADF stability test, the result reveals that under 1% significance level, the standardized returns of CSI 300 Index Futures and the underlying spot market index are both stable time series, which fits the pre-condition of establishing GARCH Model. Besides, the prices of both index futures and the underlying spot index follow first order integration, which suits for the VAR Error Correction Model.

88.3.2 Impact on the Volatility of the Spot Index Returns

It is found that there is no significant autocorrelation and partial-autocorrelation on time series of the CSI300 Index return. However there exists a correlation in the square of returns. Through ARCH-LM effect test, it is found that there exists a high-order ARCH effect with lags of eight, implying that the sequence can be modeled by GARCH Model. Utilizing AIC, SC criteria, combined with Q-Statistics test, GARCH$(1,1)$ Model is selected to simulate the volatility circumstances. The result is shown by Table 88.1.

Table 88.1 GARCH$(1,1)$ Model

	Coefficient	*P* value
Mean Equation		
C	0.0004	0.6553
Variance Equation		
C	$4.82E-06$	0.1341
RESID$(-1)^2$	0.0510	0.0002
GARCH(-1)	0.9381	0.0000

Table 88.2 GARCH$(1,1)$ Model with the dummy variable of the introduction of stock index futures Model

	Coefficient	*P* value
Mean Equation		
C	0.0005	0.5274
Variance Equation		
C	$1.72E-05$	0.0205
RESID$(-1)^2$	0.0258	0.0330
GARCH(-1)	0.9483	0.0000
DV	$-1.19E-05$	0.0151

After building GARCH$(1,1)$, the test of residual sequence and the cross correlation of squared residuals both is zero, illustrating that the impact of new information on the volatility of returns is symmetrical and is suitable for GARCH$(1,1)$. What is next, a dummy variable (DV) representing the introduction of stock index futures contracts is added into the variance equation of GARCH$(1,1)$. From Table 88.2, it can be seen that the coefficient on the variable DV is significantly negative with a

P value lower than 5%. This indicates that after the appearance of stock index futures contracts, the volatility in the underlying spot market is significantly reduced to some extent.

Table 88.3 Granger causality test

Null Hypothesis	Obs.	F-statistic	Probability
INDEXFT is not the Granger Cause of INDEX	241	3.6108	0.0586
INDEX is not the Granger Cause of INDEXFT	241	11.9208	0.0007

88.3.3 Short-term Price Discovery Function of the Stock Index Futures Market

In order to verify the short-term price discovery function of the stock index futures market, we further investigate the causality relationship between the stock index futures and the underlying market by applying the method of Granger Causality Test in the sample of CSI 300 index future (abbreviated as INDEXFT) and CSI 300 spot index (abbreviated as INDEX). The result is shown in Table 88.3. There are two null hypotheses to test: (1) The stock index future is not the Granger cause of the underlying spot market index; (2) The spot market index is not the Granger cause of the index future. As revealed in the result, at the 90% confidence level, both of the null hypotheses are rejected, showing that there is a bi-direction causation relationship between the spot stock market and the stock index futures market in the short run: the change of spot market index has an effect on the following movement of stock index futures, while at the same time, the movement of stock index future also significantly influences the following change of spot market index. However, at the 95% confidence level, The causation from stock index future to stock index is no longer significant, while the causation from stock index to stock index future is still significant even at the 99% confidence level. This result indicates that the causation relationship from stock index futures to stock market index is relatively weaker than than the one in opposite direction. Therefore, the price discovery function of the stock index futures in the short run needs to be improved.

88.3.4 Long-term Price Discovery Function in the Stock Index Futures Market

As indicated in the ADF stability tests, The price series of both CSI 300 index future and the underlying spot CSI 300 index follow first order integration. We used Johansen unit root test to verify whether these two time series are co-integrated with each other. The result of Johansen test with a lag order of two is shown in Table 88.4. It can be seen from the result that there is one but only one co-integration relationship between the series of CSI 300 index future and that of the underlying spot CSI 300 index, i.e., in the long run equilibrium, there is a stable correlation between these two series. Thus, we can further analyze process of the price adjustment of these two index series to their long run relationship in equilibrium.

Table 88.4 Johansen test

Hypothesized No. of CE(s)	Obs.	Eigen value	Trace statistic 5% critical value	Probability
None	0.0638	18.4076	15.4947	0.0177
At most1	0.0107	2.5787	3.8415	0.1083

We employ the Vector Error Correction Model (VECM) to investigate the dynamic process of price adjustment in the two markets, in the condition of price equilibrium in the long term. Meanwhile, the VECM can also explore the effect of stock index futures on the future change of the underlying spot market index, as well the reverse effect of the spot market index on the future change of the stock index futures.

Table 88.5 VECM

Cointegrating Eq:	Coint Eq	
INDEXFT(−1)	1.0000	
INDEX(−1)	−1.052	
	[−44.1624]	
C	129.5953	
	[1.7848]	
Error Correction:	*D* (INDEXFT)	*D* (INDEX)
Coint Eq	−0.3741	−0.2182
	[−2.5977]	[−1.5860]
D(INDEXFT(−1))	-0.2728	0.0790
	[−1.1667]	[0.3538]
D(INDEX_FUTURES(−2))	-0.1001	-0.0892
	[−0.4601]	[−0.4294]
D(INDEX(−1))	0.2782	-0.0929
	[1.1075]	[−0.3872]
D(INDEX(−2))	0.0603	0.0653
	[0.2537]	[0.2875]

Note: In square brackets are t-statistics.

In Table 88.5, the first part of the result reveals the long term co-integration equation, also known as error correction term, which measures the long run relationship of the two market prices in equilibrium. While in the second part, the coefficients on the co-integrating equation, CointEq, indicate the price adjustment speed of stock index futures (represented as INDEXFT in the table) and the spot market index price (represented as INDEX in the table) from their current deviations to the long run relationship in equilibrium. The regression coefficient on stock index futures market is 0.37 compared with that of the spot market, 0.22, meaning that the price adjustment speed is faster in stock index futures market than in spot market index. Moreover, the negative sign of the coefficients on the error correction term are consistent with our expected adjustment direction to the long run equilibrium. This result, to some extent, reflects that the stock index futures market digests new information more efficiently and quickly. One possible explanation is that the stock index futures are more forward looking, and have lower transaction costs and higher liquidity.

88.4 Conclusions

The CSI 300 stock index future is a new weather vane for the information transmission efficiency and pricing efficiency of China's capital market. There has been quite a lot of researches on the efficiency of stock index futures in literature, but only a few of them are based on the emerging markets. Especially, empirical researches based on the recent data of stock index futures in China after the launch of the CSI 300 stock index futures in 2010 are seldom seen. This paper studies the change of stock market volatility before and after the introduction of stock index futures, as well as the interaction between and stock index futures market and spot stock market. Through the empirical analysis on the information transmission efficiency and pricing efficiency of the CSI 300 stock index futures, This paper provides some evidence on the effectiveness of the index futures market in China.

This paper first investigates the impact of the introduction of stock index futures on the volatility of spot market index by using $\mathrm{GARCH}(1,1)$ Model, and the result shows that the stock market fluctuations were alleviated after the introduction of stock index futures. Secondly, using the Granger Causation test, this paper found a reciprocal causation relationship between the spot market index and stock index futures in the short term, but the causation role of the stock index futures is relatively weaker than the spot market index. Thirdly, using the Johansen co-integration test and VECM model, this paper found a co-integrated long-run relationship between the stock index futures and spot stock index market, while the speed of price adjustment in the stock index futures from a deviation to equilibrium is greater than than that in the spot stock market. This further confirms that the stock index futures market in China generally performs the functions of price discovery and information transmission efficiently in the long run.

Thanks to the merits of low transaction cost and the high liquidity, stock index futures contract is an effective tool for risk management and price discovery.

Nevertheless, it is yet a two-edged weapon with the characteristic of high leverage, which can be abused by some irrational investors to manipulate and tempest market. The government and relevant administrative organizations should thus improve the surveillance system to insure the sound performance of the stock index futures market.

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Chapter 89
Market Reaction to Repurchase Announcement-A Study for UK 2010-2011 Stock Market Reaction

Yong Zheng and Rui Gong

Abstract To examine the market reaction of a share repurchase announcement and try to determine a proper explanation for the reaction pattern, this paper uses the traditional event study method with 148 UK cross-sectional observations between 1th January 2010 and 1th December 2011. We choose average abnormal return and cumulative abnormal return as dependent variables respectively, and market to book value (MTBV) and repurchase size as independent variables. two robustness regressions are going to be run for each dependent variable. PE ratio and Tobin's q will replace the MTBV to make sure the models are reliable. Through the regressions, there is a positive relationship between the average abnormal return and MTBV and a negative relationship between the average abnormal return and repurchase size. The same relationships apply to the cumulative abnormal return, MTBV and repurchase size. However, even we observed the positive relationship between abnormal return and company's growth prospect, the results are not statistical significant. Therefore, through my data, I cannot prove the signaling theory or agency theory of free cash flow.

Keywords Abnormal return · Growth prospect · Signaling theory · Agency theory

89.1 Introduction

The action of a public listed company redeems a certain amount of outstanding shares is called stock repurchase. As a crucial tool of capital market operation, share repurchases plays an increasingly important role in security market. Among large American industry corporation, share repurchases has first time exceed cash dividend as a payout form during the period between 1999 and 2000. The total share

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repurchases amounts for Standard & Poor's 500 companies has reached 349 billion dollars in 2005, which increased by 77% compared to the previous year's data. At the same period, cash dividend only increased by 11.5%, the fund companies used to repurchase shares was 73% higher than used in case dividend.

In general, the following reasons contribute to the increasing important role of share repurchases: The first reason is share repurchases improve ownership structure. The share repurchases can change the company's original capital structure no matter share repurchases through cash or through debt. The market share posses by outside investors will be lower and the weight of stocks possesses by original shareholders will be higher if company repurchase shares from outsiders, therefore the control force of original shareholders over the company will be enhanced; Second, share repurchases stimulate market value of the company. Many empirical studied has proved that share repurchases do stimulate share price to increase; Third, share repurchases help to control speculation investors, smooth volatility in stock price and enhance the stability in stock market operation. Share repurchases is an important tool to determine a reasonable level of share price and has positive influence on speculation controlling. When macroeconomic has a downturn pressure, the market has insufficient fund and stock market may get into distress. If the downturn lasts for a relative long period and stock market will get into an even worse situation. At this time, company can buy back their shares by using their idle fund to enhance market mobility to a certain extent and raise the share price back to a reasonable level. In general, managers should be the most informed people about the company's situation, thus the repurchase price they choose can be considered as a fair value of the company (except in anti-takeover case). Also, treasury shares can be acquired through share repurchases. Treasury stock is a useful mean to suppress the overheating share price and pull them back to a fair level when the stock price is considered to be overpriced; Fifth, share repurchases are important for establishing of staff shareholder's system and stock option stimulation system. The employment stimulation system; Sixth, share repurchase can stimulate Earning per Share (EPS). When the prospect of company profitability is hard to quantify, investors rely on EPS ratio to estimate. Companies can dilute the denominators when calculated EPS by reducing the outstanding shares through share repurchases. But it should be very clear such manipulation is one-off action and the manipulated EPS boost effect is temporary. This tool should be only used under extreme circumstances like financial distress.

Since the semi-strong hypothesis of EMH suggests that the market price of shares should include all public information, and the market should be reacted to new information immediately, there should be a significant abnormal return at the announcement day when the share repurchase happens if the repurchase news itself is economically significant. Many great empirical studies have shown us the abnormal return does exist, and the abnormal returns tend to be positive. Academic have an explanation to the positive and negative abnormal return: the positive abnormal return indicates that investors think the management will only exercise the repurchase when the company's shares are undervalue; the negative abnormal return indicates the investors think the management exercise the share repurchase to avoid presenting too much cash on the company's balance sheet since the company is lack of potential profitable projects to invest, though it is not supported by the empirical results. The above reasons release the signaling theory and agency theory of free cash flow. However, in this paper, we are going to investigate the story behind the abnormal return. Assuming all the investors in the market are EMH believer, what they are pursuing is to maximize the short-term abnormal return. The growth factors drive up or down the abnormal return will be my research objects.

89.2 Literature Review

Modigliani and Miller [8] suggests that payout policy is irrelevant to returns since the tax benefits the company achieved offset the negative effect of debt, like increased borrow rate. But some assumptions of M&M fail and some empirical studies have shown payout policy does closely relate to return. Bray et al [1] releases that clienteles is a strong reason for firms to set out their payout policies. Even large normal institutional investors have no preference between share repurchases and dividend payout, most small institution and individual investors do prefer to receive dividend. Those preferences may distort the returns from the normal level.

According to Wang et al [8], the market delivers a negative abnormal return to glamour stock. They have shown that there is a negative relationship between the Tobin's q and returns. Also, they give evidence that market become unfavourable when the same firm exercise repurchases consecutively. Since McNally [10] indicates the repurchase size are positively linked to shares' return from 1984 to 1988 in US market, we will put and test this factor in my model in UK market from 2010 to 2011.

The signaling theory and the agency theory of free cash flow are two widely accepted theories that explain the key motivations of share repurchases. Under signaling theory, the self-tender repurchase company has to pay a premium in order to make sure the transaction goes smoothly. Dann [2] examed the effect of share repurchases on shareholders' return, and concludes that the main motivation for companies to implement the share repurchases is delivering a positive signal to investors. However, there is no clear explanation that why company prefer choosing expensive tender offer purchases rather than other cheap alternatives in his paper.

Netter and Mitchell [9] investigate the repurchase and internal transaction cases in US stock market after crash in October 1987. They found the following discoveries: abnormal return do exist and it lasts for 40 trading days after the repurchase announcement; Since the problem of asymmetric information, Insiders will buy stocks if they believe the prospect of company is good and sell stocks if the company's prospect is bad, the company's future performance can be estimated by those information. Their findings support the signaling theory exists in stock repurchases.

Ikenberry et al [5] shows the average abnormal returns is 3.5% after the open market repurchases announcement. Their findings are consistent with previous studies, estimations and the signaling theory hypothesis. However, the 3.5% abnormal return is too small to cover the underestimate part of stock price. They suggests under reaction hypothesis emerge, investors will retain suspicious attitude at the beginning. Stock price will adjust gradually to its estimated level only after an adequate period of time with the release of positive information, that is, they believe the event period of the reaction will be a relatively longer than traditionally estimated. The same paper of them proved under reaction hypothesis, the cumulative abnormal return for 4 years is 12% if investors use buy-and-hold strategy after on-month from the announcement day.

Signaling theory and Agency theory of free cash flow are two contradictive theoretical support of the relationship between abnormal return and share repurchases. It is well known that the traditional signaling theory indicates that the management will only exercise the share repurchases from the market when they believe the company's shares are undervalued. This signaling theory mainly comes from the assumption of asymmetric information, and the theory suggests the share price is positive related with the share repurchases event. On the other hand, Agency theory of free cash flow suggests the relationship between abnormal return and share repurchases event is negative since the repurchase itself implies the company is lack of good investment opportunities and fund management skills.

According to Hjelmstad et al [4], the native relationship between company's growth prospect and abnormal return do exist and quite significant. In their paper, they choose four different growth indicators to test the data: Market to book value (MTBV), PE ratio, relative industry PE ratio and modified Tobin's q. Among those indicators, MTBV is the basic one, and other three indicators are proxies to test the robustness of the model. Generally, the market believes all those four indicators are related to the company's growth prospect: the higher the numbers, the higher future growth rate of the company will have. The results of the their paper are: there is a negative relationship between proxies and abnormal return and all four indicators deliver the same results and statistically reliable. Their paper implies that the agency theory of free cash flow dominants over the signaling theory.

This research is going to exam the real relationship between shares repurchase and share price in UK stock market from 2010 to 2011, and will answer the question: whether the relationship between share repurchases and abnormal return still exist after a catastrophic financial crisis, are investors become more suspicious or they turn around and become a signaling theory believer?

We choose UK stock market over US stock market as the research market because the following reasons: Although US firms are required to disclose their capital truncations in their cash flow statements since 1982, the disclosures are not in details and sometimes it contains other forms of capital transactions, such as convert other type of or other class of equity into common stock, retirement of common and preferred stock or redemption of redeemable stocks. Those polluted data are not good for my estimation about the effect of share repurchases.

89.3 Methodology

89.3.1 Data Collection and Screening

The data we use come from listed stocks in London Stock Exchange from 1st January 2010 to 1st December 2011.

To ensure the effectiveness of the model, sample companies was derived from all industry sectors on London Stock Exchange. There are over 14337 equity transaction announcements from year 2010 to 2011. The announcements of internally transfer owned share to treasury or transaction about preferred shares is about 37% of overall data; the announcements of employment benefit scheme transactions is about 15%. The above types of data should be removed from the total data.

Table 89.1 Screening process

	Number of announcements	%
Original total number from LSE RNS	14337	
Less:		
Not ordinary share repurchase	5246	36.59
Repurchase for employment benefit scheme	2062	14.38
Less:		
No repurchase price or volume	29	0.20
No share remaining figure	73	0.51
No Yahoo finance code	542	3.78
No accounting data in thomson one banker	730	5.09
Repeated repurchase annoucement in short term	5507	38.41
Final sample	148	1.03

The remaining data have to be further filtered in order to satisfy the purpose of my research. The suitable data have to meet the following conditions: first, the repurchased shares should be ordinary shares only. Second, to ensure the market reaction to share repurchases is immediately and adequately, the repurchases announcement must be the first announcement in the past 6 months. Third, to investigate the effect of share repurchases, this research make sure the repurchase is an isolate event and no other types of major corporate events before or after 5 days of the repurchase announcement day. In addition, under the case of some repurchase events may be along with several further repurchase activities within a month, we only consider the first share repurchase. The date screening process can be showed at Table 89.1.

89.3.2 Data Descriptive

(1) Industry analysis

As mentioned above in Table 89.1, to increase the reliability of the model, the research includes all industries classified by London Exchange Stock. The 148 companies distributed in 29 different industries. Except equity investment instruments industry and financial services industry, we include all share repurchase transactions in other industries. The reason we do not include all the transactions in those two industries because there are too many share repurchase transactions in those industries, and we try to avoid the bias in samples.

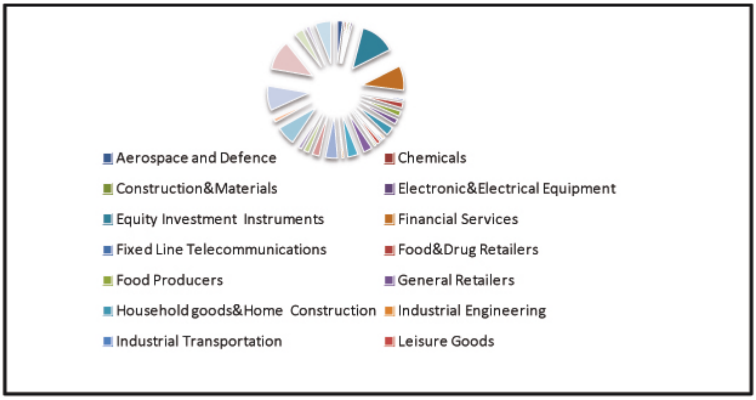

Fig. 89.1 Sector analysis

(2) Capital value analysis

Fig. 89.2 shows the classification of companies by their market values. Most of those companies have a market value below 100 million pounds, which called those companies small-cap companies. Those companies are not traded as actively as large-cap companies. In this situation, the signaling theory and agency theory of free cash flow may be severely suppressed because of the low popularity of the data. However, it is good opportunity for us to study whether the signaling and agency theory still exist in those small-cap companies.

(3) Trading day returns

Fig. 89.3 shows the average abnormal returns and cumulative abnormal returns. Both lines suggest the fluctuation of stock price during the 5 days event period. It is clear from the graph that the average abnormal returns were positive during the 5 days and peaked at one-day before the share repurchase announcement, reached around 0.51%. The least average abnormal return occurred after 2 days of the share repurchase announcement, was only around 0.16%, and this is consistent with other empirical results, that the post-event return falls back to zero gradually. From the figure above, we can see: the cumulative abnormal returns significantly derivate

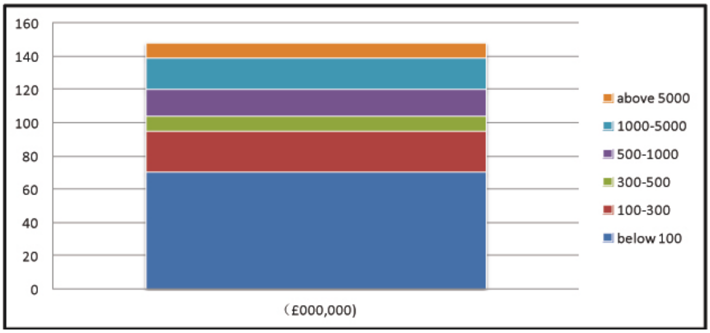

Fig. 89.2 Capital value analysis

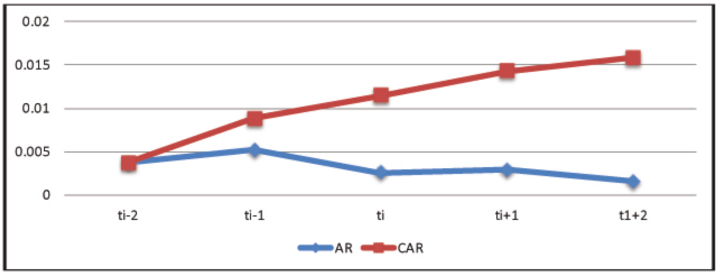

Fig. 89.3 Trading day returns

from zero and higher than the trading day returns and the largest of it occurred at 2dyas after the share repurchase announcement, reached around 1.6%. This result is same as some other empirical studies.

(4) Market model

Table 89.2 Market model parameters analysis

	Tobin's *q*	MTBV	PE ratio	Relative repurchase size (%)
Mean	2.917971	3.753447	20.0973	0.008848236
Median	1.437825	1.101745	12.9	0.001234656
Std. Derivation	8.676507	19.93896	23.09026	0.025756326
High	96.24743	239.8534	168.3	0.176250012
Low	0.243396	−9.24211	0.6	5.17998E−05

Table 89.2 shows the mean, median, Std. Derivation and maximum and minimum of all three parameters in my market model and the relative repurchase size. Since Tobin's *q* is a measure of market value and the replacement of the company's asset and the median is higher than one shows most companies in my data set are overvalued. The median of MTBV ratio is also positive, which implies companies'

market value is larger than its book value, and considered to be over value. Relative repurchase size is calculated by divide the share remaining after the repurchase by the amount of share repurchases. It is should be noticed that the shares remaining number exclude the reassure stock amount.

89.3.3 Methodology

A traditional event study procedure is used to exam the relationship between share repurchases announcement and share price. In general, the existence after-announcement of abnormal return suggests the positive effect from the announcement itself, and the size of return indicates the effectiveness of the announcement. The model I use in this paper to acquire the abnormal return is the market model:

$$AR_{i,t} = R_{i,t} - \alpha_i - \beta_i R_{M,t},$$

where $AR_{i,t}$ = Abnormal return of the event; $R_{i,t}$ = Return of the event; $R_{M,t}$ = Market return of the event period; α_i and β_i = market model parameters, representing the slope and intercept from OLS regression.

The estimation period is 6 months until 1 day before the share repurchase event, the actual effective trading calendar days is 120 to 135 days. The market model parameters, α_i and β_i, can be derive using Excel "Slope" and "Intercept" function (Please see Excel files for more detail). Market return is the return of FTSE All-Share Index. All the companies' return and shares' return mainly come from Yahoo Finance along with some supplementary information from Google Finance.

We use the 1 day's return as event window. In addition, to improve the validity, I extend the event window of my model by considering a cumulative abnormal return (CAR). The formula is:

$$\mathrm{CAR}_{-t,t} = \sum_{i=-t}^{t} AR_i$$

and it will take the pre-announcement 1 and 2 day and post-announcement 1 and 2 days as event window. Considering public holidays and weekend, the window consists 3-5 calendar trading days. The market-to-book (MTBV) ratio is the key indicator of growth prospect. According to signaling theory, a higher MTBV ratio company indicates a better growth prospect, so the abnormal return obtained from the share repurchases should be higher than the companies with lower MTBV ratio. Otherwise, the agency theory suggests a negative relationship between MTBV and abnormal return. Therefore, we will add two other proxies to test the robustness of my model: PE ratio and modified tobin's q. PE ratio are known to be similar as MTBV ratios. Investors believe a company with higher PE ratio will has a higher growth prospect in the near future, vice versa. The modified Tobin's q is an alternative indicator of the companies' future growth prospect in Marshall and Walmsley

[4]. It is a ratio between total fund value available to investors (including all available funds like preferred shares, common shares and debt) and the book value of available operation assets or working capital. The formula of modified Tobin's q is:

$$q = \frac{\mathrm{MV} + \mathrm{PREF} + \mathrm{DEBT}}{\mathrm{ASSETS}},$$

where MV = market value of company's pre-event common share. Note that the market value was calculated using the pre-event (before repurchase) share number times the repurchase price. PREF = book value of company's year-end preference share, this figure will not change frequently, so I the fiscal year-end balance sheet numbers. DEBT = book value of company' s year-end book value of total debt. ASSET = asset employed by company's operation, generally know as operating asset or working capital, computed by total assets minus current liabilities.

Most fundamental information of the company, such as book value of the company, PE ratio and some balance sheet figure of the company, come from Thomson one banker data base along with some supplementary information from London stock Exchange.

89.4 Results

89.4.1 Hypothesis Test

First, we test whether the event day abnormal returns are significantly deviate and above from zero by simple T-test.
$H_0 : AR_t \leq 0$
$H_1 : AR_t > 0$

$$T = \frac{AT_t - 0}{\frac{\mathrm{Sta.Dev}(AR_t)}{\sqrt{n}}} \sim t(n-k),$$

where N = 148 (Sample size); K = 1 (Estimate parameters); T = 23.5064; The critical value of 147 degrees of freedom is 3.145 (one-tail 1% significant level); So the null hypothesis should be rejected. So the trading day abnormal return is statistically significant.

Second, the same T-test is used to test the significant of CAR.
H_0 : CAR ≤ 0 (market reaction normal),
H_1 : CAR > 0 (cumulative abnormal return exist)

$$T = \frac{\mathrm{CAR}_t - 0}{\frac{\mathrm{Sta.Dev}(\mathrm{CAR}_t)}{\sqrt{n}}} \sim t(n-k),$$

where $N = 148$ (Sample size); $K = 1$ (Estimate parameters); $T = 59.66$; the critical value of 147 degrees of freedom is 3.145 (one-tail 1% significant level); So the null hypothesis should be rejected. So the cumulative abnormal return is statistically significant.

From the above hypothesis test, both abnormal return and cumulative abnormal return are significant. This result is consistent with other empirical studies.

89.4.2 Empirical Results

The software this research used to run all regressions in this paper is PcGive. The regression will be use the one day abnormal return and 5 days event window abnormal return as dependent parameters respectively. The basic regression contains the AR and CAR with MTBV and relative repurchase size, and MTBV and relative repurchase size are the independent parameters. Also, a robustness test will be run in the following, and PE ratio and Tobin's q will replace MTBV as a proxy respectively.

Table 89.3 shows the results of the following regression:

$$AR_i = \alpha_i + \beta X_i + \lambda Z_i + \varepsilon_i, \tag{89.1}$$

where α_i = constant; β = MTBV of the firm i; λ = the percentage size of the share repurchase of firm i; ε_i = Random error term; AR_i = Average Abnormal return of firm i.

Table 89.3 Regression results – I

	Coefficient	Std. Error	t-value	t-prob	Part. R^2
Constant	0.00424748	0.001368	3.11	0.0023	0.0624
MTBV	2.80865e−005	6.394e−005	0.439	0.6611	0.0013
Repurchase size	−0.133550	0.04950	−2.70	0.0078	0.0478
sigma	0.0154432	RSS		0.0345813717	
R^2	0.0497507	$F(2,147) =$		3.796 [0.025]*	
Log-likelihood	408.759	DW		2.17	
No. of observations	148	no. of parameters		3	
mean (Y)	0.00317122	var(Y)		0.000245891	

The results shows there is a positive relationship between MTBV and average abnormal return while the relationship between the repurchases size and average abnormal return is negative. However, the positive value of MTBV is quite small and the t value of MTBV is 0.439. Those results mean the data is not significant at the 5% level. The t-value of repurchases size is −2.7, which is significant at 1% level. The R square is 5% of my model, which is a respectable level. Although we obtained the positive relationship between MTBV and average abnormal return, which is consistent with the signaling theory, the results is not statistically significant.

Table 89.4 Regression results – II

	Coefficient	Std. Error	t-value	t-prob	Part. R^2
Constant	0.0212374	0.006838	3.11	0.0023	0.0624
MV/BV	0.000140432	0.0003197	0.439	0.6611	0.0013
Repurchase size	−0.667750	0.2475	−2.70	0.0078	0.0478
sigma	0.077216	RSS		0.864534293	
R^2	0.0497507	$F(2,147) =$		3.796 [0.025]*	
Log-likelihood	170.563	DW		2.17	
No. of observations	148	no. of parameters		3	
mean (Y)	0.0158561	var(Y)		0.00614728	

Table 89.4 shows the results of the following regression:

$$\mathrm{CAR}_i = \alpha + \beta X_i + \lambda Z_i + \varepsilon_i, \tag{89.2}$$

where α_i = constant; β = MTBV of the firm i; λ = the percentage size of the share repurchase of firm i; ε_i = Random error term; CAR_i = the cumulative abnormal return of firm i.

The results show the MTBV is positively related with cumulative abnormal return while repurchase size is negatively related with cumulative abnormal return. However, the problem is the same as the above regression. Even though I still obtained a positive relationship between MTBV and CRA, its t-value is 0.439, which is not statistically significant. The t-value of repurchases size is −2.7, which is significant at 1% level. The model still has a respectable explanatory power since the R square of the model is 5%.

In the following, four regressions is run to test the reliability of the above two regressions.

Table 89.5 and Table 89.6 are the robustness tests of the regression in Table 89.3. PE ratio and Tobin's are replaced MTBV in the new regression while I still keep the repurchase size as another independent variable. In Table 89.5, there is a negative relationship between PE ratio and average abnormal return while the repurchase size is still negatively linked with average abnormal return. The t-values of PE ratio still indicates that it is not statistical significant at 5% level. We cannot prove the signaling theory or agency theory of free cash flow by those results. Like the regression results in Table 89.3, the relationship between repurchase size and average abnormal return is negative and statistical significant. R square of the regression 5.7%, which means our model still keep an acceptable explanatory power. In Table 89.6, Tobin's q is used to replace MTBV and we obtained the consistent results as the Table 89.3: the relationship between Tobin's q and average abnormal return is positive although it is not statistical significant as the t-value of Tobin's q is only 0.901. On

Table 89.5 Regression results – III

	Coefficient	Std. Error	t-value	t-prob	Part. R^2
Constant	0.00571820	0.001773	3.23	0.0016	0.0669
PE Ratio	$-6.44904e{-}005$	$5.533e{-}005$	-1.17	0.2457	0.0093
Repurchase size	-0.141372	0.04961	-2.85	0.0050	0.0530
sigma	0.0153816	RSS		0.0343060081	
R^2	0.0573173	$F(2,147) =$		4.408 [0.014]*	
Log-likelihood	409.351	DW		2.2	
No. of observations	148	no. of parameters		3	
mean (Y)	0.00317122	var(Y)		0.000245891	

Table 89.6 Regression results – IV

	Coefficient	Std. Error	t-value	t-prob	Part. R^2
Constant	0.00395528	0.001414	2.80	0.0058	0.0512
Tobin's Q	0.000132230	0.0001467	0.901	0.3688	0.0056
Repurchase size	-0.132219	0.04941	-2.68	0.0083	0.0471
sigma	0.034704	RSS		0.0344344023	
R^2	0.0154103	$F(2,147) =$		4.121 [0.018]*	
Log-likelihood	0.0537892	DW		2.17	
No. of observations	148	no. of parameters		3	
mean (Y)	0.00317122	var(Y)		0.000245891	

the other hand, the repurchase size is native linked with average abnormal return and significant at 1% level.

To summary, in all three regressions, we obtained the same result for the relationship between share repurchase size and average abnormal return: they are negatively related and the relationship is statistical significant, that is, the larger the size of share repurchase event, the smaller average abnormal return the investors will obtained. On the contrary, the relationship between MTBV and the average abnormal return is positive, which is consistent with the signaling theory, that is, investors believe the management will only exercise the share repurchases only when they believe the company's shares are undervalued, so the positive signal lead to a positive average abnormal return. However, there are two problems here: first, the result is not statistical significant. Second, I did not obtained the consistent results during the robustness regressions. Although the Tobin's q is positive relate to average abnormal return, the PE ratio obtained a different relationship. Therefore, from the regressions in Tables 89.3, 89.5 and 89.6, we cannot prove the signaling theory or agency theory of free cash flows.

In the following, we run the robustness regressions for regression 2 by replacing MTBV with PE ratio and Tobin's q.

Table 89.7 Regression results – V

	Coefficient	Std. Error	t-value	t-prob	Part. R^2
Constant	0.0285910	0.008865	3.23	0.0016	0.0669
PE Ratio	−0.000322452	0.0002767	−1.17	0.2457	0.0093
Repurchase size	−0.706861	0.2480	−2.85	0.0050	0.0530
sigma	0.0769079	RSS		0.857650203	
R^2	0.0573173	$F(2,147) =$		4.408 [0.014]	
Log-likelihood	171.154	DW		2.2	
No. of observations	148	no. of parameters		3	
mean (Y)	0.0158561	var(Y)		0.00614728	

Table 89.8 Regression results – VI

	Coefficient	Std. Error	t-value	t-prob	Part. R^2
Constant	0.0197764	0.007068	2.80	0.0058	0.0512
Tobin's Q	0.000661151	0.0007334	0.901	0.3688	0.0056
Repurchase size	−0.661093	0.2471	−2.68	0.0083	0.0471
sigma	0.0770517	RSS		0.860860058	
R^2	0.0537892	$F(2,147) =$		4.121 [0.018]*	
Log-likelihood	170.878	DW		2.17	
No. of observations	148	no. of parameters		3	
mean (Y)	0.0158561	var(Y)		0.00614728	

Table 89.7 and Table 89.8 show the results of the robustness regressions. From the above tables, it is clear that we obtained the same results when we run the robustness regressions for average abnormal return: there is a negative relationship between PE ration and cumulative abnormal return and a positive relationship between Tobin's q and cumulative abnormal return is proven. However, those relationships are also not significant. The share repurchase size has a negative and significant relationship with cumulative abnormal return. R squares of both regressions are remaining respectable, which are 5.7% and 5.3% respectively.

In conclusion, the robustness regressions of regression 2 have the same problems as the robustness regressions of regressions 1. The results are not significant and inconsistent. I still cannot prove that the signaling theory and agency theory of free cash flow through those regressions. However, I still prove the relationship between the share repurchase size and cumulative abnormal return. As the average abnormal return, the cumulative abnormal return will be decrease when the share repurchases size increase. Their negative relationship is significant at 1% level.

Although we obtained the positive relationships between average abnormal return and MTBV as well as the positive relationships between 5 days cumulative abnormal return and MTBV, the problem here we did not obtain a statistical significant result. These problems may because most of my choosing companies have capital value under £100 million. Therefore, we decide to divide my sample into two sub-samples: companies with market value under £100 million and companies with market value above £100 million, and run the regression 1 and 2 again to check whether the "small-cap" problem deviate my results from signaling theory or agency theory of free cash flow. The following tables show the regressions of small-cap companies.

Table 89.9 Regression results – VII

	Coefficient	Std. Error	t-value	t-prob	Part. R^2
Constant	0.00686585	0.002840	2.42	0.0183	0.0802
MTBV	−0.000327353	0.001374	−0.238	0.8124	0.0008
Repurchase size	−0.151148	0.06402	−2.36	0.0211	0.0768
sigma	0.0190596	RSS		0.0243388951	
R^2	0.0773099	$F(2,147) =$		2.807 [0.068]*	
Log-likelihood	179.42	DW		1.53	
No. of observations	70	no. of parameters		3	
mean (Y)	0.00408126	var(Y)		0.00376831	

Table 89.10 Regression results – VIII

	Coefficient	Std. Error	t-value	t-prob	Part. R^2
Constant	0.0343293	0.01420	2.42	0.0183	0.0802
MTBV	−0.00163677	0.006868	−0.238	0.8124	0.0008
Repurchase size	−0.755738	0.3201	−2.36	0.0211	0.0768
sigma	0.0952978	RSS		0.608472378	
R^2	0.0773099	$F(2,147) =$		2.807 [0.068]*	
Log-likelihood	66.7598	DW		1.53	
No. of observations	70	no. of parameters		3	
mean (Y)	0.0204063	var(Y)		0.00942078	

From Table 89.9 and Table 89.10, it is clear there is a negative relationship both between average abnormal return and MTBV and cumulative abnormal return and MTBV. However, it seems that I did not solve the problem since the relationships are still not significant. The t-value of MTBV are both −0.238, which means the results are not statistical significant. The R squares of both regressions are acceptable.

Unfortunately, according to Tables 89.11 and 89.12, the t-values of MTBV are still not significant. This means even for those large cap companies, who are trade frequently on market, the signaling theory or the agency theory of free cash flow cannot be proved through the data.

Table 89.11 Regression results – IX

	Coefficient	Std. Error	t-value	t-prob	Part. R^2
Constant	0.00305675	0.001464	2.09	0.0402	0.0549
MTBV	3.94303e−005	4.717e−005	0.836	0.4058	0.0092
Repurchase size	−0.447772	0.3016	−1.48	0.1418	0.0286
sigma	0.0112644	RSS		0.00951654886	
R^2	0.0390921	$F(2,147) =$		1.526 [0.244]	
Log-likelihood	240.769	DW		1.95	
No. of observations	78	no. of parameters		3	
mean (Y)	0.00235452	var(Y)		0.000126971	

Table 89.12 Regression results – X

	Coefficient	Std. Error	t-value	t-prob	Part. R^2
Constant	0.0152837	0.007321	2.09	0.0402	0.0549
MTBV	0.000197151	0.0022358	0.836	0.4058	0.0092
Repurchase size	−2.23886	1.508	−1.48	0.1418	0.0286
sigma	0.0563221	RSS		0.237913722	
R^2	0.0390921	$F(2,147) =$		1.526 [0.244]	
Log-likelihood	115.232	DW		1.95	
No. of observations	78	no. of parameters		3	
mean (Y)	0.0117726	var(Y)		0.00317426	

89.5 Conclusion

This paper exam the market reaction to the announcement of share repurchases and tries to find a suitable explanation for such reaction. It was found that there is positive relationship between the company's growth prospect and one day abnormal return and cumulative abnormal return in London Stock Exchange during the period of 1st January 2010 to 1st December 2011. This is consistent with the signaling theory, that is, investors believe share repurchase event is positive information since managers believe the company's share value is undervalued and the company's future prospect is going to be better. However, the problem here I did not obtain a statistical significant result. I divide the whole samples into two sub-samples, companies with market value under £100 million and companies with market value above £100 million, to fix the problem. Unfortunately, the problem is not solved; therefore the signaling theory and the agency theory of free cash flow are not related to the company's size. I also achieve the conclusion that there is negative relationship between share repurchase size and average abnormal return and cumulative abnormal return, which means the larger the repurchase size, the less average abnormal return and cumulative abnormal return the investors obtained. It should be noticed that since the data I obtained from a relative short period, the regression results may be influenced by some same factors, such as macroeconomic conditions. The short period of time may lead to the results are bias. In addition, some data of some companies are not available in one database; I have to search data in other supplementary database. The problem here is different database may have difference in data, such as the market value may be estimated at different standard in different database. Also, some companies with negative earnings in the estimation period could not provide the PE ratio data. Those limitations can be improved by expanding the data collection range, for example, expanding the estimation period from 2 years to 5 years and try to avoid some significant influential events, such as the event of Lehman Brothers.

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Chapter 90
Strategic HRM Practices in Roche Pharmacueticals, Pakistan

Nadeem A. Syed, Farooq A. Cheema, Asif Kamran and Noman Khalid

Abstract In an organization, people working individually or collectively contribute to the achievement of the objectives of business. The use of a strategic and coherent approach to the management of organization's most valuable assets-the people working is known as Human Resource Management (HRM). This paper entails the extent the "best practices" are being practiced by Roche Pharmaceuticals, Pakistan for superior performance. We would like to recommend to the management that other HR practices should be applied like reverse mentoring. The concept of reverse mentoring is that of filling in the gaps of knowledge and skill of the older employees with regard to emerging trends. As most of the employees around 70% are above the age of 30 so this practice will really be applied in order to gain profitability. The main objective of the study is to understand the changes in strategic HRM practices (Role and Structure of HR department, Recruitment, Retraining and Redeployment, Performance Appraisal, Compensation, Career Planning and Performance Management System) in Roche Pharmaceuticals, Pakistan. The HR is playing an important role in the transformation of Pakistan from an underdeveloped country to prosperous nation. Roche is conducting induction training for all their employees.

Keywords Human Resource Management (HRM) · Strategic Human Resource Management (SHRM)

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90.1 Introduction

In an organization, people working individually or collectively contribute to the achievement of the objectives of business. The use of a strategic and coherent approach to the management of organization's most valuable assets-the people working is known as Human Resource Management (HRM) (wikipedia). As per Zareen HRM plays much more strategic role in business, aligning its practices to support the business philosophy and strategy of the firm [1]. The recognition that management of HR plays critical role in firms' performance is relatively important. The question of how strategic is HRM and how strategic human resource management (SHRM) is linked to organizational performance is of great interest. Strategic human resource management practices in Roche pharmaceuticals, Pakistan limited. It will be focusing on the different implications of strategic HRM practices in Roche Pharmaceuticals for managing the relations of the workforce.

90.1.1 Industry Overview

The pharmaceutical industry consists of numerous players, all of whom hold only a small market share of the industry [2]. In "A Bigger, Richer World," Kim Clark cited Glaxo Wellcome as the second largest revenue earning company in pharmaceuticals, though it only holds 4.7% market share. It is only preceded in the market by Novartis, created by the 1996 merger of Sandoz and Ciba-Geigy.

The 1996 Global 500 lists ten international pharmaceutical companies: Johnson & Johnson (7.35%), Merck (6.5%), Bristol-Myers Squibb (5.3%), American Home Products (5.22%), Sandoz (5.03%), Roche Holding (4.86%), Glaxo Wellcome (4.7%), SmithKline Beecham (4.3%), Pfizer (3.9%), and Abbott Laboratories (3.9%). The Fortune 500 listing of only American companies lists fifteen pharmaceutical companies. Other notable global pharmaceutical companies, such as Bayer, are not included because their primary business is not in pharmaceuticals.

90.1.2 Roche Pakistan

Roche products were available in the sub-continent even before partition. After Pakistan emerged on the world map, imports continued, and after a few years some products started to be toll manufactured in Karachi. In the year 1984, the foundation of the Roche plant was laid in Korangi Industrial Area on the outskirts of Karachi. Within a span of three years the plant was constructed and Roche Pakistan started local manufacturing in October 1987.

Today Roche Pakistan's business covers both Pharmaceuticals and Diagnostics. In the Pharma market Roche is ranked among the top ten companies while in the Diagnostic sector Roche is the market leader. We play a leading role in therapeutic areas such as cancer, virology and transplantation. The combined strengths of our diagnostics and pharmaceutical businesses, coupled with expertise in the emerging genetic sciences, equip us to develop integrated healthcare solutions and therapeutic approaches tailored to individual patients' needs. Roche's products and services address the entire healthcare spectrum, from screening for genetic risk factors, to preventing, diagnosing and treating disease, and monitoring the treatment response.

The direct and related stakeholders are Medical Professions, Patients, Suppliers, Society, Environment, Shareholders and Investors, Employees.

90.2 Literature Review

90.2.1 HR Policies and Practices in the Context of Pakistan

The idea of HRM is to build up the productive contribution of people in business. It is the development of society to get consistent [3]. In the less developed countries, increasing demand of HR is an effort by growing idea and development. HRM has undergone to bring changes. Currently, the consistent change in the nurture of HRM is mandatory in organizations [4]. This move smoothly includes labor force involvement, high skilled growth, and globalization and brings revolution in the intellect of workers [5]. HRM is doing very significant work to select, recruit and train the right people at the right time at the right place for right type of work. Today's HR managers work on operational levels, managerial levels and strategic levels. HRM practices and policies can change employee commitment and enabling the organization better [6]. The knowledge, education, training, skills and expertise of a firm's worker act the expense of physical capital like equipment, machinery and the physical plant. The HR of an organization consists of all people who act upon its activities. HRM Professionals has up to date knowledge about activities as HR planning, equal employment opportunity, recruitment and training. Just before achieving purpose and objectives, the HR departments obtain, develop, utilize, evaluate, maintain and retain the exact records and form of employees to supply labor force [3]. Manufacturing jobs in the steel, vehicle, rubber and fabric trade are being reestablished by organizations in high skilled manufacturing as aerospace, computer, telecommunication, home electronics, pharmaceuticals, therapeutic machine and creating new products, new services, and new ways of turning out goods cheaper. These companies are depending on employee's creativity and skills and placing pressure on the employee's brainpower. Every company increasingly depends on knowledge, process, management skills, technologies, information about customers, suppliers, experience and intellectual capital [7].

90.2.2 HR Roles Portfolio Specific to Organizational Context

According to HR experts HR roles can be divided according to organizational contexts such as organizational size, ownership pattern, marketing conditions, board representation and time [8], a brief review of some of them is as follows.

90.2.3 Organizational Size as a Context

Professor Ingi [9], reviewed HRM profession in New Zealand based on a survey of 1,100 medium-sized and large organizations all employing more than 100 staff. Responses highlighted a number of trends in HRM. These included: the growth in specialist HRM employees; practitioners need for a greater professionalization; the changing demographic profile of HRM staff; devolution of HRM practices to line managers; and emphasize on diversity and strategic focus. Carter and Scarbrough [10] noted that HRM role is becoming increasingly strategic. Prevailing labeling is changing from ‘personnel’ to ‘human resource’ management. This apart, HRM is being increasingly used to achieve competitive advantage.

90.3 Research Methodology

(1) Research design

The study will be both qualitative and quantitative too as it involves facts and figures.

(2) Procedure

The study will be accomplished through survey, where questionnaires will be given and filled by employees at Roche Pharmaceuticals, Pakistan.

(3) Population

Population is homogeneous.

(4) Sampling method

It is random sampling, as questionnaires will be filled out from employees randomly.

(5) Measurement/instrument selection

Primary data will be collected through survey, where questionnaires will be used in order to collect data from large employees at Roche. Secondary data will be collected through internet text books and journals.

(6) Variables

The range of outcome variables includes

- Improved employee knowledge
- Skills and abilities
- Increased motivation

- Career Planning
- Improved retention of quality employees

These variables will be measured through financial results.

90.3.1 Data Analysis

Data Analysis on the Basis of Frequency and Percentages
(1) Gender

50 employees have been taken from different departments of ROCHE Pharmaceuticals as sample. Out of which 37 are males which makes 74% and remaining 13 are females which makes 26% of the sample size. Actually most of the males are being employed in ROCHE Pharmaceuticals Pakistan.

(2) Age

Among the 50 employees of ROCHE Pharma, 24 employees are lying in the age of 31-50, 12 people are lying in the age of 50 above, 9 d to employees are lying in the age of 21-30 and remaining 5 employees didn't respond to this question.

It means that 10% of the sample size didn't mention their age, 18% lies in the age of 21-30, and most of the people 48% lies in the age of 31-50 and 24% of employees are above age of 50 years.

(3) Experience

When asked about the experience of the employees, 5 people has spent less than two years in ROCHE Pharmaceuticals Pakistan, 29 people has spent between 2 to 5years in Roche Pharma, and remaining 16 employees have spent more than 5 years in ROCHE Pharma. Out of 50 people, 10% has experience of less than two years, about 58% of the employees have experience of 2-5years and 32% of people have experience of above 5years. It means most of the employees have spent 2 to 5 years in ROCHE Pharmaceuticals Pakistan.

- **Q.1** When the question was asked about the induction trainings provided to these employees, 50 people which means that 100% of the employees responded that they are provided induction trainings by the management of ROCHE Pharmaceuticals Pakistan. The management of ROCHE is very effective and efficient in providing the trainings to their employees.
- **Q.2** The effectiveness and efficiency of the management of ROCHE is clear with this result that all of the 50 employees of the sample are very much satisfied with the development, training and quality improvement programs provided to them by this organization.
- **Q.3** 2% out of the 100% of the employees is not agreed that its performance get improved after induction training while 98% of the employees are satisfied with their performance level after training.
- **Q.4** As ROCHE is the pharmaceutical company, employees must be provided any sought of product knowledge training, fortunately this training is provided by ROCHE to their employees as all are agreed on it.

- **Q.5** Almost 98% of the employees responded positively to the question that, are they provided by the supervisory trainings.
- **Q.6** When employees were asked about the availability of any formal system for redressing employees' grievances in ROCHE, 31 means 62% employees responded that yes, there is the formal system for redressing employees' grievances in ROCHE. While 18 people means 36% responded that to some extent there is a formal system.
- **Q.7** Employees have different point of view regarding the specific programs for redressing employees' grievances as 26 employees means 52% said that through informal meetings grievances are handled and 24 means 48% said that through union meetings these grievances are handled.
- **Q.8** When employees were asked about the awareness of their career path in ROCHE, 34 employees 68% said that most of the employees are aware, while 14 employees 28% said that few of the employees are aware of their career path.
- **Q.9** 56% means 28 employees said that job enrichment is used, 22% means 11 said that job rotation is used and 20% means 10 said that mentoring is used as career planning tool.
- **Q.10** 47 employees who mean 94% said that performance appraisals done in ROCHE on Semi-Annual basis, while 2 and 1 said that on quarterly and annually basis it is done.
- **Q.11** 58% means 29 employees are satisfied with the pay-for-performance compensation program in ROCHE, 14 means 28% are satisfied to some extent and 7 means 14% are not satisfied with the pay-for-performance compensation program in ROCHE.
- **Q.12** When asked about the performance management linkage with the career planning, 2 means 4% were completely disagree, 22 means 44% were mostly disagree, 18 means 36% were moderately agree and 7 means 14% were mostly agree with this, while 1 didn't respond.
- **Q.13** When asked about the performance management linkage with the training analysis, 15 means 30% were mostly disagree, 23 means 46% were moderately agree, 8 means 16% were mostly agree and 3 means 6% were completely agree with this, while 1 didn't respond.
- **Q.14** When asked about the performance management linkage with the compensation and reward, 9 means 18% were mostly disagree, 21 means 42% were moderately agree, 15 means 30% were mostly agree and 2 means 4% were completely agree with this, while 3 didn't respond.
- **Q.15** When asked about the performance management focus for the growth and development, 1 means 2% was completely disagree, 11 means 22% were mostly disagree, 22 means 44% were moderately agree and 9 means 18% were mostly agree and 6 means 12% were completely agree with this, while 1 didn't respond.

90.3.2 Descriptive Analysis

(1) Trainings provided

Interpretation: The factor "Training provided" consists of five questions whose interpretation is like that, the mean of question 1 is coming around 1.04, which means that almost all of the employees are agreed that induction training is provided to them. The mean of question 2 is around 1.06 which means that almost all are satisfied with the personal development, training and quality improvement program in ROCHE Pharmaceuticals Pakistan. The mean of question 3 is around 1.10 which means that most of the employees are agreed that their performance has improved after getting induction training. The mean of question 4 is around 1.10 which means that almost all of the employees are agree that they are provided product knowledge training. The mean of question 5 is around 1.14 which means that most of the employees are agreed that supervisory training is provided to them.

(2) Performance management system

Interpretation: The factor "Performance Management System" consists of question 12 to question 15. The mean of question 12 is around 2.56 which mean that most of the employees disagree and most of the employees moderately agree that performance management system is linked to career planning. The mean of question 13 is around 2.92 which mean that most of the employees moderately agree that performance management system is linked to training analysis. The mean of question 14 is 3.02 which mean that almost all of the employees are agree that performance management system is linked to compensation and reward. The mean of question 15 is 3.10 which mean that most of the employees agree that performance management system is focused for growth and development.

90.3.3 Gender, Experience and Age Wise Analysis

(1) Training provided

a. Gender Wise

- **Q.1** According to gender, 37 males and 13 females are agreed that ROCHE provides induction training.
- **Q.2** According to gender, 37 males and 13 females are agreed that they are satisfied with the personal development, training and quality improvement program.
- **Q.3** According to gender, 36 males and 13 females are agreed that performance improved after training while only 1 male denied this.
- **Q.4** According to gender, 37 males and 13 females are agreed that ROCHE provides product knowledge trainings to their employees.
- **Q.5** According to gender, 37 males and 12 females are agreed that ROCHE provides supervisory trainings to their employees, while 1 female denied this.

b. Age Wise

- **Q.1** According to age, 9 employees who lie between age of 21-30 said yes, 24 employees who lie between 31-50 were agree and 12 employees who are above 50 were agree.
- **Q.2** According to age, 9 employees who lie between age of 21-30 said yes, 24 employees who lie between 31-50 were agree and 12 employees who are above 50 were agree.
- **Q.3** According to age, 9 employees who lie between age of 21-30 said yes, 24 employees who lie between 31-50 were agree and 11 employees who are above 50 were agree, while 1 employee who is above 50 denied this.
- **Q.4** According to age, 9 employees who lie between age of 21-30 said yes, 24 employees who lie between 31-50 were agree and 12 employees who are above 50 were agree.
- **Q.5** According to age, 9 employees who lie between age of 21-30 said yes, 24 employees who lie between 31-50 were agree and 11 employees who are above 50 were agree, while 1 employee who is above 50 denied this.

c. Experience Wise

- **Q.1** According to experience, 5 employees who have experience of below 2 years are agreed, 29 employees who have experience of 2-5 years said yes and remaining 16 employees having experience of more then 5 years are agreed.
- **Q.2** According to experience, 5 employees who have experience of below 2 years are agreed, 29 employees who have experience of 2-5 years said yes and remaining 16 employees having experience of more then 5 years are agreed.
- **Q.3** According to experience, 5 employees who have experience of below 2 years are agreed, 28 employees who have experience of 2-5 years said yes while 1 denied this and remaining 16 employees having experience of more than 5 years are agreed.
- **Q.4** According to experience, 5 employees who have experience of below 2 years are agreed, 29 employees who have experience of 2-5 years said yes and remaining 16 employees having experience of more then 5 years are agreed.
- **Q.5** According to experience, 5 employees who have experience of below 2 years are agreed, 28 employees who have experience of 2-5 years said yes while 1 denied this and remaining 16 employees having experience of more than 5 years are agreed.

(2) Performance management system
a. Experience Wise

- **Q.12** According to experience, out of 5 employees having experience of less than two years 3 are mostly disagree and 2 are moderately agree. Out of 29 employees having experience of 2-5 years 15 are mostly disagree, 9 are moderately agree and 5 are mostly agree. Out of 16 employees having more than 5 years experience 2 are completely disagree, 4 are mostly disagree, 7 are moderately agree and 2 are mostly agree while 1 didnt respond.
- **Q.13** According to experience, out of 5 employees having experience of less than two years all 5 are moderately agreed. Out of 29 employees having experience

of 2-5 years 12 are mostly disagree, 10 are moderately agree, 5 are mostly agree and 1 is completely agree while 1 didn't respond. Out of 16 employees having more than 5 years experience 3 are mostly disagree, 8 are moderately agree, 3 are mostly agree and 2 are completely agree.

- **Q.14** According to experience, out of 5 employees having experience of less than two years 2 are mostly disagree and 2 are moderately agree while 1 is mostly agree. Out of 29 employees having experience of 2-5 years 5 are mostly disagree, 15 are moderately agree and 7 are mostly agree, 1 is completely agree while 1 didn't respond. Out of 16 employees having more than 5 years experience 1 is completely agree, 2 are mostly disagree, 4 are moderately agree and 7 are mostly agree while 2 didn't respond.
- **Q.15** According to experience, out of 5 employees having experience of less than two years 1 is mostly disagree and 3 are moderately agree and 1 is mostly agree. Out of 29 employees having experience of 2-5 years 1 is completely disagree, 7 are mostly disagree, 14 are moderately agree and 4 are mostly agree, 2 are completely agree while 1 didn't respond. Out of 16 employees having more than 5 years experience 3 are mostly disagree, 5 are moderately agree and 4 are mostly agree and 4 are completely agree.

b. Gender Wise

- **Q.12** According to gender, out of 37 males 2 are completely disagree, 13 are mostly disagree, 14 are moderately agree, 7 are mostly agree while 1 didn't respond. Out of 13 females 9 are mostly disagree and 4 are moderately agree.
- **Q.13** According to gender, out of 37 males 2 are completely disagree, 10 are mostly disagree, 15 are moderately agree, 8 are mostly agree and 3 are completely agree, while 1 didn't respond. Out of 13 females 5 are mostly disagree and 8 are moderately agree.
- **Q.14** According to gender, out of 37 males 5 are mostly disagree, 12 are moderately agree, 15 are mostly agree and 2 are completely agree, while 3 didn't respond. Out of 13 females 4 are mostly disagree and 9 are moderately agree.
- **Q.15** According to gender, out of 37 males 4 are mostly disagree, 17 are moderately agree, 9 are mostly agree and 6 are completely agree, while 1 didn't respond. Out of 13 females 1 is completely disagree, 7 are mostly disagree and 5 are moderately agree.

c. Age Wise

- **Q.12** According to age, out of those 5 who didn't mention their age 1 is mostly disagree, 2 are mostly agree and 2 are moderately agree. Out of 9 employees lie in the age of 21-30, 1 is completely disagree, 5 are mostly disagree and 3 are moderately agree. Out of 24 employees lie in the age of 31-50, 14 are mostly disagree, 6 are moderately agree, 3 are mostly agree while 1 didnt respond. Out of 12 employees having age of 50 above 1 is completely disagree, 2 are mostly disagree, 7 are moderately agree and 2 are mostly agree.
- **Q.13** According to age, out of those 5 who didn't mention their age 2 are mostly disagree, 2 are mostly agree and 1 is moderately agree. Out of 9 employees lie in

the age of 21-30, 3 are mostly disagree, 4 are moderately agree and 2 are mostly agree. Out of 24 employees lie in the age of 31-50, 9 are mostly disagree, 11 are moderately agree, 2 are mostly agree and 1 is completely agree while 1 didn't respond. Out of 12 employees having age of 50 above 2 are completely agree, 1 is mostly disagree, 7 are moderately agree and 2 are mostly agree.

- **Q.14** According to age, out of those 5 who didn't mention their age 3 are mostly agree and 2 are moderately agree. Out of 9 employees lie in the age of 21-30, 3 are mostly disagree and 5 are moderately agree while 1 didn't respond. Out of 24 employees lie in the age of 31-50, 5 are mostly disagree, 12 are moderately agree, 5 are mostly agree and 1 is completely agree while 1 didn't respond. Out of 12 employees having age of 50 above 1 is completely agree, 1 is mostly disagree, 2 are moderately agree and 7 are mostly agree while 1 didn't respond.
- **Q.15** According to age, out of those 5 who didn't mention their age 1 is mostly disagree, 3 are mostly agree and 1 is moderately agree. Out of 9 employees lie in the age of 21-30, 1 is completely disagree, 2 are mostly disagree, 4 are moderately agree and 2 are mostly agree. Out of 24 employees lie in the age of 31-50, 7 are mostly disagree, 11 are moderately agree, 2 are mostly agree and 3 are completely agree while 1 didn't respond. Out of 12 employees having age of 50 above 3 are completely agree, 1 is mostly disagree, 6 are moderately agree and 2 are mostly agree.

90.4 Conclusion

The main objective of this study is to understand the changes in strategic HRM practices (Role and Structure of HR department, Recruitment, Retraining and Redeployment, Performance Appraisal, Compensation, and Rightsizing) in Roche Pharmaceuticals, Pakistan and to what extent the "best practices" are being practiced by Roche Pharmaceuticals, Pakistan for superior performance. HR plays a key role in strategic planning in Roche Pharmaceuticals, Pakistan. Majority of employees in this company are male employees as results are showing. A formal system for redressed of grievance existed in Roche, Pharmaceuticals. Roche is handling grievances or relying heavily on informal meetings/union meetings for grievance redressed. Roche is conducting induction training for all their employees. All of the employees are very much satisfied with the development; training and quality improvement programs provided to them by this organization, employees' performance has been improved and they are given product and supervisory training in Roche. In the case of career planning where a majority of the employees were aware of their career path in the company. The most commonly used tool for career planning was followed by job rotation and job enrichment. After survey, it has been known that Roche had a Performance Management System. Performance Management System was looked upon as an integral part of the overall management.

90.5 Recommendation

I would like to recommend to the management that other HR practices should be applied like reverse mentoring. The concept of reverse mentoring is that of filling in the gaps of knowledge and skill of the older employees with regard to emerging trends. As most of the employees around 70% are above the age of 30 so this practice will really be applied in order to gain profitability. The Performance Management System of Roche Pharmaceuticals, Pakistan seems not so effective so it needs an insight in this system. It will be recommended that SHRM practices will benefit to the local companies of Pakistan but it depends that either they want to implement or not.

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Chapter 91
Manager Power and Decision of Capital Expenditure: Empirical Research from China's Securities Market

Jing Xu

Abstract Manager power in the firm is so strength that weakens the effect of incentive pay, and always brings out various negative consequences. So the actual capital expenditure, which could be the engine of firm, is turning into a way for management to fertile ground for opportunism. This paper examines the relationship between manager power and capital expenditure, based on 1356 numbers from 452 listed companies in China during 2008 to 2010 as sample. We choose the level of capital expenditure as the breakthrough direction to further study the influence. Firstly, We find the bigger power leads the higher level of capital expenditure. Secondly, because the platform effect, the big companies are prone to high level of capital expenditure, and also the size weight has more influence on capital expenditure than free cash flow weight. Thirdly, manager power weakens the sensitivity of free cash flow-capital expenditure, which makes the capital expenditure feasible under insufficient condition of cash flow. Fourthly, manager power also weakens the constraint from debt to capital expenditure, whereas high debt pushes the payment to new level. Finally, compared to private-owned listed companies, the phenomenon above is more obvious in state-owned listed companies.

Keywords Manager power · Capital expenditure

91.1 Introduction

Capital expenditure decisions are the major acts for enterprises. Growth of enterprise is based on the effective capital spending [1], and also sustainable growth of cash flow can stimulate the promotion in future. However, in fact, invalid capital expenditure caused by information asymmetry [2] and agency problems [3, 4] bring

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about the big problems for any firms.Capital expenditure agency theory, which believes the maximum of enterprise scale hypothesis, contends that the purpose of corporate is the maximization of firm size rather than the maximization of market value. Because this act could enlarge the controllable resource scope, income and promotion for management [5]. Some other existing researches found the investment level exceed the rate of marginal revenue [6, 7]. Especially, when supervision of the managers becomes less, the level of capital expenditures may be higher than the level of capital expenditures in the case of supervision [8]. In addition, free cash flow theory [5], entrenchment effect [6] and overconfidence theory [9] explain intrinsic motivations of the high level of capital expenditure for no reason from various perspective.

So, is high level of capital expenditure a negative economic consequence of management power? Will the managers with high strength of the power increase corporate scale weight in overall capital expenditure? Will the corporate increase capital spending to meet firm size though high level of debt besides current free cash flow?

If so, after adding management power, how free cash flow effect and liabilities constraint effect collaborate in some way? Will the management power impair liabilities constraint effect and turn firm scale variable into more important reason to explain overhigh capital expenditure?

Nowadays, a majority of researches focused on the relationship between management power and remuneration [12, 13], and did not study management power that played a role in capital expenditure decision. At first, they overlooked the potential platform effect generated by firm scale-the bigger company get more noticed, have stronger motivation, will be more likely to boost more capital expenditure to build bigger platform. Furthermore, covered by platform effect, they ignored the phenomenon that combination of management power and firm scale affects free cash flow effect and liabilities constraint effect significantly.

Our findings indicate that management power is positively correlated with level of capital expenditure. On the other hand, compared to private-owned listed companies, the interaction is more obvious in state-owned listed companies. These findings present a balance constraint system is helpful to reduce over-spending which due to the expanding power. While, the imbalance management power makes the capital expenditure less sensitive to free cash flow and lower the constraint from liabilities to capital expenditure. In the state-owned company, this phenomenon is more obvious than the counterpart. In this paper, we will describe the reasons refer to the related theories and reality in China.

Our paper provides several contributions to the literature in several ways: first, we choose to study corporate capital spending decisions from the perspective of management power. We examine whether the high level of capital expenditure is attributed to the management power, and also we want to find the intrinsic reason and mechanism. This paper can broaden the perspective of investment theory. Second, the prevailing management power theory thinks the greater the power of the executives is able to influence their own pay contract design. What we further find is that manager use their power to enlarge the level of capital expenditure and weaken the capital expenditure liabilities constraint effect. The ineffective investment generated by abuse of power leads to improve their own salary. So, we provide more evidence on area of management power theory. Third, the existing researches didn't consider the path and vital variables, of which management power affects capital expenditure. In the light of Chinese economic transfer period and background, we add the interactive effect of management power with free cash flow and interactive effect of management power with debt as variables for capital expenditure decisions. Thus we present empirical evidence for area of enterprise financing decisions.

Our paper is organized as follows. Sect. 91.2 discusses theoretical analysis and poses the hypotheses. Sect. 91.3 builds the model. Sect. 91.4 describe our sample and test the model, and then we discusses the implications of the results. Sect. 91.5 concludes the paper.

91.2 Theoretical Analysis and Hypotheses Development

91.2.1 The Relationship between Management Power and Capital Expenditure Decisions

Finkelstein [14] suggested that management power belong to their own, Bebchuk et al [15], Bebchuk and Fried [16], Grinstein and Hribar [12] contended that management power influence directors first in order to control the remuneration decision on board. In early days, Bebchuk et al [15] studied the relationship between managers and remuneration-performance in management power theory. He claimed that manager is able to affect even decide their own salary. Therefore the rent-seeking problem may bring about. In addition, Hambrick and Finkelstein [17] documented the CEO remuneration grow fast remarkably in a firm which the executive is in charge. Finkelstein and Boyd [18] also found management power is positively correlated with remuneration.

Followed by the thought of Bebchuk et al [15], Eriksson [19], Duffhues and Kabir [20], Cheng et al [13] all documented management power is important for remuneration contract. However, the "smart" manager won't search for personal gain directly. When power imbalance between managers and shareholders appears, the motivation would be encouraged. From corporate merger, they can receive more bonuses [12]. Because the larger scale give rise to the high remuneration for managers, which result in remuneration inelastic. Actually, the performance does not improve. Meanwhile, especially there exists remuneration constraint in state-owned listed company [21] and the calling of enhancing announce manager's payoffs, the executives would like to receive more non-pecuniary compensation [22]. They have to face the pressure from market, society and public voice. The potential motivation has the chance to grow. The acts above are generalized category of capital expenditure. According to capital spending agency theory, capital expenditure is for larger corporate scale and earn profit from the process. When the agency problem is getting serious, and manager lack of supervision, the executives choose to raise level of capital expenditure. Furthermore, rational executive will make corporate scale impact for expenditure under the reasonable level of free cash flow and tolerated financial risk. That means, the current corporate scale will affect capital expenditure either. Because everyone believe big enterprise should spend more money to invest and build bigger platform.

Besides, in china's capital market, state-owned listed companies have "owner absence" and other innate property deficiency. State-owned listed companies appear the typical characteristics of MBO under administrative intervention [23]. On the one hand, administrative intervention empowers state-owned companies the responsibilities of performance, guarantee of national interest and serve of community. Especially in transfer period, state-owned companies in revolution need to burden various responsibilities to maintain social stability [24]. And also administrative intervention explains lots of capital expenditure decisions. On the other hand, state-owned companies can't offer management the relative marketed salary because of administrative intervention. By reasons of the lack of regulation and supervision of executives in state-owned companies and dispersion of shareholders, state-owned enterprises actually are under the supervision of the implementation of the senior management agent by government officials [25]. Meanwhile, the less supervised motivation, tempt of rent-seeking and shortage of information degraded the supervision. Thus, the executives have the substantial control power [26]. For state-owned enterprises, they have more advantage of policy and official path. Government and management are closely related, so the executives can negotiate easily with government sectors. This close relationship supports the increasing power for management [27]. This phenomenon produces the consequence that, in capital spending process, executives are prone to consider their personal potential promotion and salary from the scale of investment while lose sight of high level of debt.

Therefore, this paper develops assumption 1 and assumption 2:

Assumption 1a. in the case of management power theory and other conditions remain unchanged, the level of capital expenditure has a higher scale weight.

Assumption 1b. in the case of management power theory and other conditions remain unchanged, compared to private-owned companies, the level of capital expenditure of state-owned companies has higher scale weight.

Assumption 2a. in the case of management power theory and other conditions remain unchanged, power of management power is positively correlated with level of capital expenditure.

Assumption 2b. in the case of management power theory and other conditions remain unchanged, compared to private-owned companies, correlation between the power of management power and level of corporate capital expenditure in state-owned companies is more obvious.

91.2.2 The Effect on Capital Expenditure-free Cash Flow Relationship from Management Power

Free cash flow is such important for capital expenditures research [28]. Jensen [3] suggested free cash flow is remaining fund that left by the objects that are beyond the capital demand and MPV is positive. So, in other word, they are not utilized properly. Strong and Meyer [29] found the free cash flow is positively correlated with any investment from the samples. They also had proved the agency problem leads to the over-investment. With historical data of industry in America, Ghose et al [30] had documented when the international oil price rose, the rich unexpected cash flow led random investment. From corporate governance standpoint, Pawlina and Renneboog [31] studied the investment-cash flow sensitivity in British listed companies. They found free cash flow problem explains the investment-capital sensitivity.

In China, Ding [32], Tang et al [33] demonstrated free cash flow is positively collated with expenditure. Owing to the existence of information asymmetry and agency problem, executives would like to increase the capital expenditure because it meets the manager self-interest [34]. Moreover, weak constraint makes this behavior feasible, and this sensitive connection is more significant in an enterprise has rich free cash flow. In this situation, we develop assumption 3:

Assumption 3a. in case of other conditions remain unchanged, management power is positively correlated with sensitivity of free cash flow-capital expenditure.

Assumption 3b. in case of other conditions remain unchanged, compared to private-owned companies, the correlation between management power and sensitivity of free cash flow-capital expenditure in state-owned companies is more obvious in state-owned companies.

91.2.3 The Effect on Constraint of Capital Expenditure and Debt from Management Power

Under the conditions of a market economy, capital and interest repayment, debt has two roles in corporate in enterprises. One is for financing and the other is for management. Paper by Jensen [5] has extensively discussed the debt has the restricted function to regulate capital expenditure, which can reduce those behaviors managers use of free cash flow to build business empires. However, a majority of listed companies in China are transferred from state-owned enterprise reform. Owner absence in state-owned companies results in insider control, and this is becoming more common and serious. Additionally, bankruptcy mechanism, professional manager market and flawed control market also bring out less effectiveness of debt. Thus, to some extent, debt constraint turns out to be “soft constraint”. In particular, state-owned enterprise has a better relationship with government than private-owned enterprise so they have advantage of bank loan. The higher level of long-term loan, the restriction and regulation managers faced become weaker.

Therefore, we develop the assumption 4:

Assumption 4a. in case of other conditions remain unchanged, the debt negatively correlated with level of capital expenditure.

Assumption 4b. in case of other conditions remain unchanged, management power can weaken even change the sensitivity of debt-capital expenditure. That is to say, management power positively correlated or uncorrelated with level of debt-capital expenditure.

Assumption 4c. in case of other conditions remain unchanged, compared to private-owned listed companies, management power in state-owned make the debt-level of capital expenditure less sensitive or even insensitive.

91.3 Research Design

91.3.1 Sample Data and Resources

Our initial sample consists of non-financial listed companies of A-shares in Shanghai and Shenzhen stock exchange during 2008 to 2010. Because ST and PT firms are in unusual financial situation or in a deficit for more than 2 years, we delete them from this paper. Otherwise, it will impact reliability and consistency. Besides, We delete the listed companies that had a chairman of the board or chief executive changes in the research period as well. Besides, we winsorized all the continuous variables and finally received 1358 observed value. Of all the companies, there are 789 under the control of state while 569 not. The data collected from Shanghai stock exchange, Shenzhen stock exchange, CSMAR solution, www.jrj.com.cn and http://finance.sina.com.cn.

91.3.2 Descriptive Variables

(1) Level of capital expenditure

We promote capital expenditure variables used by Hu et al [6]. We consider that capital expenditure is "the cash for intangible assets, fixed assets and other long-term assets", which means capital equal to the cash for intangible assets, fixed assets and other long-term assets.

(2) Management power

Drawing on model of Finkelstein [14] and the description of management power by Lv and Xu [35], Quan et al [10], we combine the management power in 5 ways in order to form the aggregate indicator. ① Management positions. If chairman of the board and chief executive is same, variable takes the value of 1 and otherwise 0.

② Scale of board. ③ The percentage of inside directors. ④ Proportion of executives shareholding. ⑤ Serving time. The last four variables selection is based on whether the number is more than the median in related industry. If the variable passed, take the value of 1, otherwise 0. The 5 variables above describe management power partly, so this paper uses principal component analysis to combine power variable [36] and measure the management power by equal-weighted average (see Table 91.1).

Table 91.1 Variable explanation

Variable name	Abbr.	Variable definition
Level of capital expenditure	Capital	The cash for intangible assets, fixed assets and other long-term assets
Management power 1	Power 1	The selection for strength management power from combination of 5 dummy variables principal component
Management power 2	Power 2	Equal-weighted average value of 5 dummy variable is took as the strength of management power
Free cash flow	Cash	Previous operating net cash flow - hedge investment − expected investment
Liability-asset ratio	Lev	Debt / asset
Ownership nature	SOE	If the controller is government or state-owned enterprise, the variable take the value of 1, 0 otherwise.
Total assets	Size	Total assets mean corporate scale
Company's growth	Growth	Sales growth rate of major operation. The formula = (main business income for the year − previous main business income) / main business income for the year
Earning power	ROA	Return on total assets. The formula = net profits / average assets.
Industry	IND	20 industrial dummy variables, if it's in any industry, the variable take the value of 1, 0 otherwise.

91.3.3 Model Construction

In this paper, we use these models to testify the related theories and assumptions.
(1) Separate regression model (91.1)

$$\begin{aligned}\ln \text{capital} = \; & a_0 + a_1 * \ln \text{Size} + a_2 \ln \text{Cash} + a_3 * \text{Power}_i + a_4 * \text{SOE} + a_5 * \text{Lev} \\ & + a_6 * \text{Growth} + a_7 * \text{ROA} + a_i * \text{IND}_i + \varepsilon. \end{aligned} \tag{91.1}$$

(2) Variable interaction regression model (91.2)

$$\begin{aligned} \ln \text{capital} = \; & a_0 + a_1 * \text{Power}_i + a_2 \text{SOE} + a_3 * \ln \text{Cash} + a_4 * \text{Lev} \\ & + a_5 * \text{Power}_i * \ln \text{Cash} + a_6 * \text{Power}_i * \text{Lev} + a_7 * \ln \text{Size} \\ & + a_8 * \text{Growth} + a_9 * \text{ROA} + a_i * \text{IND}_i + \varepsilon. \end{aligned} \tag{91.2}$$

91.4 Empirical Results

91.4.1 Descriptive Statistical Analysis

Table 91.2 presents the descriptive statistical numbers of main characteristics: Table 91.2 show the percentage of inside directors in Chinese listed corporates during 2008 to 2010 is 73%. It implies that independent director system is implemented in accordance with the requirements of the commission in most listed companies. But percentage of inside directors beyond 70% means the availability of independent director system is restricted. Meanwhile, the max capital expenditure is 11.5 billion, the minimum is 487.692 thousand. The minimum level of capital expenditure accounted for only 0.04% of the highest, which means the difference is extreme huge. Nevertheless, We also found that the highest asset size of 2.4 trillion, which is the minimum asset size of 151 million times. Anyway, it explains the corporate scale has material impact on the level of capital expenditure. Apparently, larger size corporates confront more update of fixed capital, new investment and materials purchasing anyway, so more spending has produced, which meet the "platform effect" we brought up.

Table 91.2 Descriptive statistical charts of main variables

Main variables	Minimum	Maximum	Average	Standard deviation
Scale of board (number of people)	9	27	16.07	4.365
The percentage of inside directors	0.6	0.83	0.73	0.05
Serving time (years)	1	6	2.88	0.65
Level of capital expenditure (yuan)	487692	$1.15E10$	$4.11E8$	$1.54E9$
Logarithm of the level of capital expenditure	13.1	25.47	19.662	2.5
Total assets	$1.51E8$	$2.4E12$	$1.03E11$	$3.63E11$
Logarithm of total assets	18.83	28.51	22.94	1.95
Free cash flow (yuan)	1788298	$1.71E11$	$5.29E9$	$2.07E10$
Logarithm of free cash flow	14.4	25.87	19.65	2.32
Liability-asset ratio	0.08	0.97	0.556	0.19
Main business's increasing rate of income (%)	−0.686	1.25	0.227	0.29
Return on net assets	−0.723	0.263	0.042	0.1

In addition, different level of free cash flow of the asset size is various. The maximum free cash flow is 171 billion, while the opposite is 1.78 million. Thus far, we obverse the average of liability-asset ratio, sales growth rate of major operation and earning power are 55.6%, 22.7% and 4.2% separately. Data demonstrate the growth of main business income do little enhancement to earning power. Under the condition that average ROA is 4.2%, the "robust and aggressive" debt decisions are appreciated around the firms, which show the soft liabilities constraint effect.

At last, we test correlation coefficient analysis to main variables and find capital positively correlated with Power*Cash, whereas negatively correlated with Power $*$ Lev. In the meantime, the result is obvious on level of 1%. Ideally, preliminary indication meets the expected assumptions 3 and 4. Unfortunately, limited to space, the chart is not showed.

91.4.2 Analysis of Separate Regression Model Results

Table 91.3 makes regression analysis of the model (91.1). From the chart, it indicates the formula well explains the result, and the adjusted R^2 reaches 73.8%. As the role of explanatory variable, total assets coefficient is positive and obvious on level of 1%. Meanwhile, the coefficient of cash flow is positive either and obvious on level of 5%. So far, the results meet the expectation. Except for symbol of the growth rate of the main business indicators does not match with the expected assumption, we can also find from the chart the others meet the expectations and most of them pass the significant testing. This result suggests many of enterprises attach importance to consider corporate scale, national policy, free cash flow and other factors besides the prerequisite of sustainable growth of main business.

Also, the results show management power and capital spending is positively obvious on level of 10%, which means the positive connection between management power and capital spending exists. When agent constraints disappear, the executives have the motivation or potential activities to search for self-interest by capital expenditure. Furthermore, there is significant difference between state-owned and private-owned firms in a way of positive effects from management power on capital expenditure. Subsequently, we use single sample T test to examine the capital expenditure of 2 different stock right natures and the result meet the expectation. Limited to space, the chart is not showed as well.

In addition, for assumption 1, we examine with quantitative estimation method. We use separate regression model (91.1) to split into scale spending and cash flow spending from the model valuation as follow.

$$\text{Capital}_1 = \beta_1 * \text{Size}, \tag{91.3}$$

$$\text{Capital}_2 = \beta_2 * \text{Cash}. \tag{91.4}$$

In the models, is regression estimate of model (91.1). We put mean variable in Table 91.2 and regression coefficient estimates in models (91.3) and (91.4), get the

Table 91.3 Result of separate regression

	Model (91.1)-1	Model (91.1)-2
Cons.	-4.599^{***}	-4.621^{***}
	(−2.22)	(−2.281)
ln Size	0.35^{***}	0.32^{***}
	(4.822)	(4.878)
ln Cash	0.18^{**}	0.268^{**}
	(2.256)	(3.564)
Power1	−−	0.038^{*}
	−−	(1.86)
Power 2	0.064^{*}	−−
	(2.013)	−−
SOE	0.16^{*}	0.21^{*}
	(2.188)	(2.121)
Lev	−0.3	−0.286
	(−0.31)	(−1.306)
Growth	−0.006	−0.002
	(−0.011)	(−0.004)
ROA	3.275^{**}	3.247^{**}
	(1.87)	(1.923)
IND	controlled	Controlled
Adj.R^2	0.735	0.738
F	33.05	39.085

Note: $***$ means it's obvious on level of 1%; $**$ means it's obvious on level of 5%; $*$ means it's obvious on level of 10%.

scale expenditure, cash flow spending and the percentage of them in 2 constructive spending separately. The results are in Table 91.4.

Table 91.4 Quantitative analysis on corporate constructive capital spending

	Estimate	Average	Obtained value multiplied by the coefficient	The ratio of value in capital expenditure (%)
ln capital		19.662		
ln Size	0.35	22.94	8.029	40.83
	0.32	22.94	7.3408	37.33
ln Cash	0.268	19.65	5.2662	26.78
	0.18	19.65	3.537	17.99

From the results of total sample, under the various coefficient estimates of management power, scale indicator have 40.83% and 37.33% effect on capital expenditure respectively, cash flow indicator have 26.78% and 17.99% effect on capital expenditure separately. The scale of expenditure is 1.525 times and 2.075 times the cash flow expenditure. The difference is 1.8 times after average.

Based on the data in Table 91.4, assumption 1 and 2 are valid. When the platform set up, the larger enterprises attach more attention from government and society.

These reasons push expenditure to rise for sustainable growth. Even though free cash flow is important for capital expenditure, the platform effect is more obvious than free cash flow effect when the other ways are able to raise money to support the platform expanding. So, it explains when the constraint system becomes weak, free rider problem may appear. This activity could enhance the awareness of capital expenditure and raise capital expenditure.

Table 91.5 Results of interaction regression

	Model (91.2)-1	Model (91.2)-2
Cons.	-6.431^{***}	-6.276^{***}
	(−3.13)	(−2.983)
ln Size	0.983^{***}	0.914^{***}
	(5.442)	(4.826)
ln Cash	0.909	0.236
	(1.084)	(0.666)
Power 1	0.318^{*}	−−
	(1.645)	−−
Power2	−−	0.571^{*}
	−−	(1.342)
Power1*ln Cash	−1.024	−−
	(0.885)	−−
Power1*ln Lev	41.719^{***}	−−
	(2.431)	−−
Power2*ln Cash	−−	−0.022
	−−	(−0.196)
Power2*ln Lev	−−	38.476^{**}
	−−	(1.987)
SOE	0.103^{*}	0.03^{*}
	(2.342)	(2.211)
Lev	-30.621^{***}	-28.232^{**}
	(−2.457)	(−2.119)
Growth	0.184	−0.019
	(0.321)	(−0.031)
ROA	3.143 ∗∗	2.986^{**}
	(1.913)	(1.898)
IND	controlled	Controlled
Adj.R^2	0.886	0.871
F	29.19	25.212

Note: ∗∗∗ means it's obvious on level of 1%; ∗∗ means it's obvious on level of 5%; ∗ means it's obvious on level of 10%.

91.4.3 Analysis on Multiple Regression Results

Table 91.5 presents the interactive regression results around variables of management power, free cash flow and liability-asset ratio. As is shown, the formula well explains the reason and adjusted R^2 reaches 87.1%. Among the data, scale variables and capital expenditure are obvious on the level of 1%, which means the platform effect exists in large companies. Next, management power and capital expenditure show the positive and obvious features on the level of 10%. This phenomenon implies that imbalance management power leads the agency problems to become more prominent. Furthermore, larger platform provide the better reason to raise capital expenditure by management power. Additionally, we find free cash flow theory changed in those enterprises that have weak management constraint. Because the rich free cash flow is the premise for investment and is a necessary condition for corporate capital spending. In theory, the rich free cash flow makes the high capital spending possible. However, in large corporate, management power will not comply with the rules above completely. Market opportunities, external growth national policies or any other factor maybe more important than free cash flow. Because executives believe missed opportunities for market growth will no longer exist in the future. Therefore, the missed opportunities can't help them to promote performance. So the opportunism activities cannot implement easily. Compared to the market opportunities, the shortage of funds can compensate from new debt. Consequently, we find that great management power result in insensitivity between free cash flow and capital spending. Though the consequence does not meet the expectation of assumption 3, in reality, these activities are reasonable. Moreover, such acts in state-owned enterprise become more serious than in private-owned ones.

In the same time, these acts weaken the constraint from debt to capital expenditure. As is shown in data, interaction of management power and liability-asset ratio positively correlated with capital expenditure. That is to say, default risk and bankruptcy results from high liabilities have a little bit of restrain to management. After all, bankruptcy does not happen immediately, they will raise the funds for investment in new projects, regardless of the source of funds and whether its own funds can afford. This conclusion meets the expectation of assumption 4.

91.5 Conclusions and Suggestions

Nowadays, the research about consequence of management power economic mainly concentrates on the result from such acts that management power decides their own salary and relationship between management power and sensitivity of compensation and performance. But, Existing theories are rarely involved in the management of power and capital spending decisions. In that case, based on the sample of revealed information about management power and level of capital expenditure around listed companies in China during 2008 to 2010, we empirically test the relationship between two factors. The findings are as follow. (1) The management power is greater, the level of capital expenditure becomes higher. It means that management power positively correlated with capital expenditure. Moreover, compared to private-owned listed companies, the consistency between them is more obvious in state-owned companies. (2) Platform effect is significant around firms, which means large enterprises intend to increase the capital expenditure. This case corresponds with the opportunism motivation of management. Therefore, scale weights more effect capital expenditure than free cash flow weight. (3) Management power increases the level of capital expenditures by means of "platform effect". They ignore the free cash flow situation, which leads the insensitivity between free cash flow and capital expenditure. (4) For higher level of capital expenditure, executives increase the debt though their own free cash is not enough, which result the constraint effect become weak on capital expenditure from debt. Meanwhile, compared to private-owned listed companies, the data shows that the above phenomenon is more obvious in state-owned companies.

Our research explores the specific path that how management use power to decide their own salary and the intrinsic reasons of chronically high level of capital spending. This paper enriches the results of management power economic. In the process of economic transition, our findings have prominent theoretical and guidable meaning for sustainable reform in state-owned companies. Management can use power to distort the capital expenditure system. Thus, it is necessary to keep an eye on the formulation and implementation process. Under the request of preservation and improvement of state-owned assets, we should improve the board to construct actual constraint system of management power by means of rebuild the supervision system of state-owned enterprises. In particular, the independence of special committees should be kept. Furthermore, we should improve corporate governance; limit the single executive's control power and influence in the process of capital expenditure decision; choose reasonable performance appraisal indicators. All the acts above are to protect the interests of investors.

Limited to the data, this paper merely studies the relationship between management power and capital expenditure decision, but barely consider the relationship between specifics of capital spending such as fixed assets expenditure, R&D expenditures, etc. However, we do little think to the limited effect from corporate governance behavior on management power. With the development of research on management power, those questions above will be the next step research directions.

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Chapter 92
The Driving Force of University Patent Transaction: Evidence from Twenty-six Provinces of China

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Abstract University is an important source of innovation and driving force of regional economic development. Countries all over the world pay more human and financial resources into college R&D activities, but these resources have the same effects on technical innovation output. This paper studies on University patent transfer amount and value in 26 provinces of China, analyzes the relationships between economic and educational resources, R&D investment factors and transfer amount and value. Presents it is important to enhance the level of knowledge and skills in the human resources inputted, and improve the forms of working organization. Also proposes that the directly and strictly controlled capital can promote the patent transactions.

Keywords University patent transaction · Regional innovation resources · Panel data analysis

92.1 Introduction

Universities are ones of the most important main parts of the technological innovation system, playing important roles in the national economic system: create and spread knowledge, at the same time to educate innovative talents people. Also are the technological innovation springs of the state. Countries pay more and more attention to university R&D activities. China also attaches importance to the University R&D activities and the resources put in increasing year by year.

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In the past several years, scholars have fixed their eyes on the factors which are influencing university technology transfer especially the patent transaction. Thorsby [1] found a high quality teacher team can often bring more inventions, more licensing and more industry technological researches. Powers [2] researched on the universities in the United States, and have found that the universities with more financial support got more technology commercialization. Lockett [3] and Svenson [4] have investigated the universities in U.K. and Sweden found the human resources directly put into the technical activities had obvious influence on university technology transfer. Related research also have been made by Chinese scholars: Zhou [5] have studies fifty-eight universities of China from the angle of resource, find the amount of resources have a significant effect on the value and amount of R&D patent transfer. Yuan [6] observed ninety-eight universities from the view of resource base, and found that different type of the universities are not equally sensitive to the funds and stuff input.

Up to nowadays, related researches show there is a specific link between resources input and university technology transfer [7–9]. However, most of these researches studied on single university, seldom investigated the relationships of input and output from the angle of region. Study the relationship from the angle of province region is very realistic, for the province financial support is another important resource besides country government's. From the angle of study objects, some of these related researches examed technology transfer contracts, and some examed the patent application. But the most important symbol of the R&D value is whether the R&D out put was accepted by markets. So, in this paper, study the amount and total value of traded patent can be much more closer to R&D activities' market value.

92.2 Influencing Factors of University Patent Transaction

92.2.1 University R&D Inner Investment Factors

R&D is systemic activities which a unit in order to increase the amount of knowledge and use that knowledge to create new applications. The size, strength and level of R&D are usually seen as a important reflecting index of the the regional science and technology competition ability. The purpose of the R&D program characterized by creation and innovation is to explore and improve the knowledge of technology or a new application of it, often leads to new discovery or innovation. R&D activities always are seen as symbol of university's intrinsic driving force to seek innovation and creation. Investment input in R&D activities is mainly composed of funds and human resources [2]. R&D internal expenditure is mainly uses for instrument, equipment assets and staff labor costs, and it is the capital investment input in R&D activities.

Some studies use personnel equivalent for the R&D human resource input, but this paper use the number of staff. Because research activity is not a simple physical work, and the labor input can not be measured by working hours. A R&D staff go to the laboratory working 2 hours every day, does not mean the contribution amount of him is two times of the one who works 1 hour. It is more reasonable to use R&D staff number in this case.

At present, universities pay more and more attentions to the teachers' educational background, many colleges and universities ask new teachers for doctoral diplomas. Chinese education system emphasized more on paper production, and most of the university use the amount of published papers as a doctoral degree granting standards, do not attach great importance to the practical and knowledge application abilities. Though related researches [1] found the teacher's quality has a significant impact on the output of science and technology activities. In order to investigate the influence of doctor diploma in patent transaction, this paper use the number of R&D researchers with doctoral diplomas as one of university patent transaction variables.

Besides direct R&D activities inputs by government, the enterprises and institutions of project expenditure funds for scientific research are also included. Government and enterprises' investment for science and technology activities reflects the universities' ability of getting various funding resources. But the funding resources are effectively transformed to the patent transaction? Do the amount and value of patent transaction increase with the funding increading? This is what this paper intends to discuss.

92.2.2 University R&D Outer Investment Factors

Regional innovation ability has a close relationship with the region economy growth level and the development of education level. If a regional economic level reaches a certain standard, the ability of creation increases corresponding. This paper use the GDP per person as the economic environment variable and expenditure on education as the education level index variable.

Besides direct investment of human and financial resources, university technology development resources also include economic environment and government policy support in funds. For example, the Chinese government has implement the "985 Project" which is a significant platform built for 39 University in China. The goal of the project is to build a group of first-class universities in the world. These universities are only in the proportion of less than 3% among 2000 universities in China. But has concentrated more than 50% of the country's doctoral students, national key branches of learning and laboratories, more than half of the scientists. "985 project" universities have also have the advantages of resources, they should also become an important source of Chinese university technology output. So the "985 project" universities' contribution is used as another variable.

This paper investigate the universities' science and technology activities of "province" and "municipal", try to find out the "expenditure on education in colleges and universities", "985 project universities'contribution", "R&D internal fund expenditure", "the number of person expended in R&D", "the number of R&D staff with doctoral diploma", and "GDP per person" effectiveness on university patent transaction amount and value.

92.3 Data, Method, and the Means of Estimation

92.3.1 Data Collections

Because of Xinjiang, Tibet, Ningxia, Qinghai, Inner Mongolia, Hong Kong and Macao's statistical data is not complete, we have collect 104 samples through 4 years of 26 provinces in China according to the people's Republic of China Intellectual Property Right Bureau website statistics, "China Statistical Yearbook", "College Science and Technology Statistics", and "China Statistical Yearbook" through 2008 2011.

The observing variables are "expenditure on education in colleges and universities", "985 project universities contribution", "R&D internal fund expenditure", "the number of person expended in R&D", "the number of R&D staff with doctoral diploma", and "GDP per person", university patent transaction amount and value.

92.3.2 Variables and Statistic Characters

(1) Variables

Independent variables are university patent transaction amount (unit: piece) and patent transaction value (unit: 10 thousand Yuan) of provinces.

Dependent variables: "expenditure on education in colleges and universities (unit: 10thousand Yuan)", "985 project universities contribution (unit: piece)", "R&D internal fund expenditure (unit: 10thousand Yuan)", "the number of person expended in R&D (unit: person)", "the number of R&D staff with doctoral diploma (unit: person)", and "GDP per person (unit: Yuan)", the variable name Abbreviation illustrated in Table 92.1.

(2) Statistic characters of samples

Table 92.2 shows the statistics of each variable. University patent transfer value ranked top 4 are Beijing, Shanghai, Jiangsu and Guangdong in these four years. Beijing in 2011 reached 288.83 million yuan, and the least is Hainan Province in 2008, only 30000 yuan. As to the number of transactions, Shanghai, Zhejiang, Jiangsu, Hubei are high in each year, Jiangsu in 2011 had 256 pieces, and the least is Hainan in 2008 had transfered 1 piece. The highest GDP per person is Shanghai, in 2011 reached 85213 yuan, the lowest is Guizhou in 2008, only 8824 yuan. The standard variance indicates there is a large gap of the economic environment between

Table 92.1 Variable abbreviation

Number	Tag	Variable
1	Province	province
2	Code	code
3	Year	year
4	University patent transaction value (unit: 10thousand Yuan)	ptv
5	University patent transaction amount (unit: piece)	ptp
6	GDP per person (unit: 10thousand Yuan)	gdpp
7	985 project universities contribution (unit: piece)	nef
8	Expenditure on education (unit: 10thousand Yuan)	edfs
9	Expenditure on science activies in colleges and universities (unit: 10thousand Yuan)	ssf
10	R&D inner expenture (unit: 10thousand Yuan)	rdie
11	Number of person expended in R&D (unit: person)	rdip
12	Number of R&D staff with doctral diploma (unit: person)	rdphd

these provinces and cities. As to education funding, the top two is Guangdong and Jiangsu, the fewest is Hainan. Science and technology funding, R&D internal expenditure, R&D staff number, R&D staff with doctral diploma, are concentrated in Beijing, Shanghai, Jiangsu, Shanxi, Hubei Province. The ranking lowest are Hainan, Guizhou and Gansu. The large standard deviation still reflects great differences of technology investment in these provinces.

Table 92.2 Statistic characters of samples

Variable	Obs	Mean	Std. Dev	Min	Max
ptv	104	1493.503	3156.071	3	28883
ptp	104	65.84615	61.55427	1	256
gdpp	104	32818.52	18492.8	8824	85213
ssf	104	84520.56	177500	1040	123816
rdie	104	663101.56	1208092	6518	766535
rdip	104	19001.7	11902.15	342	64946
edfs	104	5037340	2832842	2088.54	153000
rdphd	104	4635.433	4115.808	98	23420
nef	104	18.32692	27.3359	0	136

(3) Distribution of patent transaction value

Fig. 92.1 is the distribution of Patent Transaction Value, and it is “bell-shaped curve” matching to Gaussian distribution. So, it is reasonable to estimate the model by loggaussian distribution.

Fig. 92.2 is the distribution of patent transaction amount, and is also “bell-shaped curve” matching to poisson distribution. So, it is reasonable to estimate the model by log- distribution, as the number of sample is large, and the probability is small.

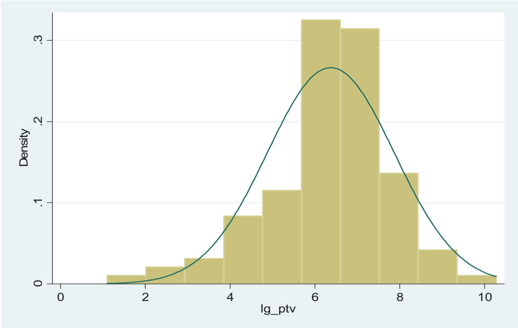

Fig. 92.1 Distribution of patent transaction value

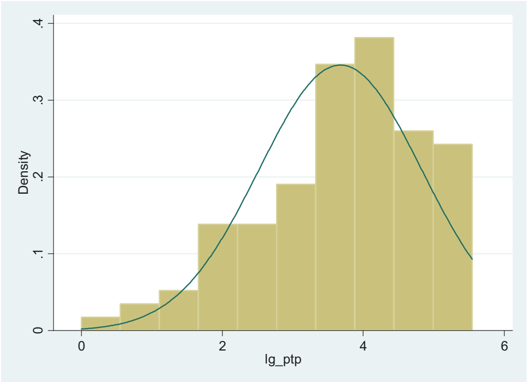

Fig. 92.2 Distribution of patent transferred amount

92.3.3 Estimation

(1) Estimation models

The technological production process is a period often longer than one year. The patent sold in market often lagged after R&D resources invested, so consider using the one year earlier depended variables for estimation.

Expenditure on science activities in colleges and universities affect the R&D internal expenditure, at the same time affects the patent transaction amount. R&D staff number and the number of doctoral researcher have similar effects, so the interaction variables X_1, X_2, X_3 and X_4 are induced which are defined as:

$$\begin{aligned} X_1 &= \mathrm{Std}(\mathrm{rdie}) \times \mathrm{Std}(\mathrm{ssf}), \\ X_2 &= \mathrm{Std}(\mathrm{rdphd}) \times \mathrm{Std}(\mathrm{rdip}), \\ X_3 &= \mathrm{Std}(\mathrm{edfs}) \times \mathrm{Std}(\mathrm{rdie}), \\ X_4 &= \mathrm{Std}(\mathrm{ssf}) \times \mathrm{Std}(\mathrm{rdphd}), \mathrm{Stdis\ standard\ function.} \end{aligned}$$

The model linking variable transaction value, transaction amount and factors is: $E[\ln(\mathrm{ptv}_{it})] = f(\mathrm{rdie}_{it-1}, \mathrm{rdip}_{it-1}, \mathrm{rdphd}_{it-1}, \mathrm{nef}_{it-1}, \mathrm{ssf}_{it-1}, \mathrm{edfs}_{it-1}, \mathrm{gdpp}_t, \mathrm{nef}, X_1,$

X_2, X_3, X_4), and, $\ln(\text{ptv}_{it}) \sim$Poisson;
$E[\ln(\text{ptp}_{it})] = f(\text{rdie}_{it-1}, \text{rdip}_{it-1}, \text{rdphd}_{it-1}, \text{nef}_{it-1}, \text{ssf}_{it-1}, \text{edfs}_{it-1}, \text{gdpp}_t, \text{nef}, X_1, X_2, X_4)$, and, $\ln(\text{ptp}_{it}) \sim$ Gaussian, $i = 1, 2, \cdots, 26$ indicating the province, $t = 2008, 2009, \cdots, 2011$ is the year.

(2) Statistic and estimations

We use the panel-data of 26 sample provinces through four years and the software stata11 generalized linear model (GEE) to estimate the effect of different factors on university patent amount, patent transfer value. Panel-data Generalized linear model estimation combines the advantages of cross section and time series data, also can eliminate the heteroscedasticity, multicollinearity problems of cross-section data analysis. The retention factor does not change with time, is a kind of a combination of dynamic and static data analysis method.

(3) Analysis of statistical results on the value of the patent transfer

The log-Gaussian generalized linear estimation on value of the transfer results is shown in Table 92.3. We can see that GDP per person, R&D internal expenditure, the number of person expended in R&D, 985 project universities contribution have positive effects on university patent transaction value, and statistically significant; the interaction term of R&D internal expenditure & funds of scientific and technological activities also has a positive effect on transaction amount, but not statistically significant.

Table 92.3 Results on the value of the patent transfer

GEE population-averaged model			Number of obs = 56		
Group variable: code Link: log Family: gaussian Correlation: exchangeable Scale parameter: 2072927			Number of groups = 17 Obs per group: min = 2 Avg = 3.3 Max = 4 Wald chi2(11) = 1205064 Prob > chi2 = 0.0000		
(Std. Err. adjusted for clustering on code)					
ptv	Semirobust				
	Coef.	Std. Err.	z	$P > \|z\|$	[95% Conf. Interval]
gdpp	0.0000168	$6.78e-06$	2.48	0.013	[$3.53e-06$ 0.0000301]
ssf	−0.0001338	0.0000204	−6.55	0.010	[−0.0001739 −0.0000938]
rdie	0.0000187	$2.85e-06$	6.56	0.038	[0.0000131 0.0000243]
rdip	−0.00016	0.0000648	−2.47	0.014	[−0.000287 −0.0000329]
edfs	$-2.70e-07$	$7.01e-08$	−3.85	0.012	[$-4.07e-07$ $-1.33e-07$]
rdphd	0.0003406	0.0001524	2.24	0.025	[0.0000419 0.0006392]
nef	0.1178886	0.0248977	4.73	0.011	[0.06909 0.1666871]
X_1	−17.21216	2.954199	−5.83	0.004	[−23.00228 −11.42204]
X_2	−2.153374	0.7138849	−3.02	0.003	[−3.552563 −0.7541852]
X_3	0.181562	0.1744432	1.04	0.298	[−0.1603405 0.5234644]
X_4	−0.4096793	0.451358	−0.91	0.364	[−1.294325 0.4749661]
_cons	4.315545	0.7760786	5.56	0.000	[2.794459 5.836631]

Expenditure on science activities in colleges and universities, education funds, the number of R&D staff, R&D internal expenditure of funds for scientific & technological activities interaction term and R&D doctoral degree staff & R&D staff number interaction term have negative effects on transfer value, and statistically significant; expenditure on science activities in colleges and universities & doctoral degree has a negative effect on the value of the transfer, but not statistically significant.

(4) Analysis of statistical results on the amount of the patent transfer

The log-Poisson generalized linear estimation on amount of the transfer results is shown in Table 92.4. We can see that GDP per person, 985 project universities contribution, R&D internal expenditure, the number of person expended in R&D have positive effects on university patent transaction amount, and statistically significant; The number of R&D staff with doctoral diploma, expenditure on education also have positive effects on transaction amount, but not statistically significant.

Table 92.4 Statistical results on the amount of the patent transfer

GEE population-averaged model					Number of obs = 56
Group variable: code					Number of groups = 17
Link: log					Obs per group: min = 2
Family: poisson					Avg = 3.3
Correlation: exchangeable					Max = 4
Scale parameter: 1					Wald chi2(10) = 1205064
					Prob > chi2 = 0.0000
(Std. Err. adjusted for clustering on code)					
ptv	Semirobust				
	Coef.	Std. Err.	z	$P > \|z\|$	[95% Conf. Interval]
gdpp	0.0000164	$4.21e-06$	3.90	0.001	[$8.19e-06$ 0.0000247]
ssf	$-3.62e-06$	$1.23e-06$	−2.94	0.003	[$-6.03e-06$ $-1.20e-06$]
rdie	$5.83e-07$	$1.81e-07$	3.22	0.001	[$2.28e-07$ $9.38e-07$]
rdip	$-5.52e-06$	0.0000103	−0.53	0.594	[−0.0000258 0.0000148]
edfs	$3.19e-09$	$1.19e-08$	0.27	0.788	[$-2.01e-08$ $2.65e-08$]
rdphd	0.0000253	0.0000275	0.92	0.358	[−0.0000286 0.0000792]
nef	0.0058106	0.0033767	1.72	0.085	[−0.0008076 0.0124288]
X_1	0.0147367	0.0065199	2.26	0.024	[0.0019579 0.0275154]
X_2	−0.0444244	0.0162577	−2.73	0.006	[−0.0762889 −0.01256]
X_4	−0.0510072	0.0155556	−3.28	0.001	[−0.0814955 −0.0205188]
_cons	3.520388	0.2903366	12.13	0.000	[2.951338 4.089437]

Expenditure on science activities in colleges and universities, R&D doctoral degree staff number & R&D staff number interaction term, R&D internal expenditure of funds for scientific & technological activities interaction term have negative effects on transfer amount, and statistically significant; the number of person expended in R&D has a negative effect on the amount of the transfer, but not statistically significant.

92.4 Analysis and Conclusions

In Table 92.5, the positive relationships between GDP per person on patent transaction amount and value are significant. The result is consistent with the majority of other studies. The level of economic development is the interactive results with industry, technology and the human investments, technological innovation and accumulation, and also the driving force of innovation. Higher GDP per person shows that the technology accumulation level of the area is higher and higher levels of demands for future technological change. Shanghai, Beijing, Guangdong, Jiangsu and Zhejiang are high economic developed, and they are also the most actively innovational region. Guizhou, Gansu, Yunnan, in contrast, have least university patent transaction and they are also lowest GDP per person areas. In 2011 the GDP per person is not more than 20000 yuan, lower than the national average GDP per person 32818 yuan. So for the relatively low economic level areas, due to its economic foundation is weak, government should increase innovation policy force to stimulate their innovation activities.

Table 92.5 Relations between independed and depended variables

Depended variables	Independed variables	
	Value of university patent transaction (unit: 10thousand Yuan)	Amount of university patent transaction (unit: piece)
GDP per person (unit: 10thousand Yuan)	$+(*)$	$+(*)$
985 project universities contribution (unit: piece)	$+(*)$	$+(*)$
Expenditure on education (unit: 10thousand Yuan)	$-(*)$	$+$
Expenditure on science activies in colleges and universities (unit: 10thousand Yuan)	$-(*)$	$-(*)$
R&D internal expenture (unit: 10thousand Yuan)	$+(*)$	$+(*)$
Number of person expended in R&D (unit: person)	$-(*)$	$-$
Number of R&D staff with doctral diploma(unit: person)	$+(*)$	$+$
$X_1 = 3 * 5$	$-(*)$	$+(*)$
$X_2 = 7 * 6$	$-(*)$	$(*)$
$X_3 = 4 * 5$	$+$	$-$
$X_4 = 4 * 7$	$-$	$-(*)$

$* : P < 0.05$

The “985 project” universities contributions positively affect both amount and value significantly. The “985 project” goal is to create the world first-class universities and the high level universities. These “985 project” universities are not experienced university emerge, because of the industrial characters. Each of them has at least two top branches of learning, deep industry background accumulation and the good reputation, high degree of recognition in collaborating. At present, 8 of 39 “985 project” universities are in Beijing, 4 in Shanghai, 3 in Sichuan, Hunan also has 3, and the rest are in Tianjin, Hubei and Shanxi. Beijing, Shanghai and Shanxi. These provinces are the leaders of university patent transactions. Though, “985 project” universities’ contribution on amount is 30 percent of total, but accounted for about 50% of the proportion of the total value of the transaction. That implicates the “985 project” university patent achievements relative higher market value than the other universities. Therefore, the construction of high level of academic platform has strengthened the university collaborative innovation, and technology spillover of Colleges and universities is of great significance.

Expenditure on education is negative to university patent transaction value and has statistical significance, but is positive to university patent transaction amount and statistical insignificance. Guangdong Province has spent the most education funds, but the value and amount of patent assignment by Guangdong Universities is lower than Beijing, Jiangsu, Zhejiang and in Shanxi Province. On the contrary, Shanxi had spent the education funds almost equal to Yunnan and other western provinces, but the patent transaction amount and value is equal to eastern provinces. Because the education funding is input in compulsory education system, can effectively improve the local compulsory education level. But the university entrance exam system and other factors disperse the educational capital investment; little of it is rested in the original region.

Expenditure on science activities in colleges and universities has significantly statistical negative relationship with patent transfer value and amount. Shows that expenditure on science activities in colleges and universities is not the major patent transaction force. Expenditure on science activities in colleges and universities is consist of direct government investment and enterprises collaborative research funding. Only part of these findings can be transferred to successful patent transaction. The outputs of university research activities are not only patents but also papers and other open technological results, especially those universities have strong basic research abilities. The negative coefficient between expenditure on science activities and patent transaction indicates the decenting proportion of pure activities with the purpose of patent transactions. Otherwise, some studies indicate that funding investment is less efficient than human investment. For funding management is more difficult, and there is more waste.

University R&D internal expenditure is positively and significantly correlated with patent transaction amount and value. University of R&D internal expenditure is mainly used for basic research, applied research, experimental development, and daily expenses. The R&D internal expenditure is applied to the specific R&D activities with clear usage point. So the higher R&D internal expenditure means more realistic directivity research activities which bring more practical efficient outputs.

The R&D staff number and patent transaction value have significantly negative relationship; the R&D staff number is also negative with amount but not statistically significant. Related research shows the number of personnel in scientific and technological activities has close relation to the contract number of technology transfer. Chapple [10] confirmed the organization forms of R&D staff had an important influence on the efficiency of scientific technological activities. It is needed to optimize the organizational structure and improve the skills of staff to enhance work efficiency. Therefore, not only increase the number of R&D staff input is important, but also improve work efficiency.

The number of R&D staff with doctoral diploma and patent transaction amount is positively relevant and significant, but doctoral staff number with the patent number is not statistically significant. Studies show that the personnel of high education levels have valid efficiency on patent and technology output, binging more high level productions. This study is consistent with Thursby's [1]. More and more attention paid to the teacher's education level in universities over these years in China, and doctoral degree R&D number is rising up. High education level means more knowledge accumulation and a strong spirit of exploration which can bring high market value of patent outputs.

The interaction terms shows the factors' comparative influences. The positive influence of doctoral R&D staff is weaker than the negative impact of worker's number, resulting in that X_2 has negative relationship with amount and value of patent transaction. The negative effect of expenditure on science activities in colleges and universities is stronger than the positive effect of Dr. R&D number, resulting in that X_4 has negative relationship with the amount and value of patent transaction.

Based on the above analysis, to improve technology efficiency can't rely only on investment [11–13], but should improve the utilization of resources. At the same time for the staff should pay attention to the quality and collaboration skills of personnel engaged in scientific and technological activities. Only by improving the human capital with the appropriate economic capital, can reduce waste and improve the efficiency of technological innovation.

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Chapter 93
The Exploration of Risk Management Issues for Leisure Sports

Ming Xu and Lei Xu

Abstract In this paper, I mainly talk about the background, definition, the risk and risk management of leisure sports. After the analysis of the of risk features and problems of risk management in leisure sports, risk identification and risk management in fitness industry, I find that risk management is very necessary to avoid risk in leisure sports, that both the operators and participants or consumers need to be responsible for themselves and others, development of organizational risk management plans, identification of risk sources, risk assessment, and the development of risk response measures are effective ways to cope with risks in fitness industry. In the end, I propose methods to solving the problems in risk management of leisure sport:the government and the fitness industry should offer cooperation opportunity mutually and contribute to promoting the continuous and healthy development of leisure sports industry at the same time, as well as strong support for the harmonious and healthy development of the entire sports industry.

Keywords Leisure sports · Risk identification · Risk management · Risk management measures

93.1 What Is Leisure Sports?

As a physical activity, Leisure sports is the experience of the free nature in the spirit world and the freedom of life "generation", and the comfort and ease after getting rid of all kinds of greed and social relations as well as depression. It not only contains the care of life, the awakening of the meaning of life and the asking

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of the significance of life of people, but also is some kind of physical activities to experience the free and perceptive state of mind. Besides, it is the real process of the appropriation of human nature, as well as the "reversion process" [1, 2] of human's return to itself and the community (i.e. people). So we can understand the meaning of leisure sports as follows: With the help of certain sports and physical activities, people can abandon the social reality to feel the publicity and emotional catharsis of the original human nature, and perceive self-existence as an organism. This is called leisure sports.

From the perspective of the sports occasions, leisure sports can be divided into indoor leisure sports and outdoor leisure sports two categories [3, 4]. Indoor leisure sports include the fitness in gym. Fitness is a sport which especially refers to bare hands or instruments gymnastics. Gymnastics can enhance force and flexibility, increase endurance, and improve the abilities of coordination and the ability to control various parts of the body. As a result Gymnastics make the body strong. outdoor leisure sports is a collective project group held in a natural venue, which includes climbing, rock climbing cliff downhill, as well as camping, picnicking, directional movement, streams, and adventure etc in the open air. Lots of outdoor leisure sports are adventurous, Limit and extreme sports which are of a lot of challenges and irritating and the sportsmen always have the aim to embrace nature and challenge themselves [5].

93.2 What Is the Risk and What Is the Risk Management?

93.2.1 The Understanding of the Risks

(1) The definition of risk

When people are engaged in certain activities, they always expected certain results. If they are not very sure about the expected result, they will think the activity is risky. When there are expectations for future events, there are the possibilities that the expectations can not be achieved, that is to say there is a "risk". There are three expressions for risk in English: Risk, Peril and Hazard. Risk refers to the possibility of adverse events, while Peril refers to the adverse events themselves, and Hazard refers to the conditions of adverse events, i.e. the prerequisite, environment, incentives, etc. of adverse events. Modern Chinese Dictionary defines risk as "possible dangers". In general people's eyes, risks are "problems that may occur". The three key words that are related to risk are factors, risk events and risk of loss. The risk factors refer to elements that can increase or lead to the frequency and extent of the loss. In any kind of risk, only those adverse factors are the risk factors when various factors are taken into consideration. In order not to be lost in such activities, the sportsmen must take various measures to avoid or reduce the impact of unfavorable factors, that is, to eliminate or inhibit risk factors. Risk event refers to occasional events (or random events) that cause a direct loss. The risk of loss refers

to the unintentional, unplanned, unexpected reduction of the economic value that can be measured in monetary units. The understanding of risk has a very important significance to cope with risks.
(2) The features of risks

- **Objectivity** Whether people are aware of the risks, if the factors determining risks appear, the risk will takes place, for it can not be transferred by the will of human. Therefore, it is necessary to timely discovery and eliminates factors that may lead to risks in order to reduce and avoid risks. However, due to the risk factors are varied and many factors are inherently uncertain, to completely avoid the risk is impossible.
- **Abruptness** The generation of risk tends to leave human an impression with a sense of abruptness. On the surface, the abruptness of Risk has a great deal of randomness for the time it occurred is by chance. However, in fact it implies a certain inevitability. When a variety of factors deciding the generation of risk accumulate to a certain amount and reaches a critical value, the risk will inevitably occur as long as a certain induced factors appear. Therefore, we should strengthen the research of early warning and prevention of risk, set up a risk early warning system, and improves the risk prevention mechanism.
- **Variability** The variability of risk refers to the dynamic changes in the extent of damage and the nature of the risk which will be influenced by a variety of factors and have a stable form difficultly. Thus, when we develop the risk response programs, we had better develop a variety of programs and plans in order to we can have different programs and plans to choose from to deal with risks in case risks occur.
- **Invisibility** Risks are unlike the general material entities which can be very precisely depicted and portrayed. Although the invisibility of risks makes it more difficult for human to understand and cope with risks, it is still possible to identify and measure risks if the internal and external factors leading to the risks are carefully identified, and the proper quantitative methods and means are applied.

93.2.2 The Understanding of the Risk Management

In his book Risk Management and Insurance, published in 1964, American scholar Williams, put that risk management refers to management approaches that reduce the various loss caused by risks to the minimum level at the lowest cost through risk identification, measurement and control. China's Taiwan scholar Zongwei Yuan think: risk management is a set of system and scientific management methods which include the identification and measurement of risks, active risk management and effective disposal of the risks and proper processing of loss caused by risks on the base of investigation, prediction, the collection and analysis of the uncertainty and possibility of risks. The goals of risk management are: reducing the occurrence rate of unexpected events, making the possibility of loss to the lowest level. The process of risk management includes: risk identification, risk analysis, risk evaluation, risk response as well as the development and implementation other steps of risk management plans [11].

93.3 The Necessity and Problems of Risk Management in Leisure Sports

(1) The necessity of risk management

With the continuous development of the fitness industry, great changes have taken place in many aspects of fitness activities such as the occasion, the sports program, the pattern, the activities. Nowadays as people's health awareness are enhanced in general, fitness concept are greatly improved, fitness sports are becoming more and more abundant in the form, more and more profound in content, more and more innovative in concept, and more and more progressive in theory. More people are beginning to favor many risky projects and difficult action, such as climbing the mountain, rock climbing, skydiving, high-profile skiing, sand boarding, bungee jumping, diving, snorkeling, surfing, rafting and canyoning, etc. These very adventurous sports and action are stimulating and great appreciated. Besides, these sports which used to be the priority of mountaineer, explorer, and professional athletes now become a part of ordinary people's life.

However, there have been a lot of problems when people are in fanatical pursuit of fitness exercise. Fitness participants' ignorance of fitness knowledge, weak sense of their own safety, the lack of knowledge of the coaches or instructors and unreasonable arrangements in the fitness exercise load and project content lead to a variety of injury accidents [6–8]. This will not only bring great harm to the body of fitness participants, but also can cause huge economic losses to operators. Therefore, it is very important to analyze the risk correctly, prevent it effectively and response to it reasonably. It also plays a very important role in the development of the sports field: ① it is conducive to the development of more effective strategic plan. ② control the cost. ③ enhance the awareness and understanding of the risk of exposed. ④ offer a systematic, familiar and thorough method for decision-making. ⑤ Minimize losses. ⑥ use better resources. ⑦ strengthen the cultural atmosphere for continuous progress. ⑧ create one of the best places for customers to Participate and establish a good relationship with customers through experience.

(2) The main problems that should be considered in risk management of leisure sports

- To ensure that legitimate.
- Check and compare the terms, proceedings and a strict contract of the corporate organization to make sure what decisions made and actions taken by associations and organizations are full compliance with the legal requirements.
- Be familiar with and comply with all industries and the industry standards, especial the standards that are the most pressing and have been repeatedly sentenced by the court in the past.

- Check and improve the security file to ensure the completion of the system.
- Make sure that the service offered is safe by consulting experts in laws and buy sufficient insurance for all kinds of people.
- If you find any deficiencies existing, you should take corrective action immediately.
- Investigate the background and results of r all employees to ensure they have no security risks themselves.
- Ensure that all participants know the various security statutes, rules and regulations, and ensure that the rules are stressed to everyone.
- Under possible conditions, ensure the safety of each new sports facilities, including the design and construction two aspects.
- Formulate a daily security list, including inspection frequency and all information files.
- Ensure timely maintenance of sports facilities according to the sports facilities maintenance plan.
- Formulate and implement a reports system for accidents and injuries, regardless of injury severity.
- Strengthen the signs of waiver and informed consents to reduce the risk.
- Check the definition of duties and positions of the various staff to ensure that they always work within the scope of their respective responsibilities.
- Offer daily job training for all staff and members of the Committee.
- Develop a risk management plan by consulting public recreation agency in order to reduce the risk.
- Hire a private management organization to making risk management assessment of the Organization.

93.4 Risk Management in Fitness Industry

Sports Fitness Industry risk refers to the possibility that makes fitness activities participants unable to carry out normal activities or leads participants casualties, the possibility of infringement of rights and the loss of fitness areas and operators and other events [9, 10]. Related risk management is to formulate a set of management system to identify risk, assess risk and respond to risk and so on.

93.4.1 Risk Identification in Fitness Industry

Risk identification is the first step of risk management, whose aim is to Confirm the fitness industry's risk that has important influence.

- The Lack of fresh air in Gym and losing freshness. For general gym, the ventilation is managed by the central system. So the gym itself can not be free exhaust, fresh air can not enter and exhaust air can not be discharged. The Limited fresh air has to maintain large numbers of people's breath and the quality of air is undoubtedly low. Some gyms are not adequately ventilated after decoration. As a result, formaldehyde, benzene and other toxic substances exceed the standard levels and cause direct harm to human bodies.

- Laud noise in gym and incomplete disinfection. Strong and loud music in the gym, the loud and clear passwords or whistles of coaches, together with the operating sound of the instrument form the unique deafening noise. Exposure in this environment to exercise or work for a long time will accelerate myocardial aging, increase the incidence of myocardial infarction, and cause symptoms of high blood pressure, headaches, forgetfulness, hearing and mental decline, which will lead to diseases rather than fitness through exercise. Besides, the disinfection levels of equipment, wardrobe, slippers, and ground dust in gym are not the same due to the casual attitude and lack of related knowledge.
- Inadequate lighting and ventilation in Gym. Nowadays as more and more fitness centers are located in the high-end office, the fitness centers are caught by "building syndrome" such as lack of light. As a result, the exercise effects of the movement are greatly reduced. The gym a place which is most in need of fresh air, for exercise, especial aerobic exercise, will consume large amounts of oxygen. However, now many fitness centers prefer transparent glass curtain wall and a fully enclosed central air-conditioning system, leading to inadequate air exchange and the accumulation of carbon dioxide which will evoke laryngitis, bronchitis and other respiratory diseases. What is more the insufficient sunshine of Fitness center could easily lead to the body lack of calcium.
- Sports injuries. The unreasonable exercise time and exercise amount arrangements will not lead to the goals of exposure. Instead, it will cause people's body by chronic injury. Some undetectable damage in the long-term exercise is in a slow but steady erosion of the health of people. Insufficient understanding of the function and operation of fitness equipment together with movement essentials result in incorrectly use of fitness equipment which leads to injuries.

93.4.2 Risk Management in Sports Fitness Industry

Risk treatment refers to the selection and implementation of control means in risk management. Risk control means is technical measures to prevent and mitigate the loss of risk before the formation of risk. In order to minimize the loss of risk, the risk control means aims to reduce the probability of loss by avoiding, eliminating and reducing the opportunities of risk and limiting the continuous expansion of losses in the risk events that have occurred. Different disposal methods are used for different risks. Facing various kinds of risks in sports fitness industry, we had better take various methods into comprehensive use, which include risk avoidance, risk reduction, risk transfer, risk retention and risk self-protection.

One of the most important aspects in risk management embodied in the course of the gyms business is how to reduce the unexpected accident occurrence and how to reduce and pass on the unexpected costs. As is known to all, the factors leading to events are various. The possible risks in comprehensive gyms are broadly classified as: risk caused by fire, electricity, equipment, dangerous substances, accidents and acute (including sudden death). Professional risk management measures will betaken into consideration before, during, and afterwards risk.

Before Risk: measures should be taken to reduce the possibility of risk, such as staff training, anti-skid measures, creep age measures etc. Measures should be applied to pass on the assumed responsibility for risk, such as informing, expression, contract, agreement, insurance etc.

During risk: measures should be taken to reduce the probability of risk continuing to occur, such as isolating fire place, dispersing the crowd etc. Measures to reduce the loss of risk continuing to expending.

Afterwards riskApplications of measures to reduce the negative impact brought by the risk, such as Insurance claims, public relations for risk, media response. Measures should be taken to recovery production as soon as possible.

Risk management

(1) The necessity of risk management

First, the awareness of safe operation is necessary. Every manager should put the security of gyms, stability of income, reduction of unexpected cost on the most important position in the overall business strategy. What is more impression is that the awareness should be past to every employee. Only when risk management has been recognized by the high-level managers and carried out by employees will the real disaster prevention and derogation measures play an important role.

(2) Complete risk management measures

Complete risk management measures are the core of risk management. According to the classification of risk, risk management measures will response to every possible risk that threats to gyms and be controlled through before, during, and afterwards risk stages mentioned before.

Consulting to a professional risk management institute is the fastest and effective way to get access to full controlled risk measures. They have the advantage of experience and suggestions. What is more important is that they can provide a very practical training, and make necessary contingency plans, risk communications plan, business recovery plan etc.

(3) Transfer of economic loss

No matter how complete systems and measures, they can only reduce the possibility of risk events or the loss after risk events. Risk is everywhere, and can not be completely eliminated. Therefore, we can not sit back and relax as professional risk control measures exist. Operators should also transfer losses caused by risk reasonably and effectively in addition to day-to-day risk control measures.

In a word, the risk management for Sports Fitness industry is rather a cyclic, continuous and repeated process than a simple process. Development of organizational risk management plans, identification of risk sources, risk assessment, and the development of risk response measures are effective ways to cope with risks in fitness industry.

93.5 Conclusion

Leisure sports are the release of spiritual or experience of natural life after human's material requirement being achieved to a certain extend. The final destination of leisure sports is to make the participants get the biggest solace from both the physical and mental instead of a variety of potential risks. Both the operators and participants or consumers, whose responsibilities should be put into practice of the risk management process, including risk identification, risk control etc, need to be responsible for themselves and others, even the whole society. They offer cooperation opportunity mutually and contribute to promoting the continuous and healthy development of leisure sports industry at the same time, as well as strong support for the harmonious and healthy development of the entire sports industry.

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Chapter 94
Use a Balanced Scorecard to Evaluate Business Processes of Sichuan Electric Power Company

Yanfang Ma

Abstract Since the electric power industries throughout the world are undergoing enormous restructuring processes resulting in fiercer competitions than ever, it is necessary for electric power companies, especially Sichuan Electric Power Company (SEPC) as an important part of South China Power Grid Company, to make suitable and feasible strategy for their development. The objective of this study is to construct an approach based on the analytic hierarchy process (AHP) and balanced scorecard (BSC) for evaluating SEPC performance, aiming at acting as a reference to electric power industry. The BSC concept is applied to define the hierarchy with four major perspectives (i.e. financial, customer, internal business process, and learning and growth), and performance indicators are selected for each perspective. And then the AHP is used to determine the indicator weights. The results provide guidance to electric power company in the electric power industry in China regarding strategies for improving business process performance. Finally, some suggestions are given for improving the SEPC business processes.

Keywords Balanced scorecard · Analytic hierarchy process · Performance evaluation · Sichuan electric power company · Electric power industry

94.1 Introduction

Electric Power Industry is one of the most fundamental industries in China. However, compared to national economy, it is lagging behind. The electric power industries throughout the world are undergoing enormous restructuring processes, moving from the conventional monopolistic or vertically integrated environments to deregulated and competitive environments since 1978 [1]. It is generally believed

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that opening the power industry to competition will benefit consumers with lower prices and better service.

Electric power systems operations planning have been so challenged with the restructuring market environments that most of the privatized GENCOs are pressured to more efficiently schedule and commit their generators in order to maximize their profit. In recent years, considerable amounts of research have been done in the optimal planning strategies for the competitive GENCOs [2–4]. According to above statement, SEPC are facing more and more intense competition in the global markets. They have realized that efficient business process and performance of products preferred by customers at more competitive cost and shorter lead time over those offered by their competitors is crucial to their survival and development. In the deregulated and competitive environments, many methods and techniques have been suggested over the years to evaluate the investments in SEPC or the performance of SEPC departments. However, well-known financial measures such as return on investment (ROI), internal rate of return (IRR), net present value (NPV) and payback period have been demonstrated to be inadequate [5].

Kaplan and Norton [6] introduced the Balanced Scorecard (BSC) as a management system that helps organizations define their vision and strategy, and translate them into specific actions. The BSC provides feedback on internal business processes, performance, and market conditions in order to review the strategy and future plans [7]. The AHP was first introduced by Saaty in 1971 to solve the scarce resources allocation and planning needs for the military. Since its introduction, the AHP has become one of the most widely used multiple-criteria decision-making (MCDM) methods, and has been used to solve unstructured problems in different areas of human needs and interests, such as political, economic, social and management sciences [8, 9]. Since Electric Power Industry is one of the most fundamental industries in China and the government increases investment in this field, it is necessary for electric power companies to make suitable and feasible strategy for their development to enhance service and reduce administration cost and production cost. Making effective performance measurement and evaluation can help electric power companies know their business well and make suitable and feasible strategy. After electric power system reform started in 2002 in China, Sichuan Electric Power Company (SEPC) is an important part of South China Power Grid Company, and also a large state-owned enterprise. Aiming at acting as a reference to electric power industry, this article brings forward a plan to solve the above-mentioned questions through a series research of the process that SEPC took to re-engineer and recombination. After a comprehensive analysis, an incorporation of BSC and AHP is used to make the measurement of SEPC business process and the evaluation of SEPC performance.

The remainder of this paper is organized as follows: In Sect. 94.2, the business environment for operating SEPC business processes are analysed. In Sect. 94.3, the evaluation method based on the BSC is proposed, and then the SEPC business processes are evaluated by the BSC. In the end of Sect. 94.3, some suggestions are given for improving SEPC business processes. Finally, some concluding remarks are outlined in Sect. 94.4.

94.2 The SEPC Business Environment

Under market economy environment in China, there is a need to analyse the external business environment for operating SEPC business processes. The aim is to understand and analyse the SEPC external business environment from the economic driving force, including the analysis on electric power system reforming in China, the impact on suppliers and buyers, the threat from substitute products and new entrants, and the impact from the government, society and technology.

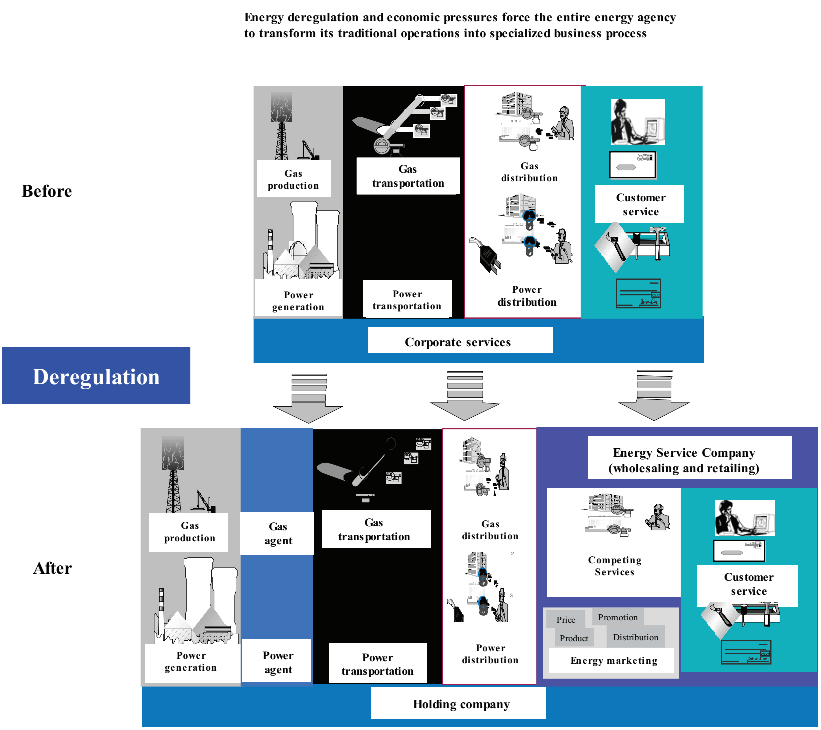

Fig. 94.1 The comparison between before and after deregulation in electric power industries

Recently, the electric power industries throughout the world are undergoing enormous restructuring processes, moving from the conventional monopolistic or vertically integrated environments to deregulated and competitive environments [1]. In a fully competitive environment, more efficient power producers and distributors will maximize their revenues, while those offering higher prices may have to improve their capabilities in order to lower the cost of power production and/or delivery. The comparison between before and after deregulation in electric power industries can be seen in Fig. 94.1. However, electric power system reform had not been started until 2002 in China. Based on the situation of Chinese electric power market in 2002, whole management scheme of Chinese electric power market of "power plants separated form electric network, competing electric price" had been proposed. Currently, the main driving forces to operate the electric power system reform are the following: (1) Over the past 20 years, China's economy keeps steady and rapid growth which promotes electricity reform; (2) Reform is the inevitable route for the power industry to seek their own development; (3) Improve the service level of the power companies. On the other side, the fact must be recognized that there are many key issues need to be determined or refined in the implementation of China's electricity reform. These problems need to be given full consideration and handled with care in the evaluation of SPEC business processes.

94.3 Evaluate SEPC Based on BSC

The details about Sichuan Electric Power Company, Chengdu Power Plant and Chengdu Electric Power Bureau have been introduced in the previous sections. And a simple discussion has been made about the SEPC problems, the root causes as well as the suggestions. According to the principle of process diagnosis and recycling, an evaluation on the SEPC business processes should be made to focus on solving the important and feasible problems which can achieve remarkable results.

94.3.1 The BSC Design Procedure

The BSC developed in 1992 by Robert Kaplan, is used as a method to evaluate corporate performance from four different perspectives, namely the financial perspective, the internal business process perspective, the customer perspective, and the learning and growth perspective [6]. The advantages of the BSC can be reflected from the following aspects: (1) It can help companies to establish a strategic management system; (2) It can provide a strategic framework for enterprise performance management; (3) It can promote enterprises for a better learning; (4) It can consider organization and coordination system when managing the company; (5) It can help enterprise find its weaknesses and find ways to improve.

The BSC design procedure for the SEPC can be seen as follows:

Step 1. Analysis. As the increasingly fierce competition and growing customer expectations in electric power market, the SEPC is faced with many internal and external environmental challenges which can be seen in details in Sect. 94.2. How to make the SEPC gain an advantage in fierce competitions requires a comprehensive analysis to formulate a clear development strategy for the SEPC.

Step 2. Determine the SEPC development strategy. Development strategy is determined based on the preceding analysis results. In the BSC design process, the designers must determine the strategic focus of the SEPC value proposition for the next three years.

Step 3. Determine the SEPC goals. After the development strategy is determined, the SEPC managers and leaders should develop specific strategic performance goals, which usually include four dimensions: financial dimension, customer dimension, internal business processes dimension and learning and growth dimension. In the BSC design process, the designers should link the BSC and the SEPC strategy in the following two aspects: financial and non-financial indicators, leading performance and lagging performance indicators.
Step 4. Disintegrate the SEPC goals. The BSC designers should transmit the SEPC strategy to the entire staff and gradually disintegrate performance goals to every employee. In the decomposition of the performance goals, they should pay attention to the SEPC internal harmonization, so that different departments can be well-collaboration in the SEPC.
Step 5. Select the specific performance indicators. The specific performance indicators selection should be based on the SEPC development strategy and goals. After collecting a wide range of views, including the SEPC internal and external communication, top-down communication, the designers find the best performance indicators which can reflect and measure the SEPC performance, and can make the BSC indicator system reach equilibrium.
Step 6. Determine the specific values for the performance indicators. The designers combine the BSC performance evaluation indicators with the SPEC development plans, and give the specific values of performance evaluation indicators for each year, each month, each employee.
Step 7. Continuously improve the BSC performance evaluation system. After the BSC performance evaluation system is established, the weaknesses in the system need to be timely corrective, and new indicators which can be better to reflect the SEPC development should be added.

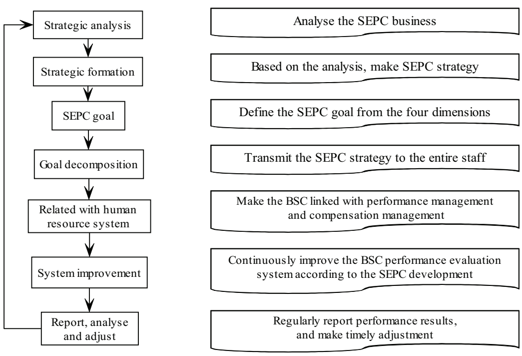

Fig. 94.2 The overall procedure of the BSC performance evaluation system design

The design procedure can be seen more clearly from Fig. 94.2 which is overall procedure of the BSC performance evaluation system design.

94.3.2 Indicator Weights Based on the AHP

In the SEPC business performance evaluation system based on the BSC, each indicator is vital for the SEPC development strategy. And the right weight of each indicator is determined according to the SEPC operating conditions. In this paper, the analytic hierarchy process (AHP) is used to determine the indicator weights. The results obtained by the AHP are more close to reality, since the AHP makes subjective judgments on the indicators.

In the hierarchy, If one element is related with all the elements the next layer has contact, this element has full hierarchy relationship with the next layer. The SEPC hierarchy diagram can be seen in Fig. 94.3. It can be divided into three levels: the target layer A and the indicator layer B. The target layer A is the development objective which can achieve the SEPC strategy.

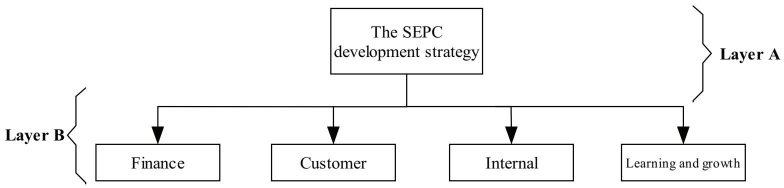

Fig. 94.3 The SEPC hierarchy diagram

After the SEPC indicator hierarchy is determined, the indicator weights should be determined. In this paper, the pairwise comparison is used to determine the indicator weight. According to the scale Table 94.1, the indicator weight can be calculated.

Table 94.1 The scale

Scale	Meaning
1	The two indicators have the same importance degree
3	One indicator is a little more important than the other one
5	One indicator is obviously more important than the other one
7	One indicator is intensely more important than the other one
9	One indicator is extremely more important than the other one
2,4,6,8	The median between the above neighbouring comparison

A survey is made among ten employees in the SEPC, and they are one general manager, one employee from the office, one from finance department, one from purchasing department, two from manufacturing department, two from engineering department and two from sales department. According to the survey results, the following the judgment matrix can be seen in Table 94.2 based on the average results.

Table 94.2 The judgment matrix

Scale	Meaning			
A	B1	B2	B3	B4
B1	1	0.581	1.44	1.68
B2	1.72	1	2.24	2.46
B3	0.694	0.446	1	2
B4	0.595	0.406	0.5	1

In the following, the product M_i in each row of the judgment matrix should be calculated, and then the $n-th$ root $\overline{W}$ is obtained as follows: $\overline{W}_1 = 1.0888$, $\overline{W}_2 = 1.7246$, $\overline{W}_3 = 0.8870$ and $\overline{W}_4 = 0.5894$. Uniformization is made on the vector $(\overline{W}_1, \overline{W}_2, \overline{W}_3, \overline{W}_4)$ to achieve the sequence weight vector W_i, and $W_i = \overline{W}_i / \sum \overline{W}_i$. The weight of each indicator can be seen as follows:

$$\begin{aligned} W_1 &= 1.0888/(1.0888+1.7546+0.8870+0.5894) = 0.2520, \\ W_2 &= 1.7546/(1.0888+1.7546+0.8870+0.5894) = 0.4062, \\ W_3 &= 0.8870/(1.0888+1.7546+0.8870+0.5894) = 0.2053, \\ W_4 &= 0.5894/(1.0888+1.7546+0.8870+0.5894) = 0.1365. \end{aligned}$$

And then, it comes to the the largest eigenvalue $\lambda_{\max} = \sum \left[\frac{(AW)_i}{nW_i} \right]$:

$$AW = \begin{pmatrix} 1 & 0.581 & 1.44 & 1.68 \\ 1.72 & 1 & 2.24 & 2.46 \\ 0.694 & 0.446 & 1 & 2 \\ 0.595 & 0.406 & 0.5 & 1 \end{pmatrix} \begin{pmatrix} 0.2520 \\ 0.4062 \\ 0.2053 \\ 0.1365 \end{pmatrix} = \begin{pmatrix} 1.0129 \\ 1.6352 \\ 0.8344 \\ 0.5540 \end{pmatrix}. \tag{94.1}$$

Based on Equation (94.1), then:

$$\begin{aligned} \lambda_{\max} &= 1.0129/(4*0.2520) + 1.6352/(4*0.02) + 0.8344/(4*0.2053) \\ &\quad +0.5540/(4*0.1365) \\ &= 1.0049 + 1.0064 + 1.0362 + 1.0147 \\ &= 4.0622. \end{aligned}$$

In the end, the judgment consistency needs to be checked according to the formulation: CR = CI/RI, in which CI $= \frac{\lambda_{\max}-n}{n-1} = \frac{4.0622-4}{4-1} = 0.021$. And RI can be obtained according to the RI query table (Table 94.3). When $n = 4$, RI = 0.90.

Above all, CR can be obtained: CR = CI/RI = 0.021/0.90 = 0.023. Since CR < 0.1, it is believed that the the judgment consistency can be accepted. Thus, the indicator weight of layer B can be seen in Table 94.4.

The SEPC work focus in the future can be clearly identified from Table 94.4. From Table 94.4, it can be seen that the weight of learning and growth is relatively

Table 94.3 The RI query table

Index	1	2	3	4
RI	0	0	0.58	0.9

Table 94.4 The indicator weight of layer *B*

Indicator	Finance	Customer	Internal	Learning and growth
Weight	25%	40%	21%	14%

smaller. This reflects the company's advantages are in technology and management. What the SEPC needs to do is to strengthen the capacity in other aspects. In the following, in each dimension, the weight of customer dimension is the biggest which also shows that the SEPC development focus is to keep old customers and develop new customers. Thus, the SEPC operating performance can be improved and the SEPC strategic objectives can be achieved.

94.3.3 Valuation Standards

It is very difficult to evaluate different business processes together. The BSC can find their similarities from several major areas, and then evaluate them. The evaluation objective is to find business processes which can not meet the requirements of the company's overall strategic goals and mission, which have the potential to reduce costs, and which are very important for improving customer satisfaction.

The BSC is a comprehensive evaluation. It arises when companies often ignore the other targets in the pursuit of one goal. For example, companies often give blindly discount price for the pursuit to expand the market, but ignore product quality and customer service. This is counterproductive and destructs the company operation balance. To this end, there is a need to establish multidimensional goals and find the best point in the multi-goals to keep company operation in the best state of equilibrium. In this paper, the BSC is used to evaluate the operational capacity of SEPC business processes in different areas. The valuation standards can be seen in Table 94.5.

94.3.4 The SEPC Business Process Evaluation

The goals of the SEPC business process evaluation can be seen as follows:

- Within the scope of SEPC business processes, find out the business processes or sub-processes which need further analysis;

Table 94.5 Valuation standards for SEPC business processes from different aspects

Aspect	Valuation standards for business processes
Finance	1. Absolute cost is big in the process 2. There is a big chance to reduce cost 3. There is a big chance to increase sales
Customer	1. It is closely related to customer satisfication 2. There is a potential opportunity to overcome competitors 3. It can gain customers and dominate the market.
Internal	1. It supports company strategies 2. It supports company vision 3. It supports company mission
Learning and growth	1. It is timely 2. It is accurate 3. It is synchronized with related operations 4. It is closely related to knowledge management 5. It has an affect on the reform and innovation

- Make sure the existing state of each process or sub-processes in order to put forward appropriate recommendations for improvement;
- Identify the business processed which may have problems;
- Identify business processes which have possible opportunities for improvement;
- Identify business processes or sub-processes which are operating well, and they can be preserved in the future design;
- Identify whether these business processes, sub-processes, operations, industry standards and operational basis are important;
- Identify the cross-sectoral, inter-cities and inter-subsidiary business processes or sub-process which need to improve operations coordination;
- Identify some potential opportunities, for example the responsibility of the business processes or sub-process can be handed over to customers, suppliers or contractors;
- Identify some potential opportunities which can make business processes or sub-process automation by available technologies.

After the indicators and criteria of business performance evaluation system are determined, in order to achieve fair and reasonable evaluation results, the scientific calculation method should be used to evaluate the specific business processes. The calculation method is divided into two parts, the quantitative and qualitative calculation. The detailed results of the assessment on financial management systems and business processes from the above four dimension can be seen in Table 94.6.

After the evaluation based on the BSC, the business processes which have big problems (●) require further analysis. Based on Table 94.6, summarize the results from four aspects into one, namely operating capacity. And make a comprehensive assessment of the business processes which can be seen in Table 94.7. In Table 94.7,

Table 94.6 Business processes operating capacity evaluation by the BSC

Node	Business process	Finance	Customer	Internal	Learning and growth
		25%	40%	21%	14%
FI03-02	Material procurement process	●	○	●	●
FI03-03	Fuel procurement and payment process	○	○	●	●
FI03-04	Project management process	●	◇	●	●
FI04-01	Fixed asset purchase	●	○	◇	○
Z001-03	Equipment maintenance and spare parts management processes	●	○	●	○

Note: ● means it has big problems, ○ some small problems and ◇ no problems.

Table 94.7 Comprehensive assessment of the business processes

Node	Business process	Importance	Operating capacity
FI03-02	Material procurement process	⋆	●
FI03-03	Fuel procurement and payment process	⋆	●
FI03-04	Project management process	⋆	●
FI04-01	Fixed asset purchase	⋆	●
Z001-03	Equipment maintenance and spare parts management processes	⋆	●

Note: ⋆ means it is very important, and ● means its operating capacity is poor.

it has considered both importance assessment and operating capacity assessment of these business processes.

94.3.5 Suggestions

According to the problems analyzed above, there is some suggestions to improve the SEPC business processes. The suggestions can be seen as follows:

- **FI03-02 Material procurement process**: Materials Company should negotiate with suppliers to delay shipments until materials being used, and then suppliers have to bear the storage costs instead of Materials Company. At the same time, the payment is delayed. Thus, fund embezzlement is avoided. Strengthen space management in warehouse. The SEPC should unify project coding rules, and then implemented by the Urban Council and the power plants.
- **FI04-01 Fixed asset purchase**: The SEPC should not only analyze the project necessity, but also make investment project feasibility study and choose the best option. Indicators on state-owned assets should be taken into consideration, when the Corporate Audit Department make audit for administrative officers. The SEPC should implement fixed asset classification management, and make a top-down criss-crossing management system. Finance department should check

the added fixed assets from grass-roots unit. As for fixed assets swapping out, grass-roots unit should make transfer procedures, and finance department should know well about the transfer results and make registration. Regularly make fixed assets inventory. When account is not following the real situation, finance department should deal with the account after getting the approval. Develop different approval processes, and must state the loss cause and the amount when submit for approval.

- **Z001-03: Equipment maintenance and spare parts management processes**: Establish a materials management system integrated with financial systems. Establish an improved inventory management system.

94.4 Conclusion

In this paper, an evaluation of SEPC business process is made for SEPC development strategy. Firstly, a comprehensive analysis about SEPC is made. And then the proposed BSC evaluation method is used to evaluate the SEPC business process, and the AHP is used to determine the indicator weights. The incorporation of BSC and AHP is an improvement for performance evaluation, in which qualitative analysis and quantitative analysis can be integrated. Thus, the SEPC business process measurement and evaluation are more scientific and practical. After the evaluation, the weaknesses of each business process are found. The weaknesses are general in the electric power industry in China. And some suggestions for improvement are given. An important area for future research is to develop a more comprehensive evaluation indicator system under a complex uncertainty environment in the real world. The FAHP can be used to deal with some uncertainties.

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Chapter 95
Impact of Demand Nature on the Bullwhip Effect. Bridging the Gap between Theoretical and Empirical Research

Juan R. Trapero, Fausto P. García and N. Kourentzes

Abstract The bullwhip effect (BE) consists of the demand variability amplification that exists in a supply chain when moving upwards. This undesirable effect produces excess inventory and poor customer service. Recently, several research papers from either a theoretical or empirical point of view have indicated the nature of the demand process as a key aspect to defining the BE. Nonetheless, they reached different conclusions. On the one hand, theoretical research quantified the BE depending on the lead time and ARIMA parameters, where ARIMA functions were employed to model the demand generator process. In turn, empirical research related nonlinearly the demand variability extent with the BE size. Although, it seems that both results are contradictory, this paper explores how those conclusions complement each other. Essentially, it is shown that the theoretical developments are precise to determine the presence of the BE based on its ARIMA parameter estimates. Nonetheless, to quantify the size of the BE, the demand coefficient of variation should be incorporated. The analysis explores a two-staged serially linked supply chain, where weekly data at SKU level from a manufacturer specialized in household products and a major UK grocery retailer have been collected.

Keywords Bullwhip effect · Demand forecasting · Supply chain management

95.1 Introduction

Since the beginning of the 20th century, one of the most interesting problems that Supply Chain Management has had to face is the bullwhip effect (BE) [10]. This

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phenomenon consists of demand variability amplification when moving from the consumer towards the supplier. These demand fluctuations might not be as a consequence of changes in the downstream demand but being generated within the supply chain. A typical example corresponds to the diaper demand shown by Procter and Gamble [12], where a stable end costumer demand became much more volatile in upstream supply chain members. This effect is of paramount importance for academics and practitioners given its harmful consequences in inventory levels and forecasting accuracy.

The research on the BE has been investigated on theoretical and empirical basis. From a theoretical perspective, the supply chain has been defined by assuming a certain underlying demand and a determined inventory policy. In reference [4] the BE is quantified by using moving average and exponential smoothing techniques for demand forecasting. In [14] forecasting procedures that minimize the expected mean-square forecast error are analyzed instead of exponential smoothing techniques. In this reference an expression for the BE is achieved, given a pre-defined demand process modeled by an ARIMA(p,d,q) [1] and an inventory policy defined by an Order-Up-To (OUT) level [5], [14]. Other theoretical approaches are focused on the influence of inventory control parameters on the BE [5].

Nonetheless, some authors claim that a theoretical analysis of the problem relies on restrictive assumptions to make it mathematically tractable and thus, they tend to be highly constrained versions of reality [2]. For example, they do not include the influence of promotional campaigns as price reductions, advertisements, etc., even when these aspects are accepted as main causes of the BE. In addition, since those factors are difficult to incorporate in statistical models, they are usually introduced into the forecasting process by managers that judgmentally adjust forecasts provided by a Forecasting Support System [8] and [16]. This judgmental forecasting approach is employed broadly in companies; in fact, in reference [7] a survey was conducted where, on average, 75% of the forecasts involved management judgment. Therefore, insights obtained from theoretical developments that do not include the aforementioned circumstances can be limited [2].

In order to overcome the theoretical analysis limitations, a second stream of research approaches the BE problem more empirically with data coming from different companies. Note that the BE may be analyzed by different levels of aggregation. In this sense, some authors investigate the BE on entire industries [3], where the strength of the BE is measured in industry-level U.S. data. Other authors analyze the BE at family level [17], where fast moving consumer goods are manufactured by a major producer and distributed by a major retailer in Italy. The latter reference found that if final consumer demand tends to be flat; the retailers are encouraged to forward buy in order to take advantage of possible manufacturer deals. On the contrary, if the final consumer demand is variable, the retailer's orders closely follow consumer demand.

In summary, on the one hand, theoretical results suggest underlying end demand parameter estimates and lead time as the main factors to explain BE, on the other hand, empirical results found end demand variability as the key aspect to determine the BE.

This article links both perspectives and employs the coefficient of variation to set the limits under which the theoretical results can be applied. The results show that when the end demand coefficient of variation is low, the theoretical results defined by the underlying demand are not enough to quantify the BE. Nevertheless, when that coefficient of variation is higher, theoretical results can be a good approximation. Additionally, the nonlinear relationship described in [17] that relates the BE with the CV at family product level is also found in our dataset at SKU level.

The rest of the paper is organized as follows: Sect. 95.2 describes the case study; Sect. 95.3 states the main research objectives of the paper; Sect. 95.4 discusses the empirical results and finally, Sect. 95.5 draws the main conclusions of the research.

95.2 Case Study

The supply chain system consists of a serially linked two-level supply chain, see Fig. 95.1. This supply chain comprises a flow of information represented by a dashed line from the market towards the manufacturer and a reverse one regarding materials represented by a solid line. Market sales and shipments from the manufacturer are the measured variables, indicated by the sensors in Fig. 95.1. Note that, unless company's fill rate is always 100%, either orders or sales do not reveal the true demand and they are only approximations [11].

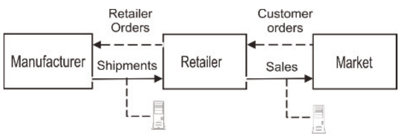


Fig. 95.1 Flow of material (solid line) and information (dashed line) for a two serially linked supply chain

Data from a manufacturing company specialized in household products have been collected. The data have been sampled weekly between October 2008 and October 2009. This manufacturing company provides products to one of the largest retailers in the UK. The data comprises shipments received by the retailer from the manufacturer, customer demand estimated by the retailer sales, as well as, promotional information.

The dataset under study comprises 16 Stock Keeping Units (SKU) with 52 observations per SKU. The average demand in each SKU ranges between 3,266.3 and 33,865.2 units, with the overall mean being 9,094.9 units. An example is depicted in Fig. 95.2, where retailer sales are in a dashed line and manufacturer shipments are in a solid line. Note that the shipments variability is higher than retailers one providing evidence of the BE.

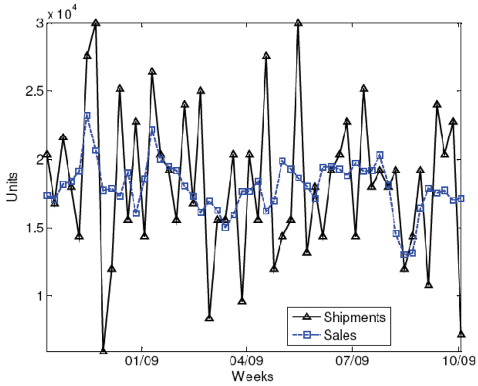


Fig. 95.2 Example of a SKU. Retailer sales are in a dashed line and shipments in a solid line

95.3 Research Questions

In this section, a set of key questions will be proposed in order to define the scope of the research. Firstly, since some papers doubt about the presence of the bullwhip effect [3], the first question is:

Q1: Is there any evidence of the bullwhip effect?

Here, it is important to define how the BE is measured. Different metrics will be shown in the next section to answer this question. Note that published papers show the BE under different levels of aggregation ranging from industries [3], to product families [17]. In this case study we calculate the BE for the lowest aggregation level, i.e. at SKU level. Assuming that the present dataset exhibited the presence of the bullwhip effect, the next question would be:

Q2: Is the bullwhip effect constant along SKUs for the same supply chain?

Despite the fact that theoretical and empirical research has aimed at the demand nature as one of the main factors to explain the bullwhip effect, there is a gap between conclusions achieved. On the one hand, theoretical works [13] conclude that different parameter values of demand processes modeled by ARIMA functions can produce the Bullwhip Effect or the Anti-Bullwhip Effect (ABE), according to which the variability of the orders placed upstream in the supply chain is lower than the variability of the demand itself. For instance, the results of their simulation show that for an AR(1) process, the BE will only take place when the autoregressive parameter is greater than zero. These results were corroborated analytically in [14]. On the other hand, an empirical analysis carried out in [17] shows that variability of the downstream demand is the main responsible to explain the different levels of BE. In order to shed some light into this, the next question is:

Q3: How the variability and the underlying demand process influence the bullwhip effect?

95.4 Empirical Results

In order to find out whether the considered dataset exhibit bullwhip effect (BE), firstly, we have to define how the BE can be measured. A possible way is to use the ratio of the coefficients of variation (CV) between the output supplier sales (shipments) and the input retailer sales [9]. Let the bullwhip ratio (BWR) be denoted by:

$$\mathrm{BWR} = \frac{\sigma_s/\mu_s}{\sigma_r/\mu_r}, \tag{95.1}$$

where σ_i is the standard deviation and μ_i is the mean for i equal to supplier shipments (s) or retailer sales (r). Other conventional bullwhip measures use the ratio of the variance (or standard deviations) instead of the coefficient of variation. Note that those measures are equivalent as long as $\mu_s = \mu_r$. In our dataset this assumption has been corroborated. Thus, aforementioned measures are equivalent.

Fig. 95.3 Histogram of the bullwhip ratio

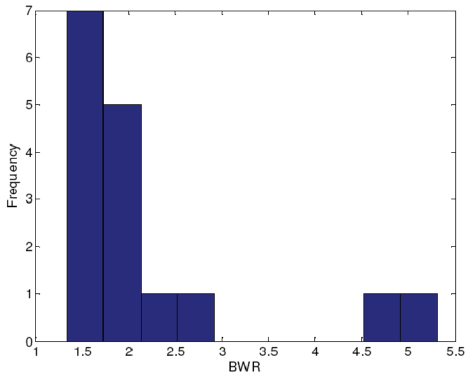


Fig. 95.3 shows the histogram of the BWR computed in the dataset. This figure shows a peak in the interval between 1.3 and 2. Interestingly, two SKUs achieve a BWR around 5. Therefore, we can answer the first two research questions given that there is empirical evidence of the BE presence since all the SKUs considered have a BWR greater than 1, as well as, the histogram shows that the BE is not constant but it possesses a variability that ranges from 1.3 to 5.3.

To find an explanation to that ample range of BWR, Fig. 95.4 and Fig. 95.5 depict the retailer sales and manufacturer shipments for the smallest and the largest BWR, respectively. Regarding the Fig. 95.4 (smallest BWR = 1.3), it is interesting to note a high variability demand due to the sales increase between 04/09 and 07/09 as a consequence of a promotion. According to Lee et al [12], price fluctuation is a source of BE, thus, we would have expected to obtain a high BWR. Conversely, the lowest BWR was achieved.

Fig. 95.5 shows a low variability retailer demand with a coefficient of variation equal to 0.08, however, the BWR is equal to 5.3. It is also interesting to point out

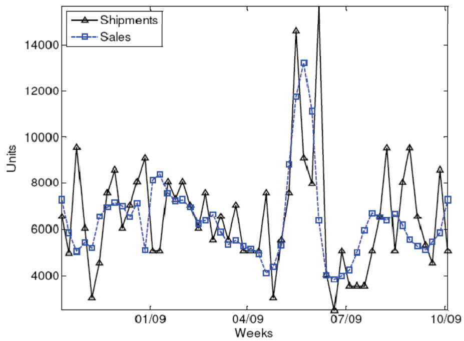


Fig. 95.4 SKU with the smallest BWR

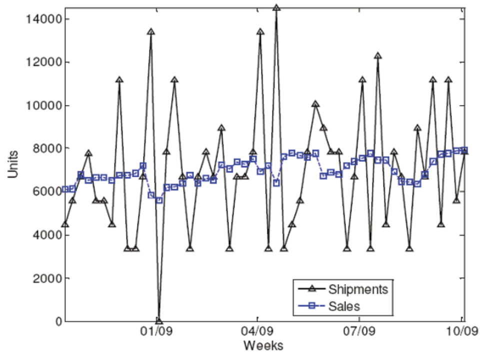


Fig. 95.5 SKU with the largest BWR

a remarkable increase of shipments before New Year. Furthermore, no promotional campaigns have been carried out for that SKU in the period under study.

Although these findings could seem controversial, in reference [17] a similar phenomenon was found in its case study based on Italy. They concluded that predictable demands of long shelf life products lead to higher BWR. The idea behind is that retailers who knew that its customer demand was stable were willing to invest on inventories in order to take advantage of the manufacturer sales force incentives to sell towards the end of the month. Unfortunately, in our case study we do not have manager information available to explain the reasons that drive the retailer to increase its orders variability when demand is relatively flat.

In order to find out whether the relationship found in [17] between the BE and downstream variability demand holds in our dataset, Fig. 95.6 shows a scatter plot between the retailer sales coefficient of variation CV_r and the BWR. This plot exhibits a similar non-linear relationship found in Fig. 95.6 [17], which can be modeled by a potential function as follows:

$$\mathrm{BWR} = k\mathrm{CV}_r^{\alpha}, \tag{95.2}$$

where k is a constant and α is the elasticity of the BWR with respect to CV_r. The estimation of both parameters results in $k = 0.47$ and $\alpha = -0.91$ (both statistically significant at 95% level). This means that 1% reduction of the coefficient of variation at retailer sales implies a 0.91% increase in the BE. The resulting function is also plotted in Fig. 95.6.

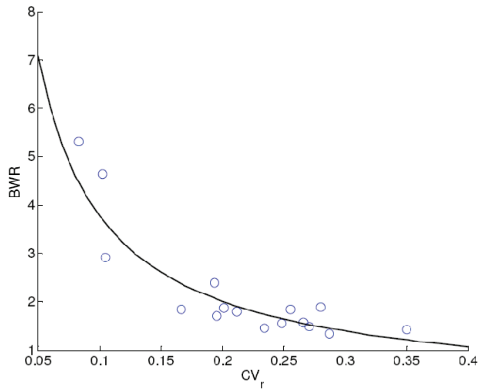


Fig. 95.6 Scatter plot between bullwhip ratio (BWR) and the retailer coefficient of variation (CV_r). It is also plotted in a solid line the fitted function defined in Equation (95.2)

Other authors have developed expressions to quantify the BWR depending on the underlying demand process and the lead time (L). According to Box et al [1], a general ARIMA(p,d,q) process is described by:

$$\Phi_p(B)\nabla^d(D_t-\mu)=\Theta_q(B)\varepsilon_t, \tag{95.3}$$

where D_t is the end-customer's demand at period t. Polynomial $\Phi_p(B)=1-\phi_1 B-\phi_2 B^2-\cdots-\phi_p B^p$ presents an AR(p) (Autoregressive) process; polynomial $\Theta_q(B)=1-\vartheta_1 B-\vartheta_2 B^2-\cdots-\vartheta_q B^q$ represents an MA(q) (Moving Average) process; B is the backward shift operator $B^j\varepsilon_t=\varepsilon_{t-j}$; ∇ is de difference operator and $\nabla^d=(1-B)^d$. In summary, (p,q) denote the order of an autoregressive and moving average process, respectively, and d the dth. difference of the original series. If $d=0$, μ defines a neighborhood to which demand eventually returns. ε_t $(t=1,2,\cdots)$ are i.i.d. normally distributed random variables with mean 0 and variance σ^2.

Reference [14] quantified the BE measured by the ratio of variances when the demand follows an ARIMA$(1,0,0)$ process such as:

$$B(L,\phi_1)=\frac{\sigma_s^2}{\sigma_r^2}=\frac{(1+\phi_1)(1-2\phi_1^{L+1})+2\phi_1^{L+2}}{1-\phi_1}, \tag{95.4}$$

where L is the lead time. The above expression means that the BE only occurs for $\phi_1>0$. Note that:

$$\text{BWR}\approx\sqrt{B(L,\phi)}. \tag{95.5}$$

In reference [6] those results were expanded for the ARIMA$(1,0,1)$ process providing the following expression:

$$B(L,\phi_1,\vartheta_1) = 1 + \frac{2(\phi_1 - \vartheta_1)(1-\phi_1^L)(1-\phi_1^{L+1} - \phi_1\vartheta_1(1-\phi_1^{L-1}))}{(1-\phi_1)(1+\vartheta_1^2 - 2\phi_1\vartheta_1)}. \tag{95.6}$$

Here, the BE only occurs for $\phi_1 > \vartheta_1$. Previous expressions were validated by simulations in [13], where it was also found that an ARIMA$(0,0,1)$ provides BE when $\vartheta_1 < 0$.

In order to corroborate the theoretical results, we have empirically identified the ARIMA process corresponding to the demands in our dataset by minimizing the normalized Bayesian Information Criterion (nBIC) such as:

$$n\text{BIC} = \ln\left(\frac{\sum \hat{a}_t^2}{n}\right) + K\ln(n)/n, \tag{95.7}$$

where $\hat{a}_t$ are the residuals of the model; K is the number of parameters used and n is the number of residuals computed for the model. The best model is the one with the smallest nBIC value, [14]. The potential ARIMA models that can be selected by the previous algorithm are limited to ARIMA$(1,0,0)$, ARIMA$(0,0,1)$ and ARIMA$(1,0,1)$, given that those models have available theoretical developments to be tested with our empirical dataset.

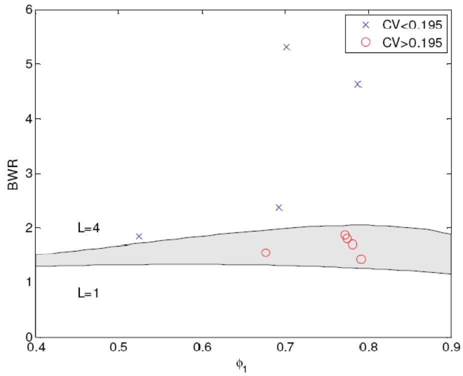
Table 95.1 Summary of identification and estimation results on the empirical dataset

ARIMA process	No. of series	% of series	Region	% estimates fall inside region
ARIMA$(1,0,0)$	9	56.25%	$\phi_1 > 0$	100%
ARIMA$(0,0,1)$	1	6.25%	$\vartheta_1 < 0$	100%
ARIMA$(1,0,1)$	6	37.5%	$\phi_1 > \vartheta_1$	100%

Table 95.1 shows the estimation results on the dataset. The first column indicates the ARIMA models under study. The second column counts the number of series that has been identified with a determined ARIMA model and the third column expresses it as a percentage. For instance, the ARIMA$(1,0,0)$ has been identified 9 out of 16, i.e., a 56.25 %. The fourth column defines the parameters region that yields BE. Recall that all the SKUs considered yield BE, i.e., BWR > 1. Finally, the fifth column represents the percentage of SKUs that having BWR > 1, its parameter estimates fall inside the region defined in the fourth column. The first conclusion extracted from Table 95.1 is that the range of parameter values defined theoretically that provided BE were validated in our dataset. In other words, 100% of the parameter estimates fulfill the condition expressed in the 4th column. For instance, all the SKUs identified as an ARIMA$(1,0,0)$ had a coefficient estimate $(\hat{\phi}_1)$ greater than zero. Interestingly, ARIMA$(1,0,0)$ is the most frequent process in our dataset, followed by the ARIMA$(1,0,1)$.

So far, we have empirically tested that theoretical results can determine whether a certain demand may produce the BE based on its demand parameterization. However, are the theoretical results precise enough to quantify the BE? To answer this question a comparison between the BE analytically and empirically computed has been carried out. Since the ARIMA$(1,0,0)$ is the most frequent process in our dataset, we will test the precision of the theoretical findings expressed in Equations (95.4) and (95.5). Fig. 95.7 shows the BWR against ϕ_1. The exact lead time is unknown in our dataset. To overcome such a limitation, we have plotted a shaded area that comprises lead times from 1 to 4 weeks. The BWR has been computed based on Equations (95.4) and (95.5). In addition, the BWR empirically computed (see Equation (95.1)) has also been plotted in the figure.

Fig. 95.7 Bullwhip ratio (BWR) against Autorregresive parameter (ϕ_1). Shaded area comprises the BWR analytically computed for lead times ranging from 1 to 4 weeks. Markers denote the BWR empirically computed



It can be seen that the magnitude of the BWR cannot only be explained by the parameter ϕ_1 and the lead time L. In order to find a reasonable explanation for the SKUs that are located out of the shaded area, we consider the empirical results previously found where the demand variability can partially explain the size of the BE. In the same figure, the SKUs with a CV > 0.195 have been plotted as blue crosses and those SKUs with a CV < 0.195 in red circles. Here, it seems that those SKUs with a high CV can be explained by using the theoretical formula in (95.4), whereas those with a low CV cannot.

The reasons behind the increase of the BE for low CV values are not totally understood and deserve further research. Author in [17] states that a flatter end demand encourages retailers to forward buy in order to take advantage of manufacturer deals usually often toward the end of the sales period to meet sales targets. In addition, it should be noted that the coefficient of variation may influence the use of a certain stock policy. In this sense, basic inventory theory suggests the use of deterministic inventory policies for low values of CV instead of stochastic inventory policies as the order-up-to.

95.5 Conclusion

Researchers and practitioners have devoted a great effort to study the BE given its harmful consequences. Two different streams can be distinguished from the operations management literature. On the one hand, theoretical analysis, which are based on initial assumptions about the underlying demand process and the stock policy, are considered to develop different expressions that quantify the BE. On the other hand, a more practical approach measure the bullwhip effect with actual data collected from different companies involved in the supply chain. Once the bullwhip measures are available, a deep analysis of causes is carried out. In principle both approaches are legitimate and they should converge to similar results, nonetheless, given the complexities associated to the system and/or particularities of each supply chain is expected to find some discrepancies. This work explores those differences at SKU level and proposes a framework to define the limits of application of theoretical results on the basis of real data coming from a case study. Summarizing, the variability of the end demand, which has been measured by means of the coefficient of variation, is the key factor. Firstly, a non-linear relationship between the BE and the end demand variability is statistically illustrated. Secondly, those SKUs with low variability do not fulfill the initial assumptions that support theoretical works and the resulting BE quantification is not precise. In turn, those SKUs with higher variability follow closely the expected magnitude of BE expected by the analytical expressions output. Further research should follow in at least two directions: i) given that our dataset did not contain SKUs with seasonal properties, the variability can be understood as a measure of forecastability. Thus, the use of forecastability rather than variability can significantly contribute to this area; and ii) these results should be expanded to other companies and at different levels of aggregation.

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Chapter 96
Impact of Human Resources Practices upon Turnover and Productivity in the Banking Sector of Pakistan

Nadeem A. Syed, Farooq A. Cheema, Asif Kamran and Hira Khalid

Abstract When we talk about the HR practices, we come to know that good HRM practices are instrumental in helping to achieve departmental objectives and enhance productivity. A firm's current and potential human resources are very important for the development and execution of the successful implementation of its strategic business plan, and so in the banking sector, retaining the trustable and loyal workforce can manage to bring productivity for the firm and lower turnover among the employees. HR practices focus clearly on changes to employees' jobs and career prospects. Situational factors such as commitment of employees change the process significantly influences over the quality and type of skills that the new employees possess. By providing them with the formal and informal training experiences, such as basic skills training, on-the-job experience, coaching, mentoring, and management development, can further influence employees' and satisfaction with the change process make important contributions to withdrawal of employee commitment, loyalty, trust, pessimism and powerlessness. The result of effectively managing human resources is an enhanced ability to attract and retain qualified employees who are motivated to perform. The results include greater profitability, low employee turnover, high product quality, lower production costs, and more rapid acceptance and implementation of corporate strategy.

Keywords Human Resource Management (HRM) · Strategic Human Resource Management (SHRM)

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96.1 Introduction

This study will comprehensively evaluate the impact of Human Resource practices, by continuing o use the methods of research that will determine the effect of perfect recruitment of employees, training, compensation benefits, and employee relations over the period of time [2]. Since in Pakistan, financial institutions are those where employees are more focused towards financial risks and rewards that comes on their way. But, since an era of globalization is headed and everything is in the continuous process of change, so nowadays, almost all of the financial sectors are also focusing towards providing the good Human Resource Practices to all those whom they want to retain. Managing human resources to achieve better outcomes means "Retaining personnel, building their expertise into the organizational routines through learning processes, and establishing mechanisms for the distribution of benefits arising from the utilization of this expertise" [14]. The sample that will be collected will be from a public sector bank, a semi-private sector bank and a private sector bank. The samples from all these three sectors will provide an insight for all the readers that which sector will impact the human resource practices to what extent. Attitude surveys are being developed by consulting firms, academicians, or others. They can also be custom-designed to address specific issues and concerns in an organization [1]. But regardless of the type of surveys used, only surveys that are valid and reliable can measure attitudes of people accurately. Often a "research" survey developed in-house is poorly structured; ask questions in a confusing manner, or leads employees to respond in ways that will give "favorable" results.

96.2 The Problem

Since the HRM systems and practices greatly emphasis to impact the cost of acquiring, developing, and retaining the portfolio of skills in a firm, the choice of HRM system affects their ability to adjust worker skill levels to maximize the value of their technological investments [6]. This establishes a system in which a firm is able to match its investments with the human capital. As human capital of the firm becomes greater than that of the investment, the level of performance and productivity of the firm start to increase of the firm need to be critically evaluated [3].

96.2.1 Research Questions to be Answered

- Do the HR practices have any impact over turnover in the private sector bank?
- Do the HR practices have any impact over productivity in the private sector bank?
- Do the HR practices have any impact over turnover in the semi-private sector bank?

- Do the HR practices have any impact over productivity in the semi-private sector bank?
- Do the HR practices have any impact over turnover in the public sector bank?
- Do the HR practices have any impact over productivity in the public sector bank?

(1) Knowledge available concerns the questions

Since the importance been started to provide the HR practices in the banking sector is new to Pakistan, and there has not been this sort of research ever been conducted, so gathering and assimilating information about HR practices in the banking sector is difficult [19]. But similar sorts of researches has already taken place in other sectors, so I can take help out of these. As far as other countries are concerned, the similar kinds of researches are available, so secondary data can be extracted out of them.

(2) Rationale of the study

The effectiveness of the highly skilled employees will be limited if those employees aren't motivated to perform, and the HRM practices can affect employee motivation by encouraging the workers to perform both harder and smarter [11]. It has also noted that the contribution of even a highly skilled and motivated workforce will be limited if jobs are structured, or programmed, it would be in such a way that employees, who presumably know their work better than any other else, do not have the opportunity to use their skills and abilities to design new and better ways of performing their roles [17].

96.2.2 Objectives of the Study

To evaluate the implementation of a set of internally consistent HR practices. This will help determine that which sector bank is using which HR practices. To help people to identify the effective human resource practices to retain the competent staff, in the banking sector [10]. It will provide an insight to the people that how top-level managers are managing to retain the loyal and committed people. Identify the use of HR practices and its impact on the financial sectors [18]. It has been usually seen that financial sectors do not provide importance to the HR practices to be performed, but since the world is been changing [20], so I want to accomplish that either the rumor about the banking sector is right or wrong. To provide an opportunity for all those who are seeking jobs at banks, to take information and determine a clear understanding about the corporate culture.

(1) Stake holders and their benefits

The stakeholders that are to be affected by the research will be all those individuals who use to work in the banking sector, which includes the people from top-level of management till the lower level managers.

(2) Reasons of the limitations

The research that I have conducted is on a very small extent, I have got limited data resources and limited time frame for the completion of the research work, so that I have to take the limitations into consideration.

96.3 Literature Review

96.3.1 Banking Industry

With the exception of Dess and Hitt [7], and Koch and Gunther [14], all of the prior research in human resource management and organizational performance has focused on the manufacturing sector, despite the fact that today most employees work in service sector industries. Services sector differ from goods in three important ways: they are intangible, they tend to be produced and consumed simultaneously, and they tend to involve the consumer in their production and delivery [4]. The simultaneous delivery and receipt of services in the face-to-face service sector brings employees and customers close together, blurring the boundary between the two groups [5]. The direct contact that exists between the employee and the customer in the service sector suggests that human resource management may be even more important in the estimated translog cost function using one calendar quarter of data (October 31, 1985, to January 31, 1986) on 563 branches of an anonymous Canadian bank; and Dyer and Reeves [8], which estimated a trans log cost function using 1988 data on 615 branches of 43 Finnish savings banks, service sector than in the manufacturing sector.

The probability of a sale given contact depends both on the characteristics of the customer (for example wealth and age) and on the ability of the branch employee to make a sale. The latter in turn is dependent on the employees' experience at the branch (more branch-specific experience leads to stronger relationships with customers) as well as their product knowledge and motivation to sell [12]. (Human resource management and organizational Performance: evidence from retail banking, Ann p. Bartel). Recent reviews of the literature on human resource management and organizational performance [9] have identified four methodological issues that researchers in this area need to consider:

- The appropriate measure of organizational performance given the context of the study;
- Whether human resource management practices should be measured at the firm level or, instead, at the business unit or facility level;
- Possible omitted variables that could bias the estimated relationship between human resource management and organizational performance; and
- The extent to which the estimated coefficients on the human resource variables can be interpreted as showing a causal relationship between human resource management and organizational performance.

96.3.2 Objectives of the Study

Adoption of effective technical HRM activities is a key to implementing a set of internally consistent HR practices. The outcome of the research would help to identify the effective human resource practices to retain the competent staff. Moreover, the findings may help the academics to do further research. This study would be continuing to establish a culture in every organization where managers will be practicing good Human Resource Management in order to retain employees and for the continuous improvement and productivity of the firm. This will also be conducted in order to create a clear understanding of the significant impact that HR practices brings out for the employees within the organization.

96.4 Research Methodology

(1) Research design

The research design to be used here is the descriptive study, since this research will be undertaken in order to ascertain and able to describe the characteristics of the variables of interest in a particular situation, that is; in the banking culture. It has been the quality of descriptive research that it is undertaken in organizations to learn about and describe the characteristics of group of employees, or to understand the characteristics of organizations that follow certain practices. Here qualitative data to the impact of HR practices on turnover, and productivity would be studied, and the data will be obtained by interviewing and making individuals to fill out the questionnaires. Quantitative data will be analyzed in terms of frequencies, or mean, and standard deviations.

(2) Procedure

We would be accomplishing this study through the research methodologies we have so far studied and with the help of questionnaires and interviews been taken from the employees and managers respectively. Managers will make judgments about implemented HRM practice from a perspective that the important and effective HRM practices are those, which managers view help the organization successfully achieve its objectives.

(3) Population

It would be covering out the bank employees of a public sector, a semi-private and a private sector bank. Mostly the lower level managers will be at the focus. I would prefer them as they are the backbone of any organization, and the HRM practices be conducted over them would only be useful for my research. They can provide me clear understanding of the all work activities that they are performing along with the compensations and other HRM practices implemented upon them.

(4) Sample and sampling method

The sample will be the lower level and middle managers of a public, a semi-private and a private bank and in the foreign and local bank. The sample size would be consisting of 200, out of which 100 questionnaires are to be filled out by lower level managers; from each sector, that is; the public sector bank, the semi-private and the private sector bank. I have chosen t take out the sample of this particular size as randomly taken information from 10 people from 10 of the foreign and local bank each will surely represent the point of all in that particular bank. No particular sampling method is being used here, because I am not taking any sample out of the population to derive results accordingly for the population.

(5) Measurement/instrument selection

The data collection would be of both the types, that is; primary and secondary. The primary data will be gathered by the surveys, questionnaires been distributed to the individuals, these questionnaires will measure them on the basis of their loyalty towards the organization due to HR practices. Interviews will be held with the managers in order to know the respective people management being done in the banking sector, by providing employees with efforts to improve their performance which is because of the Human Resource Management Systems applied at the bank. The questionnaire will be ranking the motivation level of working in the bank with reference to HR practices been done, from high to low motivation towards the job. The secondary data will be collected through various HR related books, HRM journals, research papers, HR magazines, reports related to HR practices within the firm, the websites and other sources, etc.

(6) Variables

Dependent Variables:

- Turnover
- Productivity

(7) Hypothesis

On the basis of the above we have proposed the following three hypotheses:

Hypothesis 1. HRM practices will positively impact turnover;

Hypothesis 2. HRM practices will positively impact productivity.

(8) Software Employed

Spreadsheets and SPSS will be used.

96.5 Data Analysis and Findings

(1) Organization wise

The organization wise analysis of frequencies and percentages shows that there is cumulative percentage of 5% since data of 10 questionnaires was being collected from each of the 20 banks.

(2) Sector wise

The sector-wise frequency and percentage analysis shows that 10% of the data has been collected from public sector, i.e., two banks from public sector, since there have been two banks remained only in the public sector. 20% of the data has been collected from semi-private sector, i.e., 4 banks from semi-private sector and 70% of the data has been collected from private sector, i.e., 14 banks from private sector since most of the banks in Pakistan are privatized.

(3) Type wise analysis

The sector wise analysis shows that 50% of the data has been collected from local banks and 50% of the data has been collected from foreign banks. The reason being to do this is to conduct the research with authenticity and in equal proportion of both the types.

(4) Reliability analysis of questions

The reliability analysis showed that the data collected is reliable enough since the value comes out to be 81.8%., which shows the authenticity of the data collection.

(5) Reliability analysis of factors

While conducting the research, a perfect model is been taken into account which has divided the data into 8 factors and the data collected is reliable enough since the reliability comes out to be 71.5%.

(6) Descriptive analysis of factors

The descriptive analysis of factors shows that HR practices have been present in all of the organizations, there has been 41.3% of the deviation exists in the data, which shows the diversity in point of views of employees. Training and development's presence is shown in all the banks as with this the employees can have growth opportunities, and it is showing 52% of the deviation in the data. Employee relations factor which is connected to productivity of the bank is present in all the banks, and showing 63.5% of the deviation in the data. Recruitment and placement's presence is shown in all the banks, and showing 42.3% of the deviation in the data; concludes that employees have different viewpoints. Performance appraisal's presence is shown in all the banks, and showing 63.4% of the deviation in the data, some of them commented that merit is the basis for promotion, some thought that seniority is the basis and others have commented that seniority along with merit is the basis. Productivity's presence is shown in all the banks, and showing 69% of the deviation in the data, since the data has been collected from varied banks. Compensation and benefit's presence is shown in all the banks, and showing 48.1% of the deviation in the data, employees have dissimilar viewpoints in certain cases as data has been collected from different levels and to some of them, medical leaves, insurance benefits, transportation is not been provided by the company and to others, it is. Turnover's presence is shown in all the banks, and showing 67.8% of the deviation in the data, some are satisfied with their work place and job but others are not and want improvements in their job and work places.

Correlation of factors (see Table 96.1):

- HR practices are highly co-related with productivity, since when employee will be satisfied enough with the work place, its cultural practices, and environment, they will definitely produce magnificent results.
- Training & Development is highly co-related with performance appraisal as it is a way to praise employee's performance and to consider him as an important individual contributing to day to day company's success.
- Employee relations are highly co-related with recruitment and placement as only those employees will be taking part to come to the organization who will be satisfied with the safety and security issues of the bank.
- Recruitment & Placement is highly co-related with employee relations as stated above.
- Performance appraisal is highly co-related with productivity of the organization, since the more you give importance to the employees and the more you monitor

Table 96.1 Correlation of factors

		I	II	III	IV	V	VI	VII	VIII
I	Pearson Correlation	1	.256**	.030	−.031	.215**	.264**	−.025	.340**
	N	200	200	200	200	199	199	200	199
II	Pearson Correlation	.256**	1	.020	.210**	.359**	.197**	.108	.234**
	N	200	200	200	200	199	199	200	199
III	Pearson Correlation	.030	.020	1	.767**	.198**	.147*	.111	.181*
	N	200	200	200	200	199	199	200	199
IV	Pearson Correlation	−.031	.210**	.767**	1	.236**	.099	.206**	.213**
	N	200	200	200	200	199	199	200	199
V	Pearson Correlation	.215**	.359**	.198**	.236**	1.484**	.287**	.319**	
	N	199	199	199	199	199	199	199	199
VI	Pearson Correlation	.264**	.197**	.147*	.099	.484**	1	.298**	.480**
	N	199	199	199	199	199	199	199	199
VII	Pearson Correlation	−.025	.108	.111	.206**	.287**	.298**	1	.339**
	N	200	200	200	200	199	199	200	199
VIII	Pearson Correlation	.340**	.234**	.181*	.213**	.319**	.480**	.339**	1
	N	199	199	199	199	199	199	199	199

Note: ***. Correlation is significant at the 0.01 level (2-tailed). **. Correlation is significant at the 0.05 level (2-tailed). I: HR practices; II: Training Development; III: Employee Relations; IV: Recruitment Placement; V: Performance Appraisal; VI: Productivity; VII: Compensation Benefits; VIII: Turnover.

and praise their performance, they more they will produce tremendous results and will contribute to company's day to day success.

- Productivity is highly co-related with performance appraisal as stated above.
- Compensation & benefits are highly co-related with productivity of the organization since employees are very motivated when a certain bank/company is offering good salary package along with other benefits accordingly with the performance. It leads to better results too.
- Turnover is highly co-related with productivity of the organization, since employees will leave the company when it will not be productive, and the case that they are suggesting into a particular organization is the case of fruitful and profitable bank/company.

(7) Ross tabulation analysis

The sector wise analysis of the data collected shows that 20 questionnaires have been collected from the public sector banks, 40 questionnaires have been collected from the semi-private sector banks and 140 questionnaires have been collected from the private sector banks.

96.6 Split File Analysis

96.6.1 Organization Wise

The bank wise analysis shows that:

- In Habib Bank Ltd., performance appraisal has been ranked as the highest, and training and development as the second highest. There has been highest deviation exists in performance appraisal and second highest is the productivity.
- In Bank of Khyber Ltd., training and development has been ranked as the highest, and productivity as the second highest. There has been highest deviation exists in productivity and second highest is the turnover.
- In Muslim Commercial Bank Ltd., training & development and employee relations have been ranked as the highest, and presence of HR practices as the second highest. There has been highest deviation exists in turnover and second highest is the training & development and productivity.
- In United Bank Ltd., training & development has been ranked as the highest, and productivity as the second highest. There has been highest deviation exists in employee relations and second highest is the training & development.
- In National Bank of Pakistan Ltd., training & development has been ranked as the highest, and productivity as the second highest. There has been highest deviation exists in turnover and second highest is the performance appraisal.
- In State Bank of Pakistan Ltd., productivity has been ranked as the highest, and training and development as the second highest. There has been highest deviation exists in turnover and second highest is the employee relations.
- In Allied Bank of Pakistan Ltd., employee relations has been ranked as the highest, and compensation and benefits as the second highest. There has been highest deviation exists in employee relations and second highest is the compensation and benefits.
- In BankIslami Pakistan Ltd., performance appraisal has been ranked as the highest, and productivity as the second highest. There has been highest deviation exists in performance appraisal and second highest is the productivity.
- In Bank Alfalah Ltd., performance appraisal has been ranked as the highest and turnover as the second highest. There has been highest deviation exists in turnover and second highest is the productivity.
- In Bank Al-Habib Ltd., performance has been ranked as the highest, and training and development as the second highest. There has been highest deviation exists in performance appraisal and second highest is the productivity.
- In JS Bank Ltd., productivity has been ranked as the highest, and performance appraisal as the second highest. There has been highest deviation exists in training & development and second highest is the turnover.
- In NIB Bank Ltd., productivity has been ranked as the highest and turnover as the second highest. There has been highest deviation exists in employee relations and second highest is the recruitment & placement.

- In SaudiPak Commercial Bank Ltd., employee relations have been ranked as the highest, and training & development as the second highest. There has been highest deviation exists in productivity and second highest is the turnover.
- In Faysal Bank Ltd., training & development has been ranked as the highest, and recruitment & placement as the second highest. There has been highest deviation exists in productivity and second highest is the turnover.
- In Bank Alfalah Ltd., performance appraisal has been ranked as the highest, and productivity as the second highest. There has been highest deviation exists in productivity and second highest are the employee relations and turnover.
- In Standard Chartered Bank Ltd., performance appraisal has been ranked as the highest, and productivity and compensation & benefits as the second highest. There has been highest deviation exists in turnover and second highest is the productivity.
- In Habib Metropolitan Bank Ltd., performance appraisal has been ranked as the highest, and training and development as the second highest. There has been highest deviation exists in productivity and second highest is the turnover.
- In Atlas Bank Ltd., productivity has been ranked as the highest, and training and development as the second highest. There has been highest deviation exists in compensation & benefits and second highest is the employee relations.
- In Askari Commercial Bank Ltd., employee relations and recruitment & placement have been ranked as the highest and turnover as the second highest. There has been highest deviation exists in turnover and second highest is the productivity.
- In Citibank Ltd., employee relations has been ranked as the highest, and recruitment & placement as the second highest. There has been highest deviation exists in employee relations and second highest is the productivity.
- In Soneri Bank Ltd., employee relations has been ranked as the highest, and productivity as the second highest. There has been highest deviation exists in productivity and second highest is the compensation & benefits.

96.6.2 Sector Wise

The sector-wise analysis shows that: Public sector illustrates that HR practices are present with the deviation of 46.1%, showing that employees have different point of views. Training and development is been done in certain departments so it is present with the deviation of 58.2%. Employee relations including the implementation of safety and security acts are present with the deviation of 68.1%. Recruitment and placement is present with the deviation of 47%, which shows the divergence in the view of hiring process. Performance appraisal is present with the deviation of 65%, since to some it is the seniority which is been used for promotional decision, for some it is merit and for other it's is both. Productivity is present with the deviation of 57.2%, since some believe that their organization is productive enough to stay and others do not. Compensation and benefits are present with the deviation of 54.4%, as some are satisfied to the level of salary and benefits they are been provided and other are not. Turnover is present with the deviation of 61.9%, and it illustrates that certain employees are satisfied with the work place and job and others are not.

Semi-private sector illustrates that HR practices are present with the deviation of 32.5% showing that employees have different point of views. Training and development is been done in certain departments so it is present with the deviation of 54.8%. Employee relations including the implementation of safety and security acts are present with the deviation of 76.1%. Recruitment and placement is present with the deviation of 61.9%, which shows the divergence in the view of hiring process. Performance appraisal is present with the deviation of 62.1%, since to some it is the seniority which is been used for promotional decision, for some it is merit and for other it's is both. Productivity is present with the deviation of 66.9% since some believe that their organization is productive enough to stay and others do not. Compensation and benefits are present with the deviation of 57.3% as some are satisfied to the level of salary and benefits they are been provided and other are not. Turnover is present with the deviation of 79.9%, and it illustrates that certain employees are satisfied with the work place and job and others are not.

Private sector illustrates that HR practices are present with the deviation of 43% showing that employees have different point of views. Training and development is been done in certain departments so it is present with the deviation of 48.9%. Employee relations including the implementation of safety and security acts are present with the deviation of 59.2%. Recruitment and placement is present with the deviation of 37%, which shows the divergence in the view of hiring process. Performance appraisal is present with the deviation of 63.4%, since to some it is the seniority which is been used for promotional decision, for some it is merit and for other it's is both. Productivity is present with the deviation of 71% since some believe that their organization is productive enough to stay and others do not. Compensation and benefits are present with the deviation of 44.5% as some are satisfied to the level of salary and benefits they are been provided and other are not. Turnover is present with the deviation of 66.9% and it illustrates that certain employees are satisfied with the work place and job and others are not.

96.6.3 Type Wise

The type of organization-wise analysis shows that: Local banks analysis illustrates that HR practices are present with the deviation of 38.1% showing that employees have different point of views. Training and development is been done in certain departments so it is present with the deviation of 55.7%. Employee relations including the implementation of safety and security acts are present with the deviation of 66.1%. Recruitment and placement is present with the deviation of 48.7%, which shows the divergence in the view of hiring process. Performance appraisal is present with the deviation of 76.6% since to some it is the seniority which is been used for promotional decision, for some it is merit and for other it's is both. Productivity is present with the deviation of 71.1% since some believe that their organization is productive enough to stay and others do not. Compensation and benefits are present with the deviation of 49.8% as some are satisfied to the level of salary and benefits they are been provided and other are not. Turnover is present with the deviation of 73.9% it illustrates that certain employees are satisfied with the work place and job and others are not.

Foreign banks analysis illustrates that HR practices are present with the deviation of 44.4% showing that employees have different point of views. Training and development is been done in certain departments so it is present with the deviation of 47.2%. Employee relations including the implementation of safety and security acts are present with the deviation of 60.7%. Recruitment and placement is present with the deviation of 35%, which shows the divergence in the view of hiring process. Performance appraisal is present with the deviation of 45.7%, since to some it is the seniority which is been used for promotional decision, for some it is merit and for other it's is both. Productivity is present with the deviation of 66.9% since some believe that their organization is productive enough to stay and others do not. Compensation and benefits are present with the deviation of 46.6% as some are satisfied to the level of salary and benefits they are been provided and other are not. Turnover is present with the deviation of 61.2% it illustrates that certain employees are satisfied with the work place and job and others are not.

96.7 Conclusion

Based on this study, it is concluded that there is a strong link between performances of the employees, productivity and the Human Resource practices been employed by the local and foreign banks in Pakistan. The overview of my research evaluates the proposition that employees when granted benefits other than their pay are found to be more satisfied with their bank. HR practices including comprehensive employee recruitment and selection procedures, incentive compensation and performance management systems, and extensive employee involvement and training, can improve the knowledge, skills and abilities of a firm's current and potential employees, increase their motivation, reduction in turnover, and enhance retention of quality employees while encouraging those who are non performers to work aggressively otherwise leave the firm [13]. For a particular firm, employees are in charge of providing a direct and economically significant contribution to a firm's performance. The theoretical framework clearly suggests that the behaviors of employees within a firms has important implications for organizational performance and that human resource management practices can affect individual employee performance through their influence over the employees. My research has also argued that it isn't the difference of the local and foreign bank; productivity exists among both the types of banks, the environment of Pakistan is such like that; where the Human Resource practices are almost similar in all the banks. The results for turnover are less surprising as they suggests that the use of incentive compensation systems may actually encourage the employees to perform better, who are previously performing poorly to leave a firm.

96.8 Recommendations

HRM held a great importance in retaining the quality employees at a particular bank, since HRM is an approach to identify right people for the right job. It also includes the process of socializing such identified right people to integrate them with the organization, train them for increasing their functional skill, develop them for both identified and unidentified future roles, place them in right tasks and roles, motivate them to perform well and inculcate in them a sense of belongingness. The Human Resource Department should focus over the ‘enabling’ capabilities by developing human resources, organizational health, team spirit, balanced organizational culture by conducting periodic surveys, workshops and increasing employee motivation and productivity. The periodic review of HR department is also very important in order to have call for redesigning performance appraisal, job-rotation, reward systems, career planning, promotion, selection, training and development programs, etc.

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Chapter 97
On the Actuarial Simulation of the General Pareto Distribution of Catastrophe Loss

Xiaojun Pan and Chengyi Pu

Abstract Precisely estimating of Catastrophe loss is not only the foundation of risk analysis, but also the premise of product design and the practice of insurance compensation. The Law of Large Numbers generally assumes risk obeys normal distribution that reduces the accuracy of damage assessment and influences the pricing of catastrophe insurance due to negligence of the extreme value at both sides of the distribution. Data more than 100 million yuan of earthquake disaster loss from 1969 to 2011 presents the characteristics of right skew peak, excess kurtosis and heavy-tail. Furthermore, the comparison of QQ plot, parameter estimation as well as test of model parameters between Normal distribution, Exponential distribution, Weibull distribution and Pareto distribution shows that the generalized Pareto distribution fits the earthquake loss perfectly, and significantly improves the estimate precision.

Keywords General Pareto Distribution · Catastrophe loss · Actuarial simulation

97.1 Preface

With the frequent concurrent trend of global catastrophe events in recent years, the number of casualties and economic loss is increasing rapidly. There are some disasters causing huge numbers of casualties and economic loss, such as earthquake, typhoon, storm, flood, drought, etc. (As shown in Fig. 97.1 and Table 97.1). It promotes the innovation of catastrophe insurance and its derivatives, and the integration of catastrophe insurance, disaster economics, disaster-related social psychology and

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other disciplines. Catastrophe insurance has become a important tool of disaster prevention and reduction [1]. However, Catastrophe risk analysis has been lagging behind. The Law of Large Numbers generally assumes risk obeys normal distribution that reduces the accuracy of damage assessment and influences the pricing of catastrophe insurance due to negligence of the extreme value at both sides of the distribution. Therefore, it is the key point of catastrophe risk management and catastrophe insurance product design to know how to model the direct economic loss of catastrophe which exceed the threshold value and get the extreme quantile estimator of the damage.

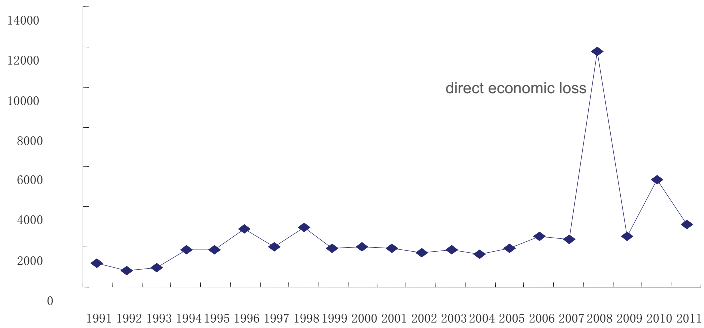


Fig. 97.1 1991-2012 loss trends of natural disasters in China. Data sources: 1991-2012 China Statistical Year book

Table 97.1 Number of earthquake worldwide for 2000-2012

Time	2000	2001	2002	2003	2004	2005	2006
Number of Earthquake	22256	23534	27454	31419	31194	30478	29568
More than magnitude 7	15	16	13	15	16	11	11
Estimated Deaths	231	21357	1685	33819	228802	88005	6605
Time	2007	2008	2009	2010	2011	2012	
Number of Earthquake	29685	31777	14825	21565	2289	7156	
More than magnitude 7	18	12	17	24	20	7	
Estimated Deaths	7122	88011	1790	320120	215953	131	

Data Source: The US Geological Survey National Earthquake Information Center [2].

97.2 Literature Review

In the fitting analysis of the overall distribution of losses from natural disasters and financial risk, traditional analysis generally assumes that the random variables obey a Gamma, Normal, Exponential, or Weibull distribution. It often leads to analysis distortion for they neglect of the extreme data and the characteristics of skew peak and fat tail of the distribution of catastrophe loss. With the emphasis on extreme value analysis, the extreme value theory is devised. At the beginning of the 20th century, a German statistician named Bortkiewicz [3] studied the distribution of the maximum and minimum values of the normal sample and proposed the extreme value concept for the first time. Subsequently, Fisher and Tippett [4] put forward three standard forms of the extreme value distribution model: Frechet, Weibull and Gumbel distribution.

Since the 1950s, the extreme value theory has been improved by the preliminary application of the statistical laws in studying random samples and stochastic processes. Jenkinson [5] proposed generalized extreme value distribution from the risk study. Mandelbrot [6] proved that the rate of return of financial assets didn't obey the normal distribution but follow "fat tail" distribution. Haan [7] found that data exceeding the threshold value obeys the general pareto distribution. Smith [8] took advantage of the observations over the threshold to build a POT (Peaks over threshold) model with GPD (generalized pareto distribution). McNeil [9] summarized and commented the extreme value theory, and used it to analyse the relationship of the tail-related and heteroscedastic financial time series with Frey [10]. Obviously, the GPD which is based on the classical pareto distribution (PD) put forward by Pickands [11], plays an important role in analyzing and forecasting the natural phenomena, such as floods, wind power, temperature and rainfall, as well as in the financial and actuarial extreme analysis. For example, the characteristics of non-normal and fat tail of stock trading volume and rate of return, the characteristics of non-negative skew peak and fat tail of the loss data of insurance object,both of them can be well fitted by the GPD model. And we can also use it to predict the maximum loss [12]. However, the parameter estimation of POT model that is based on GPD model and the proper determination of the threshold are the focus and the difficult part of the work that make the data over threshold obey generalized pareto distribution.

After 2000 domestic scholars began to concern about the extreme value theory. Tian [13] found that the extreme value theory methods had good characters in estimating VaR. The improvement of total-parametric methods and hill estimation based on POT model in EVT [14] could greatly reduce errors. What's more, to analyze the rate of return of capital market and compared with variance -covariance method [15], normal distribution simulation method [16] and the study on the tail of stock return combining with ARMA-AGARCH model, which showed that the EVT had a great advantage in the financial time series data analysis. In addition, catastrophe loss can be perfectly fitted by the EVT. A extreme quantile estimator of a heavy-tailed distribution subclass-Hall distribution class was proposed based on the exponential regression model and applied to large claim data simulation of the fire insurance by Yang et al [17]. The EVT was also fitted to the flood loss data to determine the pure premium of flood reinsurance by Xiao et al [18]. The fitting accuracy was acceptable. Liu [19] fitted lognormal distribution to earthquake losses and found one pricing model on earthquake CAT bond. Zhuo [20] analyzed the heavy-tailed distribution of catastrophe risk and discussed the POT model and its comparative advantage to fit catastrophe risk theoretically. From the statistical analysis of extreme values on historical earthquake data in Taiwan, Qian [21] found out that the number of earthquake occurrence calculated by generalized extreme value distribution was completely consistent with that of actual earthquake occurrence. Therefore, the statistical analysis of extreme value shows a high accuracy in the catastrophe risk analysis and forecasting.

Although Gamma, Normal, Exponential and Weibull distribution have convenience in fitting the overall distribution of catastrophe risk, the negligence of the tails of catastrophe loss distribution leads to the omission of important information. In contrast, the POT model under GDP depicts information contained in the tail extreme value of the catastrophe loss distribution more precisely when fitting fat-tailed distribution. However, the parameter estimation and appropriate determination of threshold of POT model under GDP becomes the key and difficult point in using POT model in extreme value analysis. Therefore, this paper based on 83 copies of earthquake loss data from 1969 to 2011 in China of which the direct economic loss is more than 100 million Yuan, by comparing the QQ plot of Gamma, Normal, Exponential and Weibull loss distribution, getting the parameters estimation and appropriate determination of threshold of POT model under GPD, to ensure the data above a certain threshold value approximately obeys GPD, improves the estimate precision of catastrophe risk loss, and lay the scientific foundation for insurance product design and practice of compensation.

The structure of this paper is as follows. In Sect. 97.3, through the practical difficulties of catastrophe risk analysis and defect analysis of the predecessors' research literature, we establish the research topic of this paper. In Sect. 97.4, we research the statistical law of earthquake loss data and extreme threshold. In Sect. 97.5, we conduct modeling and extreme value quantile estimate of losses, and in Sect. 97.6, we compare the fitting effect of different distributions. In Sect. 97.7, we give our conclusions and suggestions.

97.3 The Threshold Setting of the Earthquake Losses' Extreme Data

Exactly, how much earthquake disaster losses on earth could be called catastrophe? At present, there is no unified definition in this field, and appropriate determination of threshold of POT model under GPD is the key to extreme value analysis. Therefore, the reasonable threshold setting of extreme value data becomes a difficulty.

Catastrophes are defined by ISO's property and claims service (1998) as events which cause USD 25 million (in 1998's prices) or more in direct insured losses to property and affect a significant number of policyholders and insurers. The S&P (1999) defines catastrophes as one or a series of events that lead to more than USD 5 million losses. The OECD's (2003) definition: events that cause extensive infrastructure damage, casualties and property losses, and are beyond the government's control, and call for more domestic and international cooperation.

Chichilnisky [22] and Hansson et al [23] defined catastrophe risk as events that cause great losses of extreme small probability such as floods, earthquakes, storms, droughts and other natural disasters. The GAO [24] argued that catastrophe is rare event which can lead to serious economic loss. Mohamed [25] define catastrophe as disasters that cause more than 10000 people died or affect area more than 1000 square kilometers. Swiss's [26] catastrophe losses' definition was based on insured claims: maritime disaster losses of USD 17.52 million, aviation losses of USD 34.4 million, other losses of USD 42.7 million, or total losses of USD 85.4 million. And it was also based on casualties: more than 20 people dead or missing, more than 50 people injured or more than 2000 homeless. In earthquake insurance business, Japan defines loss more than 75 billion Yen as a catastrophe.

In China, Ma [27] defined disasters as events whose deaths are more than 10000 people, direct economic losses are above 1 billion Yuan as catastrophe. According to the proportion of the losses in GDP, Tang [28] divided the catastrophe into three levels: the ratio of national disaster losses in GDP is greater than 0.002%, the proportion of casualties is greater than 0.08%; provincial disaster losses' ratio in regional GDP is greater than 1%, the proportion of casualties is greater than 0.005%; country disaster losses' ratio in regional GDP is greater than 0.3%, the proportion of casualties is greater than 2%. Li et al [29] defined catastrophe as a risk which made different risk units have correlation and made insurance fail. Deng [30] defined catastrophe as a event which had small probability to happen and its cumulative loss is hard for the body to bear during a certain period (usually 1 year). Ma [31] corrected catastrophe definition: disaster losses that the deaths is more than 10000 people, the direct economic loss is above 100 billion Yuan. Shi et al [32] defined catastrophe from the perspective of probability of disaster-inducing factors: a once-in-a-century, wide influence, causing many casualties and property losses, people in the affected areas are unable to deal with it, and need the help of external forces.

Obviously, the catastrophe is a relative concept; it should depend on the bearing capacity of the subject to determine the threshold of extreme value data. According to China's national conditions, its per capita GDP is lower and there is less able to bear the risk, so catastrophe risk defined by this article is as follows: natural or man-made losses that affect large-scale policyholders, are more than 100 million Yuan and casualties of 200 or more.

97.4 Earthquake Loss Data of Extreme Value Statistical Description

Earthquake loss data from the “China Earthquake Yearbook” is adjusted in the price of 2005 for the standard. It describes economic loss of more than 100 million Yuan caused by earthquake from 1969 to 2011. According to group data, group frequency, frequency distribution, and frequency density are computed (Table 97.2). We can discover from Table 97.2 the maximum loss frequency density is 6.99% in the group of 1-10 billion, the group of 10-30 billion is 1.93% and the group of more than 100 billion is 0.36%.

Table 97.2 1969-2011 extreme value’s statistical description of the loss of China’s earthquake

Extreme data packets (million)	Times	Frequency	Cumulative frequency	Frequency density	Descriptive statistics of extreme data	
1-10	58	69.88		6.99	Mean	115.84
10-20	11	13.25	83.13	1.33	Q2	3.71
20-30	5	6.02	89.16	0.6	Q1	2.12
30-40	2	2.41	91.57	0.24	Q2	3.71
40-50	2	2.41	93.98	0.24	Q3	11.73
50-60	1	1.2	95.18	0.12	SD	884.34
60-70	0	0	95.18	0	Max	8048.16
70-80	1	1.2	96.39	0.12	MIN	1.06
80-90	0	0	96.39	0	SK	9.02
90-100	0	0	96.39	0	K	81.82
10 billion	3	3.61	100	0.36		

Data Source: The China Earthquake Yearbook.

In addition, from Table 97.2 it can be seen in the statistical analysis, the difference between Q1 and Q2 is small, while Q3 and Q2 is obvious. Because of the considerable data losses (such as the Wenchuan earthquake of 2008, direct economic losses amounted to 852.3 billion Yuan), the maximum value is 8,000 times of the minimum value; Coefficient of skewness is 9.02, and kurtosis is 81.82. Therefore, the loss data presents the characteristic of right skew peak, excess kurtosis and heavy-tail. The same conclusion comes from Fig. 97.2 and Fig. 97.3.

97.5 QQ Plot of Earthquake Losses’ Extreme Data Under Various Distributions

The QQ plot of Normal distribution, Exponential distribution, Weibull distribution and Pareto distribution are made by Eviews 5.0 (Figs. 97.4 $\sim$ 97.7). By comparing the results, the Normal distribution cannot fit the tail characteristics of catastrophe

Fig. 97.2 The distribution curve of loss frequency

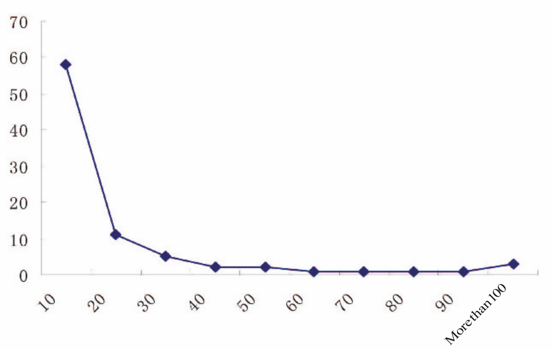
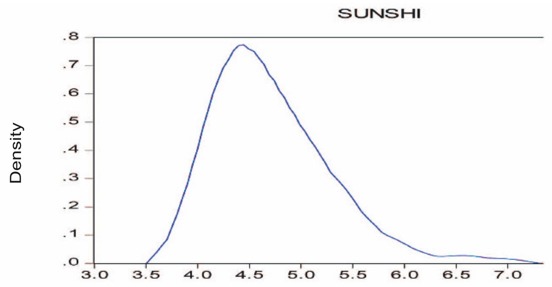


Fig. 97.3 The distribution curve of earthquake loss



losses, while the Exponential and Weibull distribution fit it better and Pareto distribution fits the extreme loss data best.

Fig. 97.4 Diagram QQ of Normal distribution

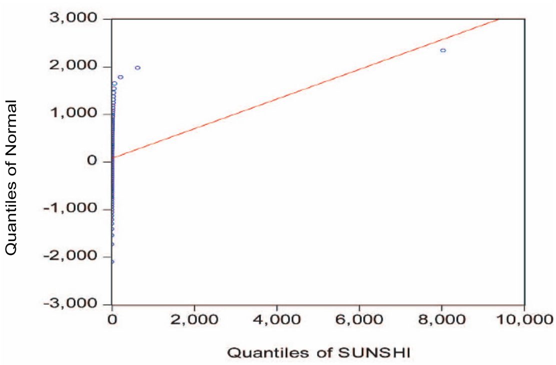


Fig. 97.5 Diagram QQ of Exponential distribution

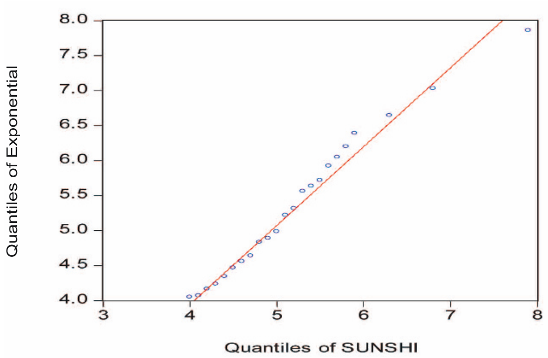


Fig. 97.6 Diagram QQ of Weibull distribution

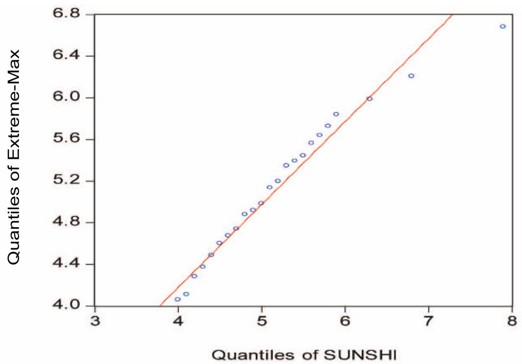
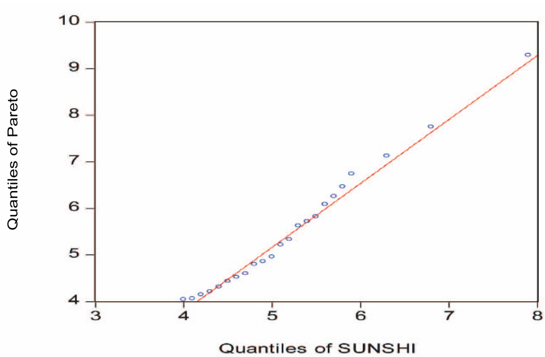


Fig. 97.7 Diagram QQ of Pareto distribution



97.6 The Comparison of Each Distribution's Goodness of Fit

97.6.1 Comparison of Each Distribution's Goodness of Fit

We use Pareto distribution, gamma distribution, normal distribution, lognormal distribution, exponential distribution, Weibull distribution to fitting extreme value data and use Maximum likelihood method to estimate parameters of these distributions. We use the K-S inspection method to test their goodness of fit so as to determine the appropriate probability distribution function. The Table 97.3 shows that Pareto distribution's goodness of fit is the best. The P value of K-S test is 0.7658, which is greater than 5% significant level. So we choose GPD to fit the extreme value data of the direct economic losses of earthquake in the end.

Table 97.3 Earthquake direct economic loss probability distribution fitting and the frequency of loss fitting

Distribution	Parameter values		The P-value of K-S test	n	Frequency	The Fitted values of Poisson
Pareto	$\lambda = 1.0553$	$\beta = 0.5950$	0.7658	0	11	9
Gamma	$\alpha = 0.8540$	$\beta = 73.2212$	0. 6558	1	5	4
Lognormal	$\mu = 3.4503$	$\theta = 1.4743$	0	2	4	3
Exponential	$\lambda = 0.1162$		0. 2743	3	3	1
Weibull	$\gamma = 0.4457$	$c = 13.3454$	0.0345	4	2	1
Normal	$\mu = 115.8355$	$\beta = 884.5950$	0. 1327	5	1	1

97.6.2 *Fitting Generalized Pareto Distribution to the Extreme Value Data*

Generalized Pareto Distribution is the improvements to the traditional Pareto distribution. Despite the traditional Pareto distribution fits the tail data of random phenomena well, Pareto distribution's probability density function: $\rho_X(x) = \beta\gamma^\beta / x^{(\beta+1)}$, β is the shape parameter. γ is threshold parameters. Its logarithmic form is $\ln(1 - F(x)) = \beta \ln r - \beta \ln x$. Clearly, the sample observation point under Pareto distribution in the double logarithmic plot is a straight line whose slope is β, this linear relationship can be used to decide whether a set of samples meets the Pareto distribution and determine the threshold value by least square method. However, this method is a little subjective. Improved generalized Pareto distribution can overcome this defect. In this paper, using the earthquake economic loss data of more than 100 million yuan from 1969 to 2011 as sample, we discuss the distribution of the observations over the threshold value.

Random variable X exceeding the threshold; the conditional distribution function: $F_\mu(y) = p(X - \mu \le y | X > \mu)$, $X \ge 0$, $Y = X - \mu$ is excess-of-loss, according to the conditional probability:

$$F_\mu(y) = \frac{F(\mu + y) - F(\mu)}{1 - F(\mu)} \Rightarrow F(x) = F_\mu(x - \mu)(1 - F(\mu)) + F(\mu),$$

$e(\mu) = E(X-\mu|X>\mu)$ is mean exceedance function. Assume the random variable obeys the distribution function:

$$F(x,\mu,\sigma,\delta) = \begin{cases} 1-\left(1+\beta\frac{x-\mu}{\lambda}\right)^{-1/\beta}, & \beta \neq 0, \\ 1-\exp\left(\frac{x-\mu}{\lambda}\right), & \beta = 0, \end{cases} \quad x \geq \mu,\ \ 1+\beta\frac{x-\mu}{\lambda} > 0,$$

where μ is a location parameter, λ is the scale parameter, γ is shape parameter. We can assert random variable X obeys a three-parameter generalized Pareto distribution and use the maximum likelihood method to estimate the parameters of GPD. Suppose that $\chi_1, \chi_2, \cdots \chi_n$ obeys the $p(\gamma,\beta)$, so the Maximum likelihood estimation value is:

$$\hat{\lambda} = \min_{1\leq i\leq n} x_i = x_n^{(1)}, \hat{\beta} = n\left[\sum_{i=1}^{n} \ln \frac{x_i}{x_n^{(1)}}\right]^{-1}.$$

The threshold value: $U = (9n-18)^{1/2}[T(2n-4)^{1/3} + 1/(9n-18) - 1]$.

n is the number of parameters, T is the fitting test statistic. Substitute this sample data in the expression we get $\hat{\gamma} = 1.0553$, $\hat{\beta} = 0.5950$. The generalized Pareto distribution of earthquake losses' extreme value:

$$F(x) = 1-\left(1+\beta\frac{x-\mu}{\lambda}\right)^{-1/\beta} = 1-\left(1+0.5950\frac{x-\mu}{1.0553}\right)^{-1/0.5950}.$$

Assume the number of earthquake losses obeys Poisson distribution:

$$p(\xi = k) = \frac{\lambda^k}{k!},\ k = 0,1,2\cdots.$$

According to the extreme value sample data of the direct economic losses in Table 97.2, moment estimation $\hat{\lambda} = EY$ is solved for $\bar{x} = 115.84$, which is first moment about the origin. Using poisson distribution to fit the number of earthquake losses, the fitting results are shown in Table 97.3. In addition, according to the fitting result above, the probabilities p_i $(i = 1,2,3,4,5,6)$ of loss exceeding 100 million Yuan are 0.44, 0.20, 0.16, 0.12, 0.08, 0.04.

97.7 Conclusion

Catastrophe loss data has characteristic of right skew peak, excess kurtosis and heavy-tail. According to the commonly used normal distribution model, the extreme value of loss can easily be overlooked and the conclusion is not accurate. Therefore, how to model the tail data of direct economic losses caused by the catastrophe and to estimate extreme value quantile of loss will become the important part of extreme value analysis. By comparing each distribution of the loss's extreme value and parameters of models, that fitted by generalized Pareto distribution is closest to the actual loss data, and the tail quantile can be accurately described. In addition, extreme value distribution has a good performance, and can improve the precision of catastrophe analysis as well as make the catastrophe insurance product design more scientifically.

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Chapter 98
Solving Unit Commitment Problem with Parallel Computing

Mikhail Sher and Avijit Banerjee

Abstract The Unit Commitment Problem (UCP) involves finding the least-cost dispatch of available generation resources to meet the electricity demands over an electrical grid. It is an important planning problem in the electric utility industry. The purpose of the UCP is to determine when to start up and when to shut down a particular generating unit and how to dispatch the committed units to meet the electricity demands and satisfy the relevant security constraints. This paper presents a procedure for modeling and solving large scale unit commitment problems (UCP) by using a parallel computing approach. We assume that the electricity demands are known, and a predetermined amount of reserve is used to guarantee the security of the system. A parallel computing version of the Lagrangian Relaxation technique is used to solve this problem efficiently.

Keywords Optimization · Parallel algorithms · Scheduling

98.1 Introduction

The unit commitment problem involves finding the optimal production schedule for the power generation units in an electrical power supply grid and the production level of each unit, over a short period, in order to minimize the operational costs. Because of the importance of UCP, a number of extensive studies have been carried out in this field, and many solution methods are proposed in the literature and have been used in practice [4].

Currently, two methods are widely used: Lagrangian Relaxation (LR) and Mixed Integer Linear Programming (MILP). MILP is widely used to solve the UCP because it is reliable and precise [3]. In the MILP formulation of the UCP, the fuel

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cost and start-up cost are formulated as a piece-wise linear function and a step-wise linear function, respectively, and are used in many instances such as NYISO [1]. However, MILP solutions are time consuming, and thus not feasible for large scale problems. Lagrangian Relaxation (LR), on the other hand, is fast, and thus, is widely used for large scale UCPs. In the LR algorithm, the dual problem of the UCP is formulated. Since the dual objective function is concave, traditional convex programming techniques, such as the sub-gradient method, can be used. An advantage of the LR algorithm is that the time of computation only increases linearly with respect to the size of the problem [2]. Moreover, the duality gap can be calculated to evaluate the algorithm's performance, which usually decreases as the number of generation units increases [2]. A disadvantage of the LR approach is that it may not be able find the optimal schedule if generator units with the same parameters exist [5]. However, the LR approach is still very effective in solving large scale problems.

The solution to UCPs is usually very time-consuming [2, 5]. In order to address the problem of computation time, the contribution of our paper was the development of a parallel computing algorithm that is used on a computation cluster, rather than on a single CPU. In our work, the UCP solver was implemented using C++ in conjunction with the OpenMPI package. We then utilize our parallel computing algorithm to solve problems with 1000 generator units by using different number of CPU cores to investigate the significance of parallel computing in reducing the time of computation. Subsequently, we solved problems with different number of generators to examine the effectiveness of parallel computation to large scale problems. Our computational results demonstrate that implementation of parallel computing algorithm we developed has resulted in significant reduction of computation time.

The paper is organized as follows. Sect. 98.2 defines the variables used in the paper. Sect. 98.3 outlines the formulation of the unit commitment problems. Sect. 98.4 provides the algorithm to solve the UCP, and in Sect. 98.5 problems with different number of generators are studied. Finally, Sect. 98.6 presents some conclusions and discusses possible future work in this area.

98.2 Nomenclature

The notation used in this paper is listed below:

$p_{i,t}$: electricity output level of generator i at time period t;
$z_{i,t}$: binary variable that is 1 if generator i is on during time period t, 0 otherwise;
$F_{i,t}()$: fuel cost function of generator i at time period t;
$S_{i,t}()$: startup cost function of generator i at time period t;
d_t : prediction of electricity demand at time period t;
d_r^t : real electricity demand at time period t;
σ_t : standard deviation of real electric demand at time period t;
Σ : covariance matrix of real electricity demands;
w_t : prediction of wind power at time period t;
w_t^r : real wind power at time period t;

σ_t^w : standard deviation of real wind power at time period t;
$p_{i,\max}$: maximum output when generator i is on;
$p_{i,\min}$: minimum output when generator i is on;
t_i^{cold} : time required to cool down after generator i is turned off;
hc_i : hot start cost of generator i;
cc_i : cold start cost of generator i;
L_i : minimum on time after generator is turned on;
l_i : minimum off time after generator i is turned off;
t_i^{off} : the number of time period that generator i has been off;
k : iteration number in the LR algorithm;
K : maximum iteration number in the LR algorithm;
ε : duality gap threshold in the LR algorithm;
α : tolerance level of electricity blackout.

98.3 Problem Formulation

We assume that the electricity demand is known, and reserve is predetermined accordingly. The basic formulation is given below:

$$\min \sum_{i=1}^{I}\sum_{t=1}^{T} F_{i,t}(z_{i,t}, p_{i,t}) + \sum_{i=1}^{I}\sum_{t=1}^{T} S_{i,t}(z_{i,t}), \tag{98.1}$$

subject to

$$\sum_{i=1}^{I} p_{i,t} \geq d_t, \quad t = 1,\cdots,T,\ i = 1,\cdots,I, \tag{98.2}$$

$$\sum_{i=1}^{I} (P_{i,\max} z_{i,t}) \geq d_t + r_t, \quad t = 1,\cdots,T,\ i = 1,\cdots,I, \tag{98.3}$$

$$p_{i,t} \leq P_{i,\max} z_{i,t}, \quad t = 1,\cdots,T,\ i = 1,\cdots,I, \tag{98.4}$$

$$p_{i,t} \geq P_{i,\min} z_{i,t}, \ t = 1,\cdots,T,\ i = 1,\cdots,I, \tag{98.5}$$

$$z_{i,t} - z_{i,t-1} \leq z_{i,\tau},\ \tau = t+1,\cdots,\ \min\{t + L_i - 1, T\},$$
$$t = 2,\cdots,T,\ i = 1,\cdots,I, \tag{98.6}$$

$$z_{i,t-1} - z_{i,t} \leq 1 - z_{i,\tau},\ \tau = t,\cdots,\ \min\{t + l_i - 1, T\},$$
$$t = 2,\cdots,T,\ i = 1,\cdots,I, \tag{98.7}$$

$$z_{i,t} \in \{0,1\},\ t = 1,\cdots,T,\ i = 1,\cdots,I. \tag{98.8}$$

The objective function (98.1) consists of two terms. The first term is the the fuel cost. When a power generator is turned on, the power cost can be formed as a quadratic function or a piecewise linear function of the power output level. In this work, a quadratic cost function is used, as shown below:

$$F_{i,t}(z_{i,t}, p_{i,t}) = z_{i,t}(a_i + b_i p_{i,t} + c_i p_{i,t}^2). \tag{98.9}$$

The variables a_i, b_i, c_i, are positive constants for power generator i. The second term is the start up cost, which can be formulated as Equation (98.10):

$$S_{i,t}(z_{i,t}) = \left(SC_i^f + SC_i^c \left(1 - e^{\frac{-t_i^{\text{off}}}{\alpha_i}} \right) \right) \max\{z_{i,t} - z_{i,t-1}, 0\}. \tag{98.10}$$

The variable SC_i^f is the fixed start cost, SC_i^c is the cost start time, and α_i is a constant for a certain generator i. In other cases, the start cost is formulated as step-wise function. In this work, a simple step-wise function is used, and is formulated as follows (98.11):

$$S_{i,t}(z_{i,t}) = \begin{cases} hc_i, & t_i^{\text{off}} \leq t_i^{\text{cold}} + l_i, \\ cc_i, & t_i^{\text{off}} > t_i^{\text{cold}} + l_i. \end{cases} \tag{98.11}$$

The problem constraints are represented by the expressions (98.2) to (98.8). Equation (98.2) is the demand constraint; Equation (98.3) is the reserve constraint, Equations (98.4) and (98.7) represent the output constraints when a power generator is on. Equations (98.6) and (98.7) are the minimum up time and minimum down time constraints.

98.4 Algorithms to Solve UCP

98.4.1 Lagrangian Relaxation Approach

The UCP problem can be solved by the Lagrangian relaxation approach. Instead of solving the original problem (primal problem) directly, we relax the demand constraint and the reserve constraint, and solve the corresponding dual problem. The objective function of dual problem can be formulated as:

$$\begin{aligned} \max_{\lambda} \min_{p_{i,t}, z_{i,t}} \Bigg(& \sum_{i=1}^{I} \sum_{t=1}^{T} F_{i,t}(z_{i,t}, p_{i,t}) + \sum_{i=1}^{I} \sum_{t=1}^{T} S_{i,t}(z_{i,t}) - \sum_{t=1}^{T} \lambda_t \left(\sum_{i=1}^{I} p_{i,t} - d_t \right) \\ & + \mu_t \left(\sum_{i=1}^{I} p_{i,\max} z_{i,t} - d_t - r_t \right) \Bigg), \end{aligned} \tag{98.12}$$

while λ_t and μ_t are lagrangian multipliers. The dual problem can be further transformed into another expression, as shown below:

$$\max_{\lambda} \min_{p_{i,t}, z_{i,t}} \left(\sum_{i=1}^{I} \sum_{t=1}^{T} F_{i,t}(z_{i,t}, p_{i,t}) + \sum_{t=1}^{T} S_{i,t}(z_{i,t}) - \sum_{t=1}^{T} (\lambda p_{i,t} + \mu_t p_{i,\max} z_{i,t}) \right)$$

$$+\frac{1}{I}(\lambda_t d_t + \mu_t(d_t + r_t))\Bigg), \tag{98.13}$$

subject to the constraints (98.4), (98.5), (98.6), (98.7) and (98.8) as formulated earlier. Since the dual problem is concave, the sub-gradient method can be used to solve the dual problem.

Define:

$$\begin{aligned} L(\lambda,\mu,p_{i,t},z_{i,t}) = & \sum_{i=1}^{I}\Bigg(\sum_{t=1}^{T} F_{i,t}(z_{i,t},p_{i,t}) + \sum_{t=1}^{T} S_{i,t}(z_{i,t}) - \sum_{t=1}^{T}(\lambda p_{i,t} + \mu_t p_{i,\max} z_{i,t}) \\ & + \frac{1}{I}(\lambda_t d_t + \mu_t(d_t + r_t))\Bigg), \end{aligned} \tag{98.14}$$

$$q(\lambda,\mu) = \min_{p_{i,t},z_{i,t}} L(\lambda,\mu,p_{i,t},z_{i,t}). \tag{98.15}$$

The Lagrangian relaxation solution algorithm is described below:

Step 1. Initialize the values of the lagrangian multipliers $\lambda^0$and μ^0. Set iteration number, $k = 0$, and set the maximum number of iteration allowed as K. Set a threshold duality gap ε. Initialize a optimal primal cost J^*.

Step 2. Solve the problem $q(\lambda^k,\mu^k) = \min_{p_{i,t},v_{i,t}} L(\lambda^k,\mu^k,p_{i,t},z_{i,t})$ to get the schedule $z^*_{i,t}$.

Step 3. Solve the dispatch problem to get the primal value J. If the schedule $z^*_{i,t}$ is not feasible, set primal value $J = \infty$. If $J < J^*$, set $J^* = J$, and save the current schedule as the optimal schedule. If this schedule is not feasible, go to step 5.

Step 4. Check the duality gap $gp = \frac{J* - q^*(\lambda^k,\mu^k)}{q^*(\lambda^k,\mu^k)}$, if $gp < \varepsilon$, STOP; or else, go to step 5.

Step 5. Update λ,μ, $k = k+1$. If $k < K$, go to step 2; or else STOP, and report the current optimal cost and optimal schedule.

Values of λ,μ are updated as follows:

Step 5a. Calculate the power output of each generator unit $p_{i,t}$ according to the value of λ.

Step 5b. Update λ,μ. The updating formula is given below:

$$\lambda_t^k = \max\left(\lambda^{k-1} + \frac{\delta_\lambda^t}{(a + b * k^{0.5})|\delta_\lambda|}, 0\right), \tag{98.16}$$

while

$$\delta_\lambda^t = d_t - \sum_{i=1}^{I} p_{i,t}, \tag{98.17}$$

$$|\delta_\lambda| = \sqrt{\sum_{t=1}^{T}(\delta_\lambda^t)^2}, \tag{98.18}$$

$$\mu_t^k = \max\left(\mu^{k-1} + \frac{\delta_\mu^t}{(a + b * k^{0.5})|\delta_\mu}, 0\right), \tag{98.19}$$

while

$$\delta_\mu^t = (d_t + r_t) - \sum_{i=1}^{I} p_{i,\max} z_{i,t}, \tag{98.20}$$

$$|\delta_\lambda| = \sqrt{\sum_{t=1}^{T} (\delta_\lambda^t)^2}. \tag{98.21}$$

The values of a and b are given as the following rule : if $\delta_\lambda^t < 0 \&\& \delta_\mu^t < 0$, $a = 0.3$, $b = 0.2$; else $a = 0.01$, $b = 0.015$.

98.4.2 Parallel Computing Scheme

From Equation (98.14), we can see that the problem represented by (98.15) can be decomposed into several single generator problems.

Define:

$$\begin{aligned} l_i(\lambda, \mu, p_{i,t}, v_{i,t}) = & \sum_{t=1}^{T} F_{i,t}(z_{i,t}, p_{i,t}) + \sum_{t=1}^{T} S_{i,t}(z_{i,t}) - \sum_{t=1}^{T} (\lambda p_{i,t} + \mu_t p_{i,\max}) \\ & + \frac{1}{I}(\lambda_t d_t + \mu_t(d_t + r_t)), \end{aligned} \tag{98.22}$$

then,

$$q(\lambda, \mu) = \sum_{i=1}^{I} q_i(\lambda, \mu) = \sum_{i=1}^{I} \min_{p_{i,t}, v_{i,t}} l_i(\lambda, p_{i,t}, v_{i,t}). \tag{98.23}$$

To solve the problem $q(\lambda, \mu) = \min_{p_{i,t}, v_{i,t}} L(\lambda, p_{i,t}, v_{i,t})$, we only need to solve I single-unit problems: $q_i(\lambda, \mu) = \min_{p_{i,t}, v_{i,t}} l_i(\lambda, p_{i,t}, v_{i,t})$. To implement a parallel computing technique, step 2 of the algorithm in Sect. 98.4.1 can be modified as follows:

Step 2a. Problem (98.23) is decomposed into I smaller problems:

$$q_i(\lambda, \mu) = \min_{p_{i,t}, v_{i,t}} l_i(\lambda, p_{i,t}, v_{i,t})$$

and these are assigned to multiple processors.

Step 2b. Solve the smaller problems by dynamic programming, and report the result to the root CPU.

Step 2c. Combine the results from each processor at root CPU.

In step $2a$, the problem is solved by dynamic programming. Since it is very fast to solve each subproblem by dynamic programming, the communication time between the processors becomes a critical issue. In this work, the schedule of paths are transferred in arrays of "short" (c++ data type) variables. The collective approach is used to transfer the data. The time complexity of communication among CPU's is

$O(logn)$, where n represents the number of processors that are used in this computational protocol.

98.5 Numerical Examples

We tested the algorithms on problems with different number of generators, using a varying number of parallel processors. The number of power generators varies from 100 to 1000. The number of processors used in computation varies from 1 to 100. The tolerance of electrical blackout is set to $\alpha = 0.001$, threshold of duality gap $\varepsilon = 0.1\%$, and the maximum iteration number allowed is set to $K = 3000$. The unit commitment solver are implemented in C++ with the MPI package.

The problem with 1000 generator units was solved with different number of processors, and the result is given in Table 98.5 and Fig. 98.1. Fig. 98.1 shows that the computation time decreases dramatically when the number of processors increases from 1 to 20, and reaches a minimum for 80 processors. The slow changing rate may be due to the communication time and time to calculate the primal solution.

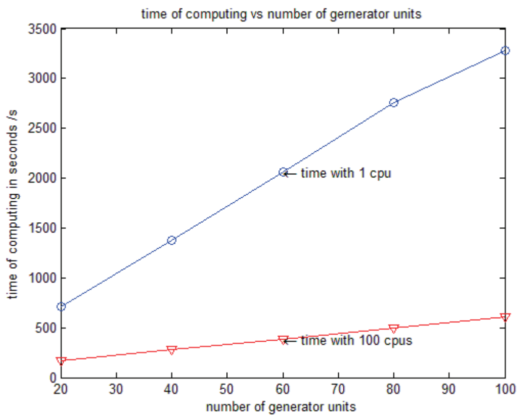

Fig. 98.1 Relationship between computation time (in seconds) and number of generator units

Table 98.1 Computation time (in seconds) when different number of CPU cores is used. Number of generators in problem: 1000

# CPU	1	2	10	20	30	50	80	100
Time	3275.88	1904.8	825.99	692.89	646.65	617.38	600.96	606.74

After this, problems with different number of generators were tested on 100 CPU cores, and the result is given in Table 98.5 and Fig. 98.2. The computation time increases linearly with respect to the problem size. When a single CPU is used, the linear relationship is due the increased number of sub-problems when solving the dual problems. When 100 CPUs are used, the linear relationship may be due to the increased communication time and increased time to calculate the primal solution. Fig. 98.2 also shows that the as the problem size increases, the savings in computation time become more significant.

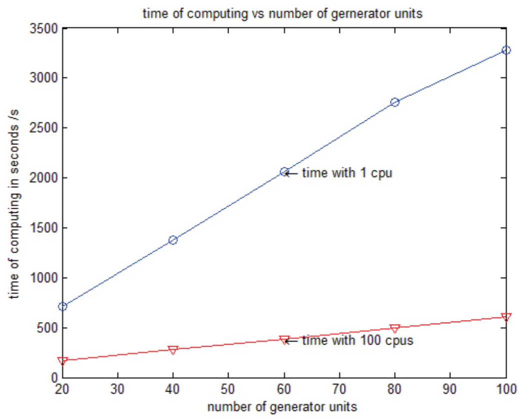

Fig. 98.2 Relationship between the computation time and problem size

Table 98.2 Computation time (in seconds) for unit commitment problems with different number of generators

# Generators	20	40	60	80	100
1 CPU	708.91	1380.89	2066.11	2756.08	3275.88
100 CPU's	170.56	278.45	383.96	501.42	606.74

98.6 Conclusion and Future Work

In this paper the Lagrangian Relaxation approach for UCP is adapted for parallel computing. Computing results show that parallel computing can significantly reduce the time of computation. In future we may consider formulation of the UCP problem involving stochastic [6] demands and also include other distributed generators such as solar, wind, and hydro. In addition, more constraints can be added to the formulation such as transmission constraints, regional constraints, etc. Furthermore, we can incorporate our methodology to study the problem of forward contracts [7] in the electricity markets using parallel computing approach as well.

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Part VII
Ecological Engineering

Chapter 99
The Evaluation of Circular Economy Development for Coal Resources City Based on Material Flow Analysis

Dianming Geng and Xiaolu Song

Abstract According to the economic development characteristics of coal resources city, constructed the cycle-economy development evaluation index system for coal resources city starting from the material flow analysis perspective. Determined the evaluation index weights using analytic hierarchy process and entropy weight, established evaluation model by the gray system related degree analytic method. Finally, taking Jining city as a case, longitudinal analyzed and compared the cycle-economy development situation in different periods, and provided some guidance and reference for other coal resources cities.

Keywords Cyclic economy · Material flow analysis · Relational degree analytic method · Jining city

99.1 Introduction

The characteristics of the coal resources city are industrial structure resource, industrial structure high energy consumption and economic growth pattern extensive. The development law is "mine-flourish-decompose". The economic development is "flourish because of coal, decompose because of coal" [1]. The coal resources city acts as an important foundation of the coal industry. It should focus on developing circular economy. Form a cycle-economy development model in the entire coal industry, then it can accelerate the regional coal industry structure upgrade and run new industrialization development path, achieve the recycling of coal resources in the region. Develop and use resources efficient and reasonable, protect the ecolog-

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ical environment, and create a harmonious eco-industrial. In order to understand the actual implementation of the circular economic development, we need to use appropriate method to analyze the cycle-economy development, and build a proper evaluation system to do a systematic and effective evaluation according to certain principles for cycle-economy development situation of the coal resources city. It has a important guiding significance for development planning of the coal resources city [2].

The basic viewpoints of material flow analysis: It largely depends on two aspects in the impact of ecological environment created by human economic activities [3]. One is the quantity and quality of resource material entered the economic system. Another is the quantity and quality of waste material from the economic system discharges to the ecological environment. The former leads to the resource depletion and the ecological environment degradation. The latter may cause the resources waste and the ecological environment pollution. Starting from the physical quality, material flow analysis research sustainable development problems through analyzing the development, use and emissions of natural resources and material. Through analyzing the mining, production, transportation, distribution, use, waste of natural resources and material, reveal the material flow characteristics and efficient use in specific areas, find the direct source of the environment pressure, and propose solutions to reduce environmental pressure, provide a scientific basis for the formulation of regional circular economy development goals [4].

99.2 Designing Evaluation Index System

The main objective of the regional cycle-economy development evaluation was to establish a scientific evaluation index system. Then through calculating by some methods and tools reflected various substances comprehensive and recycling utilization situation in the process of economic development.

The choice of evaluation indicators based on material flow analysis consider the following requirements:

- Data availability principles. The cycle-economy development evaluation object is the circular degree of economic operation. The ultimately determine of the cycle index needs pass specific implemented of the evaluation index. Therefore, it must guarantee access to the evaluation index value of different time stages, preferably can get from the existing statistical activities.
- The principles of combining level indicator and speed indicator. Evaluation index system both has the indicators of reflecting the development level and dynamic changes. Through a combination of level indicators and speed indicators, achieve the evaluation that both react results and reflect the efforts made by the human economic activities in the time-latitude. Achieve the combination of static evaluation and dynamic evaluation.
- The principles of combining cyclic stress index and cyclic ability index. Taking into account the cycle-economy needs for the economic development goals and

economic operation situation. Pay attention to the environmental impact degree from the resources consumption and human activities, and consider the status of input section and output section. However, it is not enough to consider the cycle capacity. It also needs to combine efforts that community in order to achieve circular economy and recycling-based society. Based on the above principles, establish the evaluation index system in Table 99.1 starting from the point of view of material flow analysis [5].

99.3 The Determination of Index Weights

Took the method of combining subjective empowerment and objective empowerment, when empowering the cycle-economy development evaluation indexes for Jining city. Firstly, determined every index weight of the evaluation index system by Analytic Hierarchy Process. Then corrected every index's weight coefficients by Entropy Method and got the final weight coefficients. The following is the overall idea of indexes determination:

- Divided the evaluation index system into several levels based on the index relationships. It has the target layer, rule layer, feature layer and index layer. The same level elements as a criterion, dominate the next layer and been dominated by up one layer.
- Using a combination of independent and group discussions got the judgment matrix layer by layer.
- Calculated the characteristic root of judgment matrix and the corresponding eigenvectors, and did consistency test. Got the relative importance relative to its membership factors.
- Entropy correction. Although the analytic hierarchy process technology has strong systematic in identify problems and high relative reliability. It's easy to grasp the scale inexactly and lose some information, when using Delphi Method [6]. An effective way to solve such problems is to entropy correction for weight coefficient.

99.4 The Constitution of Cycle-economy Development Evaluation System for Coal Resources City

Resources and Environment, ecological and economic have obvious structural complexity, hierarchy ambiguity, dynamic changes in randomness, incompleteness and uncertainty of indicators data, which all belong to the gray system areas. The gray system related degree analytic method is a comprehensive evaluation method based on correlation degree analysis. Correlation degree reflected each evaluation goal proximity to the ideal state. The correlation degree analysis is a method which mea-

Table 99.1 Evaluation index system of circular economy system based on material flow analysis

Rule layer	Index classification	Index name	The formula
Reduction	Material input intensity indicators	Material exploitation intensity in the region Transferred intensity outside the region Hide flow strength in the region Total amount of water intensity Per direct material input	Intraregional Material mined/GDP Transferred outside the region/ GDP Hide flow in the region/GDP Total amount of water/GDP Direct material input/ Region's total population
	Material onput intensity indicators	Emissions intensity Emissions intensity of the solid waste Dissipative material strength Export material strength Export hide flow strength The total waste water discharge strength Per intraregional production emissions	Emissions/GDP Solid waste emissions/GDP Dissipative material/GDP Export material/GDP Export hide flow/GDP The total waste water discharge/ GDP Production emissions/Region's total population
Harmless	Environmental impact indicators	Industrial waste water discharge compliance rate Industrial SO2 emission compliance rate Industrial soot emissions compliance rate Industrial dust emissions compliance rate Life garbage treatment rate Centralized urban sewage treatment rate	
Recycling	Substance comprehensive utilization indicators	Solid waste comprehensive utilization rate Output value of Waste comprehensive utilization Industrial Repeat water rate Recycling strength Recycling elastic coefficient Total investment in environmental protection	Recycling capacity/GDP GDP growth-the growth rate of the recycling

sured the degree of evaluation object close to the ideal goal by evaluating the similar or different degree of evaluation object in different time development trend [7].

Calculation steps of the gray system related degree analytic method:

(1) Determined the reference sequence and comparative sequence

(2) Dimensionless processed to indicator data

When doing correlation analysis to the indicator data, each data's dimension in sequence must be identical. So did unified dimensionless processing for data before calculating the correlation degree. Cycle economic evaluation involved many indicators, each index has different measurement unit, positive indicators and inverse indicators. This paper used poor transformation method to do dimensionless processing.

Positive indicators: denoted the biggest indicator values as 1, the smallest is 0. Convert other data using the following formula:

$$X'_{ij} = (X_{ij} - X_j \min)/(X_i \max - X_j \min).$$

Inverse indicators: denoted the smallest indicator values as 1, the biggest is 0. Convert other data using the following formula:

$$X'_{ij} = (X_{ij} - X_j \max)/(X_i \min - X_j \max).$$

(3) Seeking the gray correlation coefficient

For a original sequence b$_i$, it had many comparison sequences $a_1, a_2, \cdots, a_j$. Using correlation coefficient expressed the difference between each comparison sequence and original sequence.

$$\varepsilon_{ij}(k) = \frac{\min(j)\min(k)\left|b_i(k) - a_j(k)\right| + p(i)\max(j)\max(k)\left|b_i(k) - a_j(k)\right|}{\left|b_i(k) - a_j(k)\right| + p(i)\max(j)\max(k)\left|b_i(k) - a_j(k)\right|},$$

$\varepsilon_{ij}(k)$ is the k-Correlation coefficient in i-original sequence and j-comparison sequence.

(4) The correlation degree calculation

The relational coefficient is each index relational degree value in comparison sequence and original sequence. Correlation coefficient as independent points was too scattered to facilitate holistic comparison. Then it was necessary to make each index correlation coefficient concentrate to one value. It was the final overall evaluation objectives. Taking into account the different importance of each index in evaluation index system, used weighted method to calculate the correlation degree. The calculation formula as follows:

$$R_{ij}(b_0, a_i) = \sum \omega_i(k) e_{ij}(k),\ i = 1, 2, \cdots, n,$$

$R_{ij}(b_0, a_i)$ was the correlation degree which i-subsequence relative to the reference sequence b_0. $\omega_i(k)$ was the corresponding index weights in sequence.

99.5 Empirical Analysis

Jining City is the largest coal production base in Shandong Province, is also the East China region and the country's major coal city and the energy base, which is a typical coal resources city. Long-term coal-resources exploitation created this city's single industrial structure and irrational distribution. Through vigorously developing the circular economy, this city's economy is moving in a comprehensive coordinated and sustainable direction.

Using the above models, can be drawn the correlation of cycle-economy development level for Jining city in recent years (shown in Table 99.2).

Table 99.2 The relevance of situation of annual circular economy development from 2001 to 2010 in Jining city

		Feature layer				Target layer
		Material input strength index	Material output Strength Index	Environmental impact indicators	Comprehensive indicators	The overall level of CE development
RELEVANCE	2001	0.4986	0.4043	0.3566	0.4043	0.4166
	2002	0.4429	0.4160	0.3706	0.3909	0.4023
	2003	0.3534	0.4366	0.4290	0.4025	0.4018
	2004	0.4261	0.4876	0.4756	0.3831	0.4143
	2005	0.4945	0.5499	0.5332	0.4557	0.4834
	2006	0.5522	0.5950	0.6853	0.5106	0.5440
	2007	0.6433	0.6262	0.6904	0.4487	0.5280
	2008	0.7764	0.6523	0.7502	0.4311	0.5484
	2009	0.8308	0.7456	0.8417	0.7598	0.7750
	2010	0.8760	0.9603	0.8814	0.7321	0.8048

Results calculated from the Table 99.2, the cycle- economy development level of Jining City can be divided into three stages: The first stage was the initial stage of circular economic development (2001-2004). In this period the correlation of the cycle-economy development overall level remained largely unchanged, had been maintained at between 0.40-0.42 and low correlation. It indicated that the cycle-economy development in Jining City was only at the initial stage. The second stage was the growth stage of the cycle-economy development (2005-2008). The cycle-economy development in 2005-2008 had made great progress than the previous four years. Especially the correlation of the material input strength index had progressive significant. But the overall association had not exceed 0.60. The overall level was still low. The third stage was the growth stage of the cycle-economy development (2009-2010). The correlation of the cycle-economy development overall level in 2009 and 2010 were 0.7750 and 0.8048. The overall relational degree upgraded nearly 50% than in 2005-2008 [8, 9].

99.6 Conclusion

In period 2001-2010, the correlation of the cycle-economy development overall level continued to improve. Especially the last two years had grown rapidly. The correlation of the cycle-economy development overall level in 2009 and 2010 were 0.7750 and 0.8048. The correlation of the feature layer each index was also maintained at a high level. Especially the correlation of substance comprehensive utilization indicators had huge rise. Analysis showed that: In recent years, Jining City effectively increase the cycle-economy development efforts, built a new pillar industry as a goal, focused on the industrial chain integration, did great efforts to build eco-industrial park, made efforts to seek the industrial transformation development of resource-based cities, encouraged technological development and innovation, carried out investment actively, continued to strengthen the resource-oriented thinking to shift to the market-oriented thinking in economic development, shifted a single structure of economic operation to the diversify structure, shifted economy-growth mode extensive to intensive, promoted the city development faster and better.

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Chapter 100
A Study on Public Satisfaction with Urban-rural Integration by Structural Equation Modeling (SEM)

Rong Huang and Jun Wang

Abstract At present, urban-rural integration is primarily planned and implemented from the perspective of theoretical research and cities, while the evaluations are mainly conducted based on examining some compulsory indicators. Citing some areas where urban-integration has been integrated in Chengdu, this paper analyzed the factors affecting public satisfaction with urban-rural integration by questionnaire survey and structural equation modeling, and constructed a model for public satisfaction with urban-rural integration. The research has suggested that the satisfaction with basic public services plays a critical role in urban-rural integration and exerts significant impacts upon living indexes, public support in & evaluation of rural-urban integration as well as public satisfaction. Thus, it is of great significance to improve public satisfaction and effects incurred by implementation of rural-urban integration by further improving basic public services and gradually equalizing public services.

Keywords Urban-rural integration · Public · Satisfaction · Structural equation modelling · Chengdu

100.1 Introduction

10 years have passed since urban-rural integration was expressly defined in the report at 16th Party Congress in 2002. The coordination of rural-urban development was upgraded as a national strategy in 2003, and taken as a fundamental approach for scientific outlook on development in the report at 17th Party Congress in 2007 [1]. Urban-rural integration, no matter for solving problems of "peasants, agriculture and countryside" or narrowing the gap between urban and rural areas, eventually

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aims to promote common prosperity in rural and urban areas, achieve sustainable social & economic development, and comprehensively build a moderately prosperous & harmonious society. As a global research topic, urban-rural relationship and coordinated urban-rural development have aroused scholar's concern since Western developed countries entered the middle stage of industrialization, as regards which complete theoretical system has been constructed. Typical theories include Engels's "Urban-rural Composition" theory, Thünen's Agricultural Location theory, Ebenezer Howard's "Garden City" theory, Lewis's Dual Structure theory and Mackee's Desakota model [2]. Making a general survey of relevant studies on China's urban-rural integration, it is found that the research has mainly focused on political economy, sociology and urban planning, etc. Specifically, current studies mostly aim at urban-rural integration theory, basic connotations, policies and implementation, etc, as well as summary of domestic & foreign modes of coordinated urban-rural development and experience reference. Liu et al [3] summarized three models, namely Pearl River Delta's model for "developing rural areas through urban development", Shanghai's model for "urban-rural integration planning" and Beijing's model for collaboration in industry & agriculture as well as urban-rural integration, and Southern Jiangsu's model for development "driven by township enterprises". In Addition, some research has studied the evaluation on coordinated urban-rural development, in particular, concentrated on evaluation systems. Most scholars' indicators of evaluation system for assessing urban-rural integration mainly cover economic development, social enterprise development, living quality, population, resources, environment, etc, whereas they mainly focus on measuring compulsory indicators such as GDP/GNP, labor productivity, forest coverage and life expectancy and so on. Meanwhile, their evaluation on living quality is more inclined to some official data such as urban & rural Engel's Coefficient and income ratio, etc, but they have seldom studied residents' ordinary lives and feelings. Nonetheless, the peasants or residents shall be the people who benefit from the implementation of policies for urban-rural integration. Hence, understanding about their satisfaction with urban-rural integration and corresponding influential factors is more favorable for facilitating coordinated urban-rural development.

Chengdu, as a model in coordinated reform of urban and rural areas, has taken the lead in urban-rural integration all over China since 2003. Chengdu Municipal Committee and Government proposed strategies for "coordinated urban-rural development and integration" according to actual development of Chengdu in that period [4]. In particular, plenty of breakthroughs and results have been achieved in speeding up rural-urban integration and constructing pilot areas since Chengdu was approved as a national comprehensive pilot area for urban-rural integration in 2007. Therefore, taking Chengdu for example, this paper conducted a survey of residents in areas which are reformed for urban-rural integration in Chengdu. Based on questionnaire survey and enormous interviews, this paper conducted a statistical analysis by SPSS and constructed a model for public satisfaction with urban-rural integration by structural equation modeling. Furthermore, practical countermeasures and suggestions have been proposed to provide references for promoting coordinated urban-rural development.

100.2 Related Literatures and Research Hypotheses

Public satisfaction with urban-rural integration refers to public satisfaction with the implementation of urban-rural integration and corresponding impacts. In terms of studies on public satisfaction, there are a great number of relevant literatures home and abroad, particularly as regards customer satisfaction and university student satisfaction. The most well-known is ACSI (American Customer Satisfaction Index) model, which is a system for evaluating and measuring organizational performances on the basis of customer orientation [5]. Over the past few years, the studies on the satisfaction with public services and services in relevant specific fields have gained some results as the Government paid attentions to performances. Meanwhile, they were generally conducted by referring to customer satisfaction models. China Public Satisfaction Index (CPSI) model constructed by Sheng and Liu [6] has indicated that public satisfaction is positively correlated to the level and quality of governmental services, and significantly affects perceived quality. Regarding China's national official happiness indexes developed by related research groups, there are four major components, including residents' life satisfaction, satisfaction with public services, satisfaction with social management and environmental protection. Absolutely, provincial governments have also released happiness indexes, e.g. "employment & income, education & culture, medical hygiene & health, social security, consumption & housing, public facilities, social safety, social services, interests guarantee and human settlements" in Guangdong Province, and "social health, social welfare, social civilization and ecological environment, etc" in Shanxi Province [7].

Referring to relevant literatures, the author proposed following research hypotheses after summing up some scholars' viewpoints (see Fig. 100.1):

Hypothesis 1 (H1). satisfaction with basic public services is positively correlated to the support in and evaluation of urban-rural integration policies. In other words, the higher the satisfaction with public services is, the greater the support in and the higher the evaluation of urban-rural integration.

Hypothesis 2 (H2). there is significant positive relation between the satisfaction with basic public services and public satisfaction with urban-rural integration. Namely the public will be more satisfied with urban-rural integration if they are more satisfied with the basic public services provided by the Government.

Hypothesis 3 (H3). the satisfaction with basic public services has significant positive correlation with living index. In other words, the higher the satisfaction with public services, the higher the living index is.

Hypothesis 4 (H4). living index is significantly and positively correlated to public support in and evaluation of urban-rural integration policies.

Hypothesis 5 (H5). there is significant positive correlation between living index and public satisfaction with rural-urban integration.

Hypothesis 6 (H6). public support in and evaluation of urban-rural integration policies have significant positive correlation with public satisfaction with urban-rural integration.

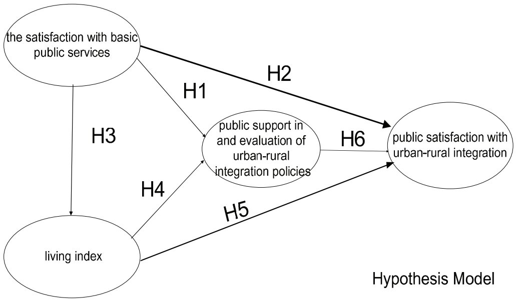

Fig. 100.1 Model for assuming public satisfaction with urban-rural integration

100.3 Research Methodology

100.3.1 Variables & Measurement

Satisfaction with basic public services refers to public satisfaction with basic public services provided mainly by public governmental departments in areas where urban-rural integration is implemented. Currently, public services mainly involve education, health, culture, employment, reemployment, social insurance, ecological environment, public infrastructure and social security, etc [8]. Hence, this paper primarily measured the satisfaction with basic public services from the perspective of five explanatory variables including "education (X1), medical treatment (X2), pension (X3), employment (X4) and rendering of other basic public services (X5)", among which two dimensions are involved in the employment, namely job opportunities and employment equality, so scores obtained in "employment" are the totaling of two items.

Living index covers two aspects including income satisfaction (X6) and consumption capacity (X7) which determine the level of living indexes.

Support and evaluation, namely public support in and evaluation of the implementation of urban-rural integration, involve four explanatory variables such as "whether support is provided for urban-rural integration (X8)", "whether it is good to transform rural areas into new communities (X9)", "whether the urban-rural integration is reasonable for the area's planning (X10)" and "whether practical benefits have been created by urban-rural integration (X11)".

Public satisfaction, referring to public overall satisfaction with the urban-rural integration, covers four dimensions, namely infrastructure 1 (X12) (e.g. transportation, communication, water, electricity and gas, etc), infrastructure 2 (X13) (e.g. culture, PE, health, entertainment and education, etc), community environment (X14) (e.g. forest coverage, disposal of household garbage and air quality, etc), and satisfaction with life (X15).

100.3.2 Data Sources and Research Methodology

In this paper, the data were collected from questionnaire surveys conducted from October to December of 2012 in some areas of Chengdu where urban-rural integration has been implemented, including 178 field survey questionnaires and 267 network questionnaires. Plenty of unfilled questionnaires lacking authenticity were removed. Meanwhile, questionnaires where a few questions were unfilled were handled by sequence mean in terms of missing value. Eventually, 435 valid questionnaires were collected, with an effective rate of 98%. The general situation of samples is shown in Table 100.1 as follows.

Table 100.1 Descriptive statistics on basic variables of samples

Category	Number (%)	Category	Number (%)
Sex	($N = 435$)	Education level	($N = 435$)
Male	180 (41.4)	Degree of primary school or below	189 (43.4)
Female	255 (58.6)	Degree of junior middle school	111 (25.5)
Age	($N = 435$)	Degree of senior high school	99 (22.8)
25 or below	76 (17.5)	Degree of college or university and above	36 (8.3)
26-45	102 (23.4)	Whether heard of the policy or not	($N = 435$)
46-60	164 (37.7)	Yes	230 (52.9)
61or older	93 (21.4)	No	205 (47.1)

By structural equation modeling (SEM), multiple dependent variables can be considered and handled simultaneously. Besides, attributes that can't be directly measured can be included in analysis and errors are allowable for the measurement of independent and dependent variables. In recent years, SEM has been extensively applied in scientific studies. This paper constructed structural equation models by AMOS 20.0, conducting hypothesis tests & analysis on constructed models. Furthermore, SPSS20.0 was utilized for auxiliary analysis.

100.4 Model Checking and Empirical Analysis

100.4.1 Reliability and Validity Tests

Please make the article around the theme as much as possible and engineering; Please enrich the content of your paper. Before model fitting and hypothesis testing, SPSS 20.0 was firstly used to test the reliability and validity of questionnaires. Internal consistency of all items in the questionnaire was tested by Cronbach α. The questionnaire is highly reliable when Cronbach α is larger than or equals to 0.70, while it is moderately reliable when $0.35 \leq$ Cronbach $\alpha < 0.70$ [9]. The validity of this questionnaire was 0.853 and the Cronbach α of various items was higher than 0.700, so this questionnaire was comparatively more reliable. The validity was tested by analyzing principal components and factors. The results showed that KMO was 0.769 and value of all factors was above 0.6. Furthermore, characteristic value was extracted by varimax rotation. The value of four factors was higher than 1, which indicated that the features of four factors including satisfaction with basic public services, living index, support & evaluation and public satisfaction were accurately reflected from the items measured in the questionnaire. The analysis results were shown in Table 100.2 as follows.

Table 100.2 Results of reliability and validity analysis

Variable	Cronbach α	KMO	Eigenvalue
Basic public service	0.812	0.707	2.307
Living index	0.826	0.609	1.439
Public support in and evaluation of urban-rural integration policies	0.820	0.732	2.103
Public satisfaction with urban-rural integration	0.828	0.767	2.648

100.4.2 Model Checking and Exploration of Optimal Model

In this paper, hypothesized models were tested by AMOS 20.0 (statistical software) and model fitting was measured by publicly acknowledged indexes [10, 11]. Generally, the value of X^2/df shall be lower than 3, while the value of RMR and RMSEA was lower than 0.05. Besides, the value of GFI, AGFI, IFI and CFI was higher than 0.9, in terms of which the closer to 1, the better. The value of PGFI and PNFI was higher than 0.05. The model fitting results are shown in Table 100.3 as follows.

Table 100.3 Results on fitting indices of models

Fit index	X^2/df	GFI	RMR	RMSEA	AGFI	CFI	IFI	PGFI	PNFI
Measurement results	1.161	0.877	0.048	0.044	0.824	0.963	0.964	0.614	0.632

After adaptation test, it was found that the model fitting was good, but there were still space for improving models, in order that the models can better match with statistical data. From the hypothesis testing of models, it can be seen that living indexes don't significantly impact public support in and evaluation of urban-rural integration. Therefore, we cancelled Hypothesis 4 of original model and explored if there were better models (shown in Fig. 100.2).

From the fit comparison of four models as shown in Table 100.4, it can be seen that exploration Model A and C can't match with observed data, while Exploration

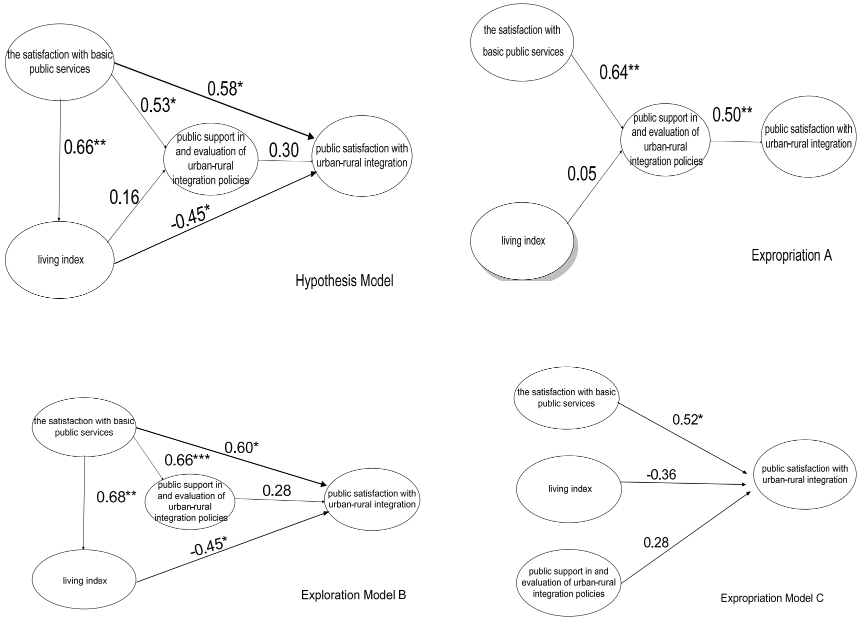

Fig. 100.2 Comparisons of fitting results for 4 exploring models

Table 100.4 Comparisons of fit indices for 4 models

Fit index		Hypothesis Model	Expropriation Model A	Expropriation Model B	Expropriation Model C
Definite fit index	X^2/df	1.161	1.249	1.157	1.813
	GFI	0.877	0.862	0.875	0.809
	RMR	0.048	0.053	0.048	0.116
	RMSEA	0.044	0.054	0.043	0.098
Relative fit index	AGFI	0.824	0.807	0.824	0.736
	CFI	0.962	0.940	0.963	0.803
	IFI	0.964	0.943	0.965	0.812
Parsimony fit index	PGFI	0.614	0.618	0.620	0.586
	PNFI	0.632	0.632	0.638	0.547

Model B somewhat differs from the hypothesized model in GFI (goodness of fit index), but the left are better than measurement results of hypothesized model, so Exploration Model B is the optimal. The results of hypothesis test by Model B are shown in Table 100.5 and standardized solution of the final model is presented in Fig. 100.3.

Table 100.5 Results of hypothesis test by model B

Hypothesis	H1	H2	H3	H4	H5	H6
Standards path coefficient	0.66	0.60	0.68	Cancel	−0.45	0.02
P	0.000	0.033	0.003	Cancel	0.033	0.154
Testing results	Accepted	Accepted	Accepted	Cancel	Unaccepted	Unaccepted

100.4.3 Discussion and Analysis

H1 passed the hypothesis test. In other words, the satisfaction with basic public services has significant positive correlation with the public support in and evaluation of urban-rural integration. In our research, Basic public services mainly including education, medical treatment, pension, employment and rendering of other basic public services, which related partly aspects of Livelihood have critical influence of people's life., so practical benefits created by public services have enabled residents to support and approve urban-rural integration policies to a larger extent. Besides, there will be greater support and higher appraisal for such policies as the quality of basic public services is further improved.

Hypothesis tests have been passed by H2 and H3 as well. The path coefficient of Hypothesis 2 (H2) was 0.68, which revealed that the satisfaction with basic public services is highly correlated to living indexes. Our survey indicated that 52.8% of residents' income has somewhat been increased, but 94.1% of them considered they spend more. Under this situation, it is impossible to measure if their living standards have been improved or not. Of course, this depends on the proportion of their income to consumption. Nevertheless, for income-less groups, it is still rather hard

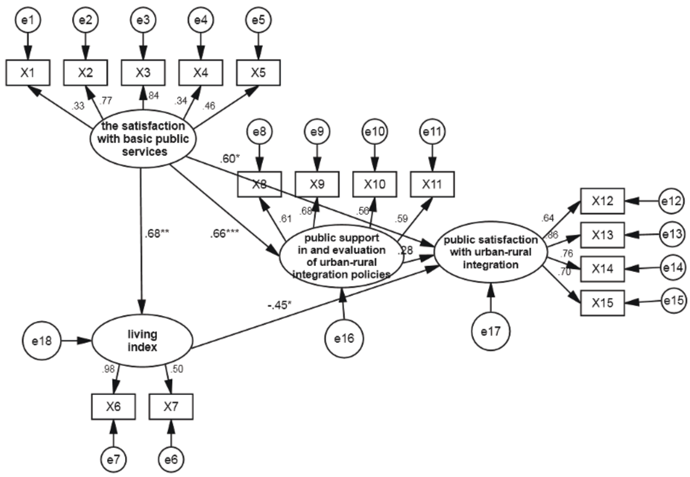

Fig. 100.3 Final results of model analysis (standardized solution)

for them to survive if their consumption is higher than expenditure. Therefore, basic public services like medical insurance and pension insurance, etc still exert great influences on living index. The reasons why H3 and H1 were tenable are somewhat in common, which reflects that public satisfaction is dependent upon basic public services provided by the Government after all.

H4 hasn't been proved tenable by hypothesis test in the original model and H5 was also contrary to our research hypothesis. In other words, the support in and evaluation of policies are not significantly influenced by living indexes. In this study, living indexes include income satisfaction and consumption capacity. As mentioned above, there will be a growth in consumption although the income has increased to certain extent. Therefore, the surplus of residents' income hasn't been greatly increased. Thus, living indexes have no significant impacts on the evaluation of and support in urban-rural integration. Likewise, public satisfaction won't be improved even if living indexes are increased, whereas they are significantly and negatively correlated. In fact, 41.2% of residents were unwilling to abandon their lands to accept governmental planning. Additionally, in our interview many people take for granted that the Government shall offer more compensations or more living benefits to them since they are required to abandon their lands. Moreover, some residents consider that peasants have sacrificed much during the industrial development of China and now it is time for them to be repaid. Hence, the satisfaction won't be improved despite there is growth in living standards.

H6 hasn't been validated tenable. In other words, public support in and evaluation of urban-rural integration are positively correlated to public satisfaction, but don't have significant impacts, which are not only subjective, but also objective. Evaluation is implemented to judge if "the plans are reasonable, or the transformation of rural areas into communities is reasonable", etc. Residents' subjective feelings are not significantly impacted no matter the plans and the transformation, etc are reasonable or not. The key lies in the benefits they can obtain from urban-rural integration. Thus, the satisfaction isn't significantly affected too, but influenced by the satisfaction with basic public services.

100.5 Conclusions and Suggestions

The research has suggested that the satisfaction with basic public services plays a crucial role in urban-rural integration, and has significant impacts upon living indexes, public support in & evaluation of urban-rural integration as well as public satisfaction. Moreover, there are no significant positive correlations between living index and public satisfaction, support and evaluation. Meanwhile, the support in and evaluation of urban-rural integration are not so favorable for remarkable improvement of public satisfaction. Hence, for the purpose of urban-rural integration, it is necessary to further improve the level of basic public services and gradually equalize public services. During the survey, it has been discovered that 62.4% of people still consider that there are unequal job opportunities for urban and rural residents, and 55.3% of residents regard there are unequal rights for them to enjoy education as well despite 61.2% of people think more job opportunities have been created by urban-rural integration. In addition, pension insurance and medical insurance remain to be improved. Thereby, the Government shall strive hard to create conditions for increasing disposable income for residents, providing them with more equal rights in education and job opportunities, and improving the level of social insurance. Furthermore, during the interview, many residents reflected that there is still great deficiency in community security and theft is a severe phenomenon even if some infrastructure is somewhat complete. Thus, it also needs to enhance the safety management in communities to promote community stability and society's harmonious development during further urban-rural implementation.

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Chapter 101
Evaluation of Agricultural Modernization Based on Maximizing Deviation and GMDH

Yue He, Weiru Deng and Lili Zhang

Abstract The level of agricultural modernization is an important indicator to measure agricultural development. China, a big agricultural country, always needs to pay attention to the development level in the process of promoting agricultural modernization. This paper makes an empirical analysis of the process of agricultural modernization in Sichuan Province in recent sixteen years to put forward a new way to evaluate the level of agricultural modernization. At first, the maximizing deviation is used to evaluate the level of agricultural modernization, and then GMDH method is applied to determine the contribution value of the factors affecting the process of agricultural modernization. The results show that the level of agricultural modernization in Sichuan is gradually increasing. This paper also indicates that it is quite important to speed up the transfer of rural labor force and improve their cultural quality, raise the level of agricultural mechanization, increase the forest coverage as well as reduce the agricultural disasters. Only in this way can we realize agricultural modernization eventually.

Keywords Maximizing deviation · GMDH · Comprehensive evaluation · Agricultural modernization

101.1 Introduction

The agricultural modernization in China is mainly a process that turns the traditional agriculture into a scientific, technological, intensified and market-oriented industry by adjusting the means of production and agricultural economy structure. It plays an important role for the fact that China has the largest population, so achieving

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the agricultural modernization has always been the orientation of agricultural development that the Chinese government adheres to. The agricultural modernization in China has made remarkable progress over the past 30 years since the reform and opening, while the agricultural modernization is a dynamic, regional, holistic process and its construction and development change with time, which suggests that the use of quantitative methods to scientifically and objectively evaluate the level of agricultural modernization has great realistic meaning that helps the government better master the process of agricultural modernization. Furthermore, finding out the factors that promote the development also has guiding significance.

At present, the study of agricultural modernization is mainly based on qualitative research methods and few papers use quantitative methods. One of the quantitative research methods they prefer to use is multi-index comprehensive evaluation method. Caio et al [1] the index system based on the studies of other scholars and used statistical method like Spearman index to find out the main factors that influenced the agricultural modernization in Brazil. While researches on the comprehensive evaluation of agricultural modernization in China are concentrated in three areas:

- Cobb-Douglas model. This approach analyzes the contribution of capital, labor, science and technology to agricultural production in order to determine the process of agricultural modernization.
- Multi-index comprehensive evaluation method. This method uses principal component analysis, clustering analysis, gray relational analysis, comprehensive index evaluation method and other methods to find out all the factors and information, then uses mathematical method to treat them and finally confirms the overall dynamic process.
- DEA method. This method is focused on input-output factors to evaluate the level of agricultural modernization by comparing the input and output of the agricultural sector as well as their respective advantages.

The second method is the most used one as we mentioned before. Shen and Hu [2] used clustering analysis, principal component analysis and AHP method to improve the tedious agricultural modernization evaluation index system. Meng and Sun [3] applied entropy weight theory to determine the weight of rating system indicators, and then calculated the composite index of the development level of modern agriculture and subsystem development level index of Huhan province. Wang [4] did the same for 108 counties of Henan province based on the theory of fixed-weight-grey-clustering, and sorting as well as comparison was also made. In the end of this paper, the strategies for agricultural development were given. Jiang and Huang [5] built the agricultural modernization evaluation index system by using AHP and evaluated the general development level of China based on that. Yang and Guo [6] brought factor analysis method to artificial neural network and used it in the multi-index comprehensive evaluation of agricultural modernization, which made the artificial neural network overcome the lack of precision in the multi-index case and put forward new ideas for the agricultural modernization comprehensive evaluation method. Wei [7] conducted comparative analysis of the course of rural modernization and urban modernization using factor analysis and principal component analysis method, which drew the conclusion that the difference would be gradually reduces in the process of development. Men and Tang [8] combined entropy method, mean TOPSIS and entropy-TOPSIS method to evaluate 6 provinces and 1 city from east of China, then divided the development level of agricultural modernization into 3 categories. TOPSIS and artificial neural network (ANN) were employed to evaluate and predict agricultural modernization level in Qi's paper [9]. The scholar found that the 5-4-1 ANN model with standardization using the mean absolute error (MAE), mean absolute percentage error (MAPE) and root mean square error (RMSE) transformation was the best model. Three multivariate statistical methods, hierarchical cluster analysis (HCA), factor analysis (FA) and discriminant analysis (DA) were applied by Qi [10] to a subgroup of the dataset to evaluate their usefulness to classify agricultural modernization in Zhejiang, and to identify agricultural modernization hidden patterns. DEA method is also widely used in the study of agricultural modernization. Guo and Chen [11] combined principal component analysis and DEA to draw a conclusion that China's agricultural modernization level of the eastern province was higher than the central and western regions. Li and Wang [12] constructed an evaluation system based on the illustrating the agricultural modernization theories and used the methods of DEA, the fixed weight of grey cluster to evaluate the process of agricultural modernization. Cao and He [13] also employed DEA theory to evaluate agricultural production efficiency of 31 provinces and cities in China in 2008 and found that Beijing and five other provinces had reached the optimal scale of agricultural production and their investment structure was effective.

The above researches are mainly based on the index evaluation system established by various methods, we notice that in some papers use quite many indexes and some indexes are a little difficult to measure. Most of the researches are about horizontal comparisons of the levels of agricultural modernization among different areas while little of them do the comparisons longitudinally. There isn't any study about agricultural modernization based on the maximizing deviation and GMDH method.

So the paper selects the index evaluation system with right quantity and easy measurement from the former papers. Then this paper uses the maximizing deviation multi-attributes decision method to make a comprehensive evaluation and comparison of the agricultural modernization in Sichuan from 1994 to 2009. Then GMDH method is used to find out the main factors that affects the development of agricultural modernization. This paper also uses cluster method to get an idea of the process of agricultural modernization. The aim of our work is to put forward a new way to evaluate agricultural modernization.

101.2 Methods

101.2.1 Maximizing Deviation Method

The main idea of maximizing deviation is that if the attribute u_j value of all solutions varies little then this attribute affects little and its weight is quite small and vice versa [14]. If the attribute u_j value of all solutions doesn't vary, it indicates that this attribute has nothing to do with the sorting of solutions and its weight should be given zero.

Let $X = (X_1, X_2, \cdots, X_n)^T$ is solutions set and $U = (u_1, u_2, \cdots, u_m)$ is attributes set, the value of attribute u_j in solution x_i is b_{ij}. The attribute decision matrix is $B = (b_{ij})_{n\times m}$ and it is $R = (r_{ij})_{n\times m}$ after standardization.

Suppose the weight vector of each attribute is $W = (w_1, w_2, \cdots, w_m)$, $w_j > 0$, and $\sum_1^m w_j^2 = 1$.

For attribute u_j, let $V_{ij}(w)$ is the deviation between the solution x_i and other solutions. It can be defined as follows:

$$V_{ij}(w) = \sum_{i=1}^{n} \mid r_{ij}w_j - r_{kj}w_j \mid, \ i \in N, \ j \in M.$$

Let $V_j(w) = \sum_{i=1}^n V_{ij}(w) = \sum_{i=1}^n \sum_{k=1}^n \mid r_{ij} - r_{kj} \mid w_j$, $j \in M$, then $V_j(w)$ is defined as the maximum deviation between all solutions for attribute u_j. So the object function is:

$$\max V(w) = \sum_{j=1}^{m} V_j(w) = \sum_{j=1}^{m}\sum_{i=1}^{n}\sum_{k=1}^{n} \mid r_{ij} - r_{kj} \mid w_j.$$

Then solving the weight vector w is equal to solving the following optimization model:

$$\begin{cases} \max\ V(w) = \sum\limits_{j=1}^{m}\sum\limits_{i=1}^{n}\sum\limits_{k=1}^{n} \mid r_{ij} - r_{kj} \mid w_j, \\ \text{s.t. } w_j \geq 0, \ j \in M, \ \sum\limits_{j=1}^{m} w_j^2 = 1. \end{cases}$$

Solving this model by making Lagrange function:

$$L(w,\xi) = \sum_{j=1}^{m}\sum_{i=1}^{n}\sum_{k=1}^{n} \mid r_{ij} - r_{kj} \mid w_j + \frac{1}{2}\xi\left(\sum_{j=1}^{m} w_j^2 - 1\right).$$

The optimal solution is solved.

$$w_j^* = \frac{\sum\limits_{i=1}^{n}\sum\limits_{k=1}^{n} \mid r_{ij} - r_{kj} \mid}{\sqrt{\sum\limits_{j=1}^{m}\left[\sum\limits_{i=1}^{n}\sum\limits_{k=1}^{n} \mid r_{ij} - r_{kj} \mid\right]^2}}, \ j \in M.$$

Traditional weight vector usually meets normalization conditions not the unit constraints. So after getting the unit weight vector w_j^*, in order to be consistent with the idioms of people, w_j^* can be normalized. Suppose:

$$w_j = \frac{w_j^*}{\sum\limits_{j=1}^{m} w_j^*},\ j \in M.$$

The final result is:

$$w_j = \frac{\sum\limits_{i=1}^{n}\sum\limits_{k=1}^{n} | r_{ij} - r_{kj} |}{\sum\limits_{j=1}^{m}\sum\limits_{i=1}^{n}\sum\limits_{k=1}^{n} | r_{ij} - r_{kj} |},\ j \in M. \tag{101.1}$$

Use from Equation (101.1) can calculate the comprehensive evaluation value of every scheme decision.

$$D_i(w) = \sum_{j=1}^{m} r_{ij} w_j. \tag{101.2}$$

101.2.2 GMDH Method

GMDH (Group Method of Data Handling) is the core of self-organizing of data mining. It was generated and developed based on the rapid development of neutral network and computer science [15]. It establishes the input-output relationship of a complex system using a multilayered perception-type structure that is similar to a feed-forward multilayer neural network. GMDH algorithm can gradually generate complicated models and find the best model based on the evaluation of their performances on a set of multi-input-single-output data pairs.

The basic idea of GMDH is from heuristic self-organization method which is the earliest data mining thought. It was developed by Ivakhnenko [16]. In the 1990s, the German scholars Mueller and Frank made the software Knowledge Miner that reflected their latest theory and algorithms, greatly improved the applicability of GMDH. The basic steps of GMDH are as follows [17]:

- The N times data sample is divided into training set A and testing set $B(N = A + B)$.
- Establish 'reference function'. The classic K-G polynomial is as follows:

$$y = a_0 + \sum_{i=1}^{m} a_i x_i + \sum_{i=1}^{m}\sum_{j=1}^{m} a_{ij} x_i x_j + \sum_{i=1}^{m}\sum_{j=1}^{m}\sum_{k=1}^{m} a_{ijk} x_i x_j x_k + \cdots$$

- Select the target rule from the rule table which has the attribute of 'external supplement'. The most selected one is regularization rule: $\Delta^2(B) = \Delta^2(B/A) = \|$

$y^B - \hat{y}^B(A) \|^2$. y^B is the actual output from sample B. $\hat{y}^B(A)$ is the estimated output from sample B calculated by the coefficient of model from sample A.
- Classify the local function based on the reference function.
- Use coefficient estimating method in the training set A to estimate all the coefficient of local function.
- Test the quality of local models in testing set B according to the selected external rule. Choose the function that has the best qualities as the best model. If not satisfied with the result, choosing F model functions (F is called selecting degrees of freedom) which have good qualities to go further analysis.

101.3 Empirical Analysis

101.3.1 Comprehensive Evaluation Index System of Agricultural Modernization

Research on the construction of comprehensive evaluation index system of agricultural modernization is always a central issue. Jiang and Xin [18] divided the evaluation index system into 7 first indicators and 20 second indicators. Han and Xin [19] built 10 indicators to evaluate the level of agricultural modernization combined his comprehension of substance of it and the internationally accepted index system to assess agricultural modernization. Zeng [20] attached importance to the sustainable development of agriculture as one of the indicators of agricultural modernization and used AHP to build 4 first indicators and 18 second indicators. Learning from these papers [18–20], we mainly considers 4 aspects including agricultural input level, agricultural science and technology as well as education level, economic development level of rural areas, sustainable development of agriculture, which is in line with the 4 basic principles of constructing indicators and availability of data. The following indicators as shown in Table 101.1 are selected to evaluate the level of agricultural modernization.

101.3.2 Comprehensive Evaluation Using Maximizing Deviation Method

- Data collection. The paper gets agricultural modernization data in 1994-2009 from *Statistical Yearbook of Sichuan* and *Rural Statistical Yearbook of China*.
- Data processing and analysis. Normalizing every indicator [14], then using maximizing deviation method to solve the weight as follows:

$$w = (0.0238, 0.0030, 0.0057, 0.0111, 0.2782, 0.0098, 0.0005, 0.4612, 0.1669, 0.0134, 0.0263).$$

Table 101.1 Description of comprehensive evaluation index system of agricultural modernization

Indicator	Description	Category
Per capita GDP (u_1)	Local GDP/Local population	Agricultural output level
Per capita gross output value of Agriculture (u_2)	Local gross output value of agriculture/ Total population in rural area	
Land productivity (u_3)	Local gross output value of agriculture/ Cultivated area	
Labor productivity (u_4)	Local gross output value of agriculture/ Total rural labor force	
Rural labor force in proportion (u_5)	Total rural labor force/Total population in rural area	Agricultural science, technology and education level
Agricultural machinery power rate of unit area (u_6)	Agricultural machinery total power/ Cultivated area	
Fertilization rate of Unit area (u_7)	Fertilization rate of Unit/Cultivated area	
Labor ratio beyond junior school education level (u_8)	Per 100 rural labor ratio beyond junior school education level	
Urban resident population in proportion (u_9)	Urban resident population/Local population	Economic development level of rural areas
Disaster area ratio (u_{10})	Reflection of the countermeasures of agricultural modernization to disasters	Sustainable development of agriculture
Forest area ratio (u_{11})	Reflection of the pros and cons of the agro-ecological environment	

So the formula to calculate comprehensive evaluation value Z is as follows:

$$\begin{aligned} Z = {} & 0.0238u_1 + 0.003u_2 + 0.0057u_3 + 0.0111u_4 + 0.2782u_5 + 0.0098u_6 \\ & + 0.0005u_7 + 0.4612u_8 + 0.1669u_9 + 0.0134u_{10} + 0.0263u_{11}. \end{aligned} \tag{101.3}$$

After getting comprehensive evaluation results from 1994 to 2009 by Equation (101.3), we get the results shown in Table 101.2. The highest score is 1.49, while the lowest is -1.34.

In Table 101.2, some scores are negative numbers which may be not easy to accept and understand. In fact, the less the absolute values of these negative numbers are, the better agricultural modernization is shown under the average development levels. So we can use the efficacy coefficient method to make the results more acceptable and understandable. The comprehensive evaluation value Z is transformed by Equation (101.4).

$$S_i = \frac{z_i - z_{\min}}{z_{\max} - z_{\min}} \times 40 + 60. \tag{101.4}$$

Then we get efficacy coefficients S from 60 to 100. It can be proved that this linear transformation does no effect on the ranks of the true results. The comprehension value is 100 in 2009, while 60 in 1994. Here, 100 doesn't mean perfect, it only tells

Table 101.2 Comprehensive evaluation value and ranks of agricultural modernization from 1994 to 2009

Year	Comprehensive evaluation value (S)	Rank	Year	Comprehensive evaluation value (S)	Rank
2009	1.49	1	2001	−0.07	9
2008	1.35	2	2000	−0.20	10
2007	1.16	3	1999	−0.35	11
2006	1.01	4	1998	−0.52	12
2005	0.88	5	1997	−0.72	13
2004	0.51	6	1996	−0.95	14
2003	0.36	7	1995	−1.21	15
2002	0.17	8	1994	−1.34	16

us that we make much progress in 2009 relatively. The full results are shown in Table 101.3.

Table 101.3 The efficacy coefficients and ranks of agricultural modernization from 1994 to 2009

Year	Comprehensive evaluation value (S)	Rank	Year	Comprehensive evaluation value (S)	Rank
2009	100	1	2001	78	9
2008	98	2	2000	76.1	10
2007	95.3	3	1999	74	11
2006	93.2	4	1998	71.6	12
2005	91.4	5	1997	68.8	13
2004	86.1	6	1996	65.5	14
2003	84	7	1995	61.8	15
2002	81.3	8	1994	60	16

Table 101.3 shows that the level of agricultural modernization in Sichuan is gradually increasing. Using Ward cluster method to analyze, we find that the development of agricultural modernization in Sichuan can be divided into 4 stages. The first stage is from 1994 to 1997. The second stage is from 1998 to 2001. The third stage is from 2002-2004 and the last one is from 2005-2009. The average development period is about 3 to 5 years. The average development period from the first stage to the third stage is gradually decreasing, which suggests that the development speeds up in these stages. However, the period of last stage becomes longer than those three. So when reaching a certain stage, the development of agricultural modernization will slow down and be on a gentle rise.

From the calculated weight, it is clear that the weight of labor ratio beyond junior school education level (u_8) is the highest which is 0.4612, followed by rural labor force in proportion (u_5) that is 0.2782 and urban resident population in proportion (u_9) that is 0.1669. Forest area ratio (u_{11}) which reflects the sustainable development level also plays an important role in agricultural modernization.

101.3.3 Using GMDH to Analyze the Main Factors Affecting Agricultural Modernization

Based on the comprehensive evaluation value from Table 101.3, we use GMDH method to find out the main factors affecting agricultural modernization. Suppose the comprehensive evaluation value is dependent variable Z and Y is independent variable selected from the indicators of Table 101.4.

Table 101.4 Factors affecting agricultural modernization

Factor	Unit	Factor	Unit
Gross agricultural output value (y_1)	100,000,000	Quantity of chemical fertilizers(y_5)	10,000 tons
Cultivated area (y_2)	1000 hectares	Labor ratio below junior school education level (y_6)	%
Total rural labor force (y_3)	10,000 people	Rural disaster area (y_7)	10,000 hectares
Agricultural machinery power (y_4)	10,000 KW	Forest area (y_8)	10,000 hectares

Put the comprehensive evaluation value Z of Sichuan agricultural modernization and independent variable Y from 1994 to 2009 into Knowledge Miner and use GMDH model then get an input-output equation as follows:

$$Z = 0.064 * y_1 - 0.419 * y_3 + 0.034 * y_4 - 0.446 * y_6 - 0.022 * y_7 + 0.025 * y_8. \tag{101.5}$$

From the model, we can see that the main factor affecting the agricultural modernization in Sichuan is gross agricultural output value (y_1), total rural labor force (y_3), agricultural machinery power (y_4), labor ratio below junior school education level (y_6), rural disaster area (y_7) and the forest area (y_8).

Agricultural machinery power (y_4) and forest coverage (y_8) is positively correlated with the level of agricultural modernization, which indicates that the raise of mechanization level of agriculture and forest coverage is a correct path towards agricultural modernization.

Total rural labor force (y_3), labor ratio below junior school education level (y_6) and rural disaster area (y_7) negatively correlated with the level of agricultural modernization. It tells us that the modernization of agriculture shouldn't become a labor-intensive industry. The right development strategy to realize agricultural modernization is to improve the cultural level of the rural labor force, develop agricultural science and technology as well as reduce agricultural disasters.

Based on the above analysis, this paper puts forward some methods which help accelerate the development of agricultural modernization:

- Promote the transfer of rural labor force. The transfer of rural labor force is divided into two directions. One is outward transfer which means rural people work in cities, the other one is inward transfer which means rural people can get a job in the local.

- Improve the education quality of rural labor force. Highly skilled workforce is a necessary condition to achieve agricultural modernization. It requires a highly qualified labor force to be matched with the improvement of agricultural mechanization, agricultural science, technology and other aspects, which is no longer a purely traditional agricultural operation mode.
- Strengthen rural infrastructure to improve the conditions of agricultural facilities and equipment, and construct water conservancy facilities as well as improve the development of micro-drip irrigation equipment. Furthermore, it needs to change for the fact that traditional agriculture is dependent on the weather situation, today we should enhance the defense capabilities of the agricultural natural disasters (such as drought, floods).
- Emphasis on the construction and protection of agricultural production environment like increasing the forest coverage and enhancing the environmental awareness of agriculture. The use of chemical fertilizers, pesticides should be reduced during the production process. On the other hand, we need to vigorously develop biotechnology as developing high yielding quality crop varieties and enhancing the adaptability of crops to adverse environmental.

101.4 Conclusions

The maximizing deviation method was used to evaluate the level of agricultural modernization in Sichuan in recent 16 year and it points out that the level is gradually increasing and the modernization of agriculture is in an orderly way. Then GMDH method is used to find out the factors that influence Agricultural modernization. The paper mentions that we should focus on the transfer of agricultural labor, improve the quality of agricultural labor force, improve agricultural infrastructure and adhere to the road of sustainable development of agriculture.

The main purpose of this paper is to put forward a new way to evaluate and analyze the level of agricultural modernization by using maximizing deviation and GMDH method and we use Sichuan province as an example. But the paper only analyses the process of agricultural modernization in Sichuan longitudinally, lacking the cross-sectional studies of other provinces. So we don't learn the experience and lessons from other provinces and the results may be one-sided. Meanwhile, the transfer of agricultural labor, as an important factor to speed up the modernization of agriculture, needs deep study like how to head up this project well.

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Chapter 102
An Empirical Study of the Technological Innovation Cooperation Performance between the Resource-based Enterprises

Guichuan Zhou

Abstract This paper will discuss the impact of cooperative technological innovation motivation and cooperation in technology innovation model of relationship-oriented cooperation between enterprises of technological innovation, and thus cooperation between enterprises of technological innovation based on the resource-based enterprises to technology innovation motivation and cooperation in technology innovation model to classify. And analysis of variance to verify its impact on the performance of the cooperation between the resource-based enterprises technological innovation. On this basis, the use of stepwise regression equation to discuss the market structure factors, natural environmental factors, technical capacity factors, government policy factors, firm size and type of business ownership on the performance of the cooperation between the resource-based enterprises technological innovation. In order to explore the cooperation between the resource-based enterprises that affect technological innovation performance influencing factors and role of law, to provide a theoretical basis and practical guidance to improve and enhance the performance of cooperative technology innovation in China's resource-based enterprises.

Keywords Resource-based enterprises · Technological cooperation innovation · Cooperation performance

102.1 Introduction

Our country's resource-based enterprises are defined by domestic scholars as types of enterprises whose core competitiveness is possession of resources. Based on possession and monopolization of natural resources, with resources exploiting as its basic mode of production and auxiliary pretreating and other subsequent procedures,

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resource-based enterprises rely on resources consumption to improve. Resource-based enterprises play an important role in national economic development. However, there are some enterprises with weak technology foundation and technical ability. In order to change from resource-dependent enterprises to technological innovation-oriented enterprises, it is a shortcut for these enterprises to pay more attention to technological innovation cooperation between enterprises.

Based on questionnaire for 103 resource-based enterprises from 2010 to 2011, this paper will classify technological innovation cooperation relationship between enterprises in technology innovation motivation and mode and also discuss how different types of cooperation relationship effect technological innovation cooperation performance. It provides theoretical and practice evidence for resource-based enterprises to seek proper partnership and then improve technological innovation performance.

102.2 Literature Review and Summary

For technological innovation cooperation performance between enterprises, Lyles et al [1] state some subjective indicators can be applied to evaluate cooperation performance, such as realization degree of cooperation goals. Mohr et al [2] prove that cooperation members' satisfaction with cooperation relationship is an important factor to weigh whether the cooperation is successful or not. Lambe et al [3] think joint revenue should be treated as successful evaluation of cooperation achievement; Mitsuhashi [4] establish evaluation indicators of cooperation performance when studying alliance performance, including four dimensions: cooperative enterprises keep their promises, and then think their cooperation relationship is very successful, and it is worthwhile to put time and energy to the developing and maintaining process and the fourth is very satisfied with the partnership. Wu et al [5] evaluate cooperation performance with four indicators: realization degree of cooperation goals, improvement of the earnings, satisfaction of cooperation and willing to cooperate in the future. and Pan [6] apply earnings improvement, goal realization, relationship lasting degree and customers' satisfaction as evaluation indicators of cooperation performance when researching cooperation performance of supply chain.

102.2.1 Cooperation and Technological Innovation Cooperation Performance of Resource-based Enterprises

There are many factors effecting technological innovation cooperation performance between enterprises, the mose direct of which is cooperation relationship between enterprises. Ingham and Mothe observe studying process of R&D Cooperation Union Organization containing many European high-tech enterprises and find that there are six factors related with technological innovation cooperation performance between enterprises, four of which reflect partnership between enterprises, including mutual trust of partners, integratability in enterprises' researching and developing activities, participation and cooperative motivations of each partner in the cooperative process, amount and mutual relationship of enterprises in the technological union [7]. Branatetter and Sakakibara [8] shows there is a positive correlativity of the participation of the cooperative enterprises and technological innovation cooperation outcome. Bouroche [9] points out in the process of technological innovation cooperation, enterprises visit others and take part in the meeting together, and it is good to promote mutual technological communications as well as it is necessary to establish early team for technological managers and workers.

Therefore, this paper will put forward the following hypothesis:
H1: Cooperation relationship has a significant effect on technological innovation cooperation performance between the resource-based enterprises.

102.2.2 Market Structure Factor and Technological Innovation Cooperation Performance between Resource-based Enterprises

Early theory [10] shows, as an independent agent, every enterprise draws on advantage and hopes to gain more profit through technological innovation cooperation between enterprises, including apparent earnings (profit, income and so on) and latent earnings (risk sharing, etc). In this competitive market, enterprises will be eliminated without core technology. The amount of enterprises in the same industry increases, which will lead to more fierce competition and reduction of the enterprises' profit; while the amount reduces, which means the competition is not so fierce and enterprises' profit will increase. There is a positive correlativity of enterprises' profit and technological innovation cooperation input. With higher profit, enterprises have more funds to invest in the cooperation; with lower profit, the investment will be reduced relatively. Therefore, when there are less enterprises and the product market structure become more centralized, enterprises will invest more funds in technological innovation cooperation and the performance will be better.

Therefore, this paper will put forward the following hypothesis:
H2: Market structure factor has a great influence on technological innovation cooperation performance between resource-based enterprises.

102.2.3 Natural Resources Factor and Technological Innovation Cooperation Performance between Resource-based Enterprises

Peteraf [11] states with illiquidity and incomplete liquidity, resources will become non-commercial and low-value, which can play a role in specific enterprises, but the resources put in the strategy by enterprises are limited, so enterprises will be expected to gain technological innovation resources through strategic behaviors. Teece et al [12] analyse the relationship of enterprises' ability, resources and strategies, and make a conclusion that the choice of improving strategies of enterprises' technology capacity depends on the resources accumulation speed and usage modes in the improving process. Wang and Mao [13] think industrial technology chain of developed countries spreads to developing countries, which allocates technology resources worldwide and makes technology chain distributed in space and time. Industrial technology chain is a group composed of many enterprises, the link of which is global essential resources. If enterprise own better natural resources, more input of technological innovation cooperation will be invested and the performance will be higher, however, if enterprise own limited natural resources, it is impossible for them to increase input so that the performance will be restricted.

Therefore, this paper will put forward the following hypothesis:

H3: Natural resources factor has a great influence on the technological innovation cooperation performance between resource-based enterprises.

102.2.4 Technical Capacity Factor and Technological Innovation Cooperation Performance between Resource-based Enterprises

Bonaceorsi et al [14] think an inverse U quadratic curve has been found to suit the relationship between technological input capacity and technological innovation cooperation. Enterprises' technology input capacity influences the depth of technological innovation cooperation, while technology transfer and digestion and absorption influence the speed of the technological innovation cooperation. Cohen [15] emphasized that technology absorption is enterprises' capacity to identify, use and commercialize outer new knowledge. Barclay [16] stated enterprises' "responsiveness" to technology is very important in technological innovation cooperation. That is to say, competitiveness can be obtained or kept through conscious reflection to important events, chance and outer threat in proper time.

Therefore, this paper will put forward the following hypothesis:

H4: Technology capacity factor has a great influence on technological innovation cooperation performance between resource-based enterprises.

102.2.5 Government Policy Factor and Technological Innovation Cooperation Performance between Resource-based Enterprises

Resource-based enterprises take part in the practice process of technological innovation cooperation, monetization encouraged and supported by government policies is another expressive form of performance. Stronger encouragement and support can help participant enterprises gain more cooperation profit, and bring higher performance to resources-based enterprises.

Therefore, this paper will put forward the following hypothesis:
H5: Government policy factor has a great influence on technological innovation cooperation performance between resource-based enterprises.

102.3 Empirical Study

102.3.1 Samples and Data Resources

The questionnaire survey in this article began in Sep, 2010 and completed in Mar, 2011. The questionnaires were dispatched to every respondent through alumnus network, and then recycled them through alumnus network.

102.3.2 Variable Measurement

This article adopts Likert scale of Five Degrees (from "the weakest" which is 1 point to "the strongest" which is 5 point)
(1) Independent variable

Types of cooperation relationship: According to the influence on the cooperation performance by technological innovation cooperation between enterprises, this article classifies the cooperation types in cooperation motivation and cooperation types, which can be seen in the Table 102.1.

In the aspect of cooperation motivation, according to Hagedoorn's study [17], this article will divide the dimension of cooperation motivation into three parts: related to research and development, related to technology studying and related to strategy aims. In the aspect of cooperation modes, according to Luo and Tang's study [18], this article will divide cooperation modes into non-property cooperation and property cooperation.

Market structure factors: According to Williamson [19], Nonaka [20], Xi [21], Zhang [22], this article will observe and market structure factors from industry developing view, market competitiveness and expected profit of cooperation.

Table 102.1 Cooperation relationship types of technological innovation cooperation between enterprises based on cooperation motivation and types

Cooperation motivation	Researching and developing motivation		Technological studying motivation		Competitive strategic motivation	
Cooperation modes	Non-property	Property	Non-property	Property	Non-property	Property
Cooperation relationship orientation	Co-working	Type of Master and servants	Type of imitation	Type of teacher and student	Cheating	Kidnapping

Natural resources factors: according to Resources Capacity Evaluation System of resource-based enterprises designed by Li [23], this article will treat resources condition, resources potential and resources transfer efficiency as three indicators to observe enterprises' natural resources factors.

Technology capacity factors: Technology input and absorption and digestion will be considered as two indicators to observe technology capacity of resource-based enterprises.

Government Policy factors: according to Xie et al [24], because most technological agent service is led or supported by local governmental institutions in previous stage, the government policy factors are mainly about research fees and tax preference.

(2) Dependent variable

The dependent variables are cooperation performances of technological innovation cooperation, including financial profit (Enterprises gain better financial profit through cooperation), technological profit (Enterprises improve their technical capacity through cooperation) and relationship profit (Enterprises establish long-term and stable cooperation relationship through cooperation).

102.4 Results of Empirical Analysis

102.4.1 Cooperation Relationship Types' Influence on Technological Innovation Cooperation Performance between Enterprises

The cooperation relationship modes can be treated as independent variable and innovation performance be dependent variable. Analysis of variance of leading effect can be done. The result shows that technological innovation cooperation relationship modes has a effect on performance ($F = 4.4$, $P = 0.01$, $R^2 = 0.638$). According to Levene's variance homogeneity to verify the result, six types' performance is variant $(F = 0.38,\ P = 0.897)$. LSD method can be applied to compare the sic different types.

Table 102.2 Multiple comparison results of performance average value of technological innovation cooperation relationship between enterprises

Relationship types	Relationship types	Average difference	Remarks
Co-working type	Type of master and servant	1.434*	Co-working Type> Type of master and servant
	Imitation type	0.450	
	Type of teacher and student	2.041*	Co-working Type> Type of teacher and student
	Cheating	−0.057	
	Kidnapping	1.794*	Co-working Type> Kidnapping
Type of master and servant	Imitation type	−0.984*	Type of master and servant <Imitation type
	Type of teacher and student	0.607	
	Cheating	−1.491*	
	Kidnapping	0.360	Type of master and servant <Imitation type
Imitation type	Type of teacher and student	1.591*	Imitation type> Type of teacher and student
	Cheating	−0.507	
	Kidnapping	1.344*	Imitation type>Kidnapping
Type of teacher and student	Cheating	−2.098*	Type of teacher and student <Imitation type
	Kidnapping	−0.247	
Imitation type	Kidnapping	1.851*	Imitation type>Kidnapping

Note: ∗ refers to the average value is above 0.05, which is very obvious.

From the Table 102.2, it can be inferred that innovation relationship orientation of co-working, imitating and cheating can bring higher performance compared with other types. However, the difference is not obvious. It shows that non-property innovation types have special advantages in technological innovation filed. With flexible and free cooperation ways, it is better for innovation activities and also can effectively reduce innovation obstacles caused by bad communication and complicated systems.

The innovation relationship orientation with type of master and servant, type of teacher and student and kidnapping type bring high cost to enterprises, but not bring high performance, because resource-based enterprises own weak technology foundation, lack of talents and low position in the industry chain instead of close cooperation relationship between enterprises. Property technological innovation cooperation can prevent the loss of core technology and resources effectively, however, for most resource-based enterprises, it is not wothywhile.

102.4.2 Other Factors' Influence on Technological Innovation Cooperation Performance between Enterprises

Market structure factors, natural environmental factors, technical capacity factors, government policy factors, firm size and type of business ownership can be treated as independent variable, while technological innovation cooperation performance can be treated as dependent variable. Through stepwise regression analysis, the result can been seen in the following Table 102.3.

From Table 102.3, we can infer factors which influence technological innovation cooperation between resource-based enterprises also has a great effect on performance. Among them, market structure factor's influence on technological innovation cooperation performance is negative, while natural resources factor, technical capacity factors and government policy factors ' influence are positive.

(1) Natural resources factor's influence on technological innovation cooperation performance between enterprises

The coefficient that natural resources factors have a great effect on technological innovation cooperation performance is 0.802. If resource-based enterprises have more advantageous natural resources, their performance will be better.

(2) Market structure factors' influence on technological innovation cooperation performance between enterprises

The coefficient that market structure factors have a influence on technological innovation cooperation performance is 0.498, which shows that the better the market environment is, the better the cooperation performance is.

(3) Technology capacity factors' influence on technological innovation cooperation performance between enterprises

The coefficient that technology capacity factors have an influence on technological innovation cooperation performance is 0.401. It can be inferred that the stronger the technology capacity is, the better the performance is.

(4) Government policy factors' influence on technological innovation cooperation performance between enterprises

Government policy factor is also one of the most important factors to effect on technological innovation cooperation performance between enterprises, whose coefficient is 0.235. The influence of government policy are mainly manifested in two aspects.

Table 102.3 Stepwise regression results of influence factors of technological innovation cooperation performance between enterprises

	Types	R^2	Unstandardized coefficients		Standardized coefficients	t	Sig.
			B	Std. Error	Beta		
1	Natural Resources Factors	0.628	0.712	0.061	0.712	14.443	0.000
2	Natural Resources Factors	0.851	0.753	0.046	0.753	16.526	0.000
	Market Structure Factors		0.426	0.046	0.426	11.481	0.000
3	Natural Resources Factors	0.880	0.786	0.038	0.786	21.084	0.000
	Market Structure Factors		0.454	0.037	0.454	13.165	0.000
	Technical Capacity Factors		0.387	0.038	0.387	11.013	0.000
4	Natural Resources Factors	0.917	0.802	0.026	0.802	23.417	0.000
	Market Structure Factors		0.498	0.026	0.498	15.871	0.000
	Technical Capacity Factors		0.401	0.026	0.401	12.345	0.000
	Government Policy Factors		0.235	0.027	0.235	5.248	0.000

102.5 Conclusions and Implications

This article empirically studies influence factors of technological innovation cooperation performance between resource-based enterprises and results of related theoretical hypothesis can be summarized in the Table 102.4.

As shown in the Table 102.4, the results of empirical study that factors' influence on technological innovation cooperation performance can be made as follows.

Table 102.4 Inspection results of hypothesis of influence factors of technological innovation cooperation motivate between resource-based enterprises

Hypothesis	Content	Inspection results
H1	Cooperation relationship has a great influence on the technological innovation cooperation performance between resource-based enterprises.	pass
H2	Market structure factor has a great influence on the technological innovation cooperation performance between resource-based enterprises.	pass
H3	Natural resources factor has a great influence on the technological innovation cooperation performance between resource-based enterprises.	pass
H4	Technical capacity factor has a great influence on the technological innovation cooperation performance between resource-based enterprises.	pass
H5	Government policy factor has a great influence on the technological innovation cooperation performance between resource-based enterprises.	pass

102.5.1 Main Conclusions

- Theory hypothesis H1: The hypothesis that cooperation relationship has a great influence on technological innovation cooperation performance between resource-based enterprises can be supported.
- Theory hypothesis H2: The hypothesis that market structure factor has a great influence on technological innovation cooperation performance between resource-based enterprises can be supported.
- Theory hypothesis H3: The Hypothesis that natural resources factor has a great influence on technological innovation cooperation performance between resource-based enterprises can be supported.
- Theory hypothesis H4: Technical capacity factor has a great influence on technological innovation cooperation performance between resource-based enterprises, which can also be supported.
- Theoretical hypothesis H5: The hypothesis that government policy factors have a great effect on technological innovation cooperation performance between resource-based enterprises can be supported.

102.5.2 Management Implications

(1) Positive technological innovation cooperation relationship is key to successful innovation

The analysis in this article shows there is different cooperation performance for different types of technological innovation cooperation relationship orientation. The "positivity" of technological innovation cooperation refers to cooperative intentions and equal relationship showed in the cooperation by both sides. The more real and stronger the cooperation intentions are, the more equal the position is and the more beneficial the development of innovation activity will be. Even though there is a deep gap in enterprises' scale, technology and resources between both sides, it is necessary to keep friendly cooperation attitude and equal cooperation relationship to achieve better cooperation performance. In the technological innovation cooperation practice of resource-based enterprises, the "positivity" of cooperation relationship orientation sometimes can be treated as "fraudulence" in strategies. Being friendly outwardly help one side with strategic aims to gain the other side's trust, and then realize its strategic intent to control partners through technological innovation cooperation.

(2) Creating good internal and external conditions, and improving technological innovation cooperation performance between enterprises

There is positively correlativity of technological innovation cooperation performance between resource-based enterprises and natural resources factor, technical capacity factor and government policy factor, which shows that resource-based enterprises can improve technological innovation cooperation performance through creating enterprises' good internal and external conditions. Resource-based enterprises should obtain better natural resources condition and cultivate enterprises' resource advantage through scientific, reasonable and sustainable development. Thus, enterprises can take a dominate position in technological innovation cooperation between enterprises and take a lead in innovation sharing.

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Chapter 103
Determinants of Gold Prices in Pakistan

Asif Kamran, Shumaila Israr and S. M. Ahsan Rizvi

Abstract Gold has been valued as the most excellent used expensive metal not only due to its usage in ornaments; Gold is well thought-out one of the most valuable metals in the world. The relationship of gold prices with many variables is well discussed in this research study. In this research paper we have to look into the empirical studies and theoretical frame work to identify the explanatory variables that have significant effect on the gold prices. We are including the rate of inflation in the pricing model as gold is considered to be a hedge against inflation. This paper has quoted few studies that relate stock prices and gold prices for the U.S., Australia and India. In this research paper the price of gold is defined as a function of inflation, Interest rate, Exchange Rate of US Dollar with Pakistani Rupee, Stock Market Performance, price of silver, per capita income and domestic savings. The reason for holding gold is guided by the individual sentiments. Like other developed countries, investment in stock market is not very common in Pakistan. Most of the people consider gold as the safe investment as the price of gold continues to increase.

Keywords Gold price (G.P.) · Inflation (INF) · Interest rates (INT) · Foreign exchange rate (FOREX) · Stock market performance (SMP) · The price of silver (SP) · Domestic savings (DS) · Per capita income (PCI)

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103.1 Introduction

Gold is considered one of the most precious metals in the world. In Pakistan, gold is also considered a precious commodity. It is treated as a commodity possessed by the rich. Normally the gold is used as jewellery. It can also be used for investment purpose and industrial purpose. From Table 103.5 [10], we can see that the demand for gold in Pakistan is the second highest as compared to other developed and developing nations. Demand for jewellery is the main driver for the demand of gold. This demand increases specially in the seasons of festivals and marriages as in Pakistan no wedding ceremony is completed without gold jewellery. Gold is considered as the most credible way of asset a saving for a rainy day.

This research paper is trying to explore the factors on which the price of gold is dependant that is the determinants of the gold prices in Pakistan. We have to look into the empirical studies and theoretical frame work to identify the explanatory variables that have considerable effect on the prices of gold.

103.1.1 Review of Literature

The gold price relationship with different variables is well discussed in the local and international research studies. Ghosh et al [1] studied monthly gold price data covering a period of 1976 to 1999 using co integration regression techniques. In this study gold can be considered as a long run inflation hedge. The study show that the movement of the nominal price of gold which is dominated by short run influences. Abken [2] examined the relationship between the gold prices and 1-month U.S. Treasury bill yields. As per Tandon and Urich [3] reported significant impacts of unexpected components of the U.S. Money Supply and Producer Price Index (PPI) announcement on a daily basis gold prices. On the other hand Sjaastad and Scacciavillani [4] reported that floating exchange rates along with the main currency have been a most important resource of price unsteadiness in the world gold market. In particular, the positive reception or decrease of European currencies has a strong effect on the price of gold in other countries. McDonald and Solnik [5] have proved based on correlations that gold bullion is an inflation hedge in the long run and also a general hedge of equity investment. Cai et al [6] are inspect the collision of 23 frequently released macroeconomic declaration in the United States and they found that the only four have significant effects on the volatility of the gold market.

On the other hands employment reports turn out to be the mainly vital announcement for the gold market, which was followed by GDP, CPI, and personal income. They have also give proof on the incremental explanatory power of the announcement effects at together the daily and intra-day frequencies. Overall, macroeconomic announcements have a lesser collision on the gold market than on the Treasury bond or foreign exchange markets.

103.1.2 Modelling for Determination of Price

Koutsoyiannis [7] has developed a dynamic model for the determination of the price of a speculative financial asset or durable speculative commodity in the very short run. This model were tested gold bullion and in this model included the US rate of inflation, prevailing US interest rates, substitutes demand that is silver and stocks and strength of the US dollar. On the other hands in this model Qualitative factor also play a important roll just like political instability. Koutsoyiannis [7] developed a Pricing model which is related to Gold markets. In this model they determinants of the gold pricing in the short run. In this model two factors are involve that is economic factors and non-economic factors. We have taken the year-end exchange rate of US dollar to Pakistani Rupee to incorporate the effect of the US economic changes in the pricing model.

The rate of interest as discussed earlier has a significant relationship with the price of gold. A change in the interest rate induces speculators to make changes in their portfolios [7]. So the expected rate of interest has been included in the model. We have included the rate of inflation in the pricing model as gold is considered to be the hedge against inflation. Table 103.3 the correlation matrix indicates the correlation coefficient of inflation against gold prices is very low at 0.049771. So when prices increase, people are expected to increase their demand resulting in increase in gold prices. Silver is perhaps the closest alternative for gold as a tentative investment in expensive metals. The correlation coefficient of gold and silver prices for the period of study as calculated is 0.983914 (Table 103.3 the correlation matrix). This is very high. Also the price of 10 gms of Silver is far less than that of Gold. Also it has more industrial uses than gold. This assumption is similar to Koutsoyiannis [7].

This paper has already quoted few studies that relate stock prices and gold prices for the U.S., Australia and India. These studies have proved that gold provides a good alternative to stocks Jaffe [8]. It can be used to diversify the portfolio too. Therefore, we have included the stock market performance in the form of aggregate market capitalization.

103.1.3 Data

The data (Table 103.1) for the study has been taken from published resources of State Bank of Pakistan, Economic surveys, Website of Karachi Stock Exchange, and ministry of finance. The prices of gold and silver are measured in Pakistani Rupees per 10 gms. The weighted average rate of returns on deposits is used for interest rate calculation. Growth rate of CPI is taken as inflation rate. The year-end exchange rate of US dollar to Pakistani Rupee is taken in foreign exchange rate. To incorporate the Stock Market Performance, aggregate Market Capitalization is taken. Per capita income at constant factor cost is included.

Table 103.1 Data

Year	Average gold prices in Pakistan	$X1$ (%)	$X2$ (%)	$X3$	$X4$	$X5$ Domestic saving at current/GDP at current factor cost	$X6$ Average silver prices in Pakistan	$X7$ (Million RS) at constant factor cost
Years	GP	INT	INF	FOREX	SMP	DS	SP	PCI
1980	1450.5	6.21	10.7	9.9	6701.2	616.02942	46.5	675
1981	1932	6.38	12.4	9.9	6583	903.02889	46	3227
1982	1571	6.48	11.1	9.9078	9379.9	876.88758	29	3349
1983	1811.5	6.18	4.7	12.7063	13326.5	903.52564	38.5	3564
1984	1936.5	6.18	7.3	13.4838	19647.4	882.51774	43.5	3566
1985	1805.5	9.16	5.7	15.1512	21953.5	803.99434	35.5	3701
1986	1958.5	8.14	4.4	16.1391	24422.4	1194.0718	34.5	3824
1987	2552.5	8.05	3.6	17.1793	31617.1	1988.1334	38.5	3860
1988	3030.5	7.28	6.3	17.5994	38151.4	1936.8502	50	3877
1989	2877	8.59	10.4	19.2154	43934.9	2239.9833	53	3913
1990	2961	10.66	6	21.4453	48626.4	2223.1739	52.5	3984
1991	3068	6	12.7	22.4228	68438.9	3016.1652	47.5	4003
1992	3131	6.38	10.6	24.8441	218357.2	4255.7266	42	4137
1993	3136	6.4	9.8	25.9598	214428.7	3463.4722	42	4097
1994	3983.5	6.37	11.3	30.1638	404578.3	4328.4432	55.5	4138
1995	4558	6.35	13	30.8517	293326.8	4076.6799	64.5	4458
1996	4531.5	6.62	10.8	33.5684	368213.8	3671.3715	67	4588
1997	4949.5	6.38	11.8	38.9936	469595.9	3891.3944	71.5	4535
1998	4493.5	6.69	7.8	43.1958	259284.7	4889.0795	79	4575
1999	5087	5.83	5.7	46.7904	286220.3	4095.8469	88.5	4662
2000	4981.5	5.39	3.6	51.7709	391860.3	6764.3767	89.5	25244
2001	5368	4.33	4.4	58.4378	339249.5	7400.28	92	25270
2002	5631.5	3.35	3.5	61.4258	407637.7	7696.5038	92	26041
2003	6388	1.13	3.1	58.4995	746434.5	7966.2857	92	27339
2004	7332.5	0.95	4.6	57.5745	1357475.2	7939.622	101.5	28234
2005	8227	1.86	9.3	59.3576	2013202.6	8212.2069	128	30695
2006	10312	2.53	7.9	59.8566	2766407	9114.0839	178	31826
2007	12611	2.66	7.8	60.6342	3980783.4	9511.729	229.5	33345
2008	16665	4.38	12	62.5465	3744124.7	7324.2039	306	33973
2009	22185.5	4.29	20.8	78.4983		6674.0999	329.5	33233

103.1.4 Model/Methodology

Subject to the above the price of gold is defined as a function of inflation, Interest rate, Exchange Rate of US Dollar with Pakistani Rupee, Stock Market Performance, price of silver, per capita income and domestic savings.

Gold Price (GP) = $f\{$Inflation (INF), Interest Rates (INT), Foreign Exchange Rate (FOREX), Stock Market Performance (SMP), the Price of Silver (SP), Domestic savings (DS), Per capita income (PCI)$\}$,

$$\text{GP} = f(\text{INT} + \text{INF} + \text{FOREX} + \text{SMP} + \text{SP} + \text{DS} + \text{PCI}).$$

The model has been tested for the period of 1980 to 2009. The actual model is as follows:

$$\begin{aligned}
\text{GP} = {} & \beta_0 + \beta_1\text{INT} + \beta_2\text{INF} + \beta_3\text{FER} + \beta_4\text{LOG(SMP)} + \beta_5\text{LOG(SP)} \\
& + \beta_6\text{LOG(DS)} + \beta_7\text{LOG(PCI)} + Ui, \\
\text{GP} = {} & -26864.6 + 46.65592\text{INT} + 47.33219\text{INF} - 79.7684\text{FER} \\
& + 1013.653\text{LOG (SMP)} + 5439.419\text{LOG (SP)} - 1378.48 \text{ LOG (DS)} \\
& + 1112.745\text{LOG (PCI)}.
\end{aligned}$$

103.1.5 Results

The results of the model are according to the expectations. The variables – per capita income, stock market performance, and silver prices are significance at 5% level of significance except for the variables domestic savings, and foreign exchange rate, which attain significance at 10% level. Inflation and interest rate are identified to be insignificant. The positive sign of the coefficient of Inflation is indicating that inflation and gold prices share a positive relationship.

103.2 Economic Evaluation of the Results

Table 103.2 that is the regression results one of the most important tables that indicate the results of the dependant and independent variables. Each independent variable and the opposite *t* value indicates whether variable is significantly contributing to the equation for predicting the Gold prices from the whole set of predictors [9]. We shall discuss the results for each variable separately.

- Inflation Rate turns out to be insignificant. The beta coefficient of inflation rate is 47.33 (Table 103.2) indicating a 47% impact on gold prices is explained by the inflation rate.
- Interest Rate is also insignificant. Correlation coefficient of interest rate is −0.636 (Table 103.3). This negative relationship indicates that rising interest rates make investors to switch their investments from gold to other interest bearing securities.
- Foreign Exchange Rate has attained significance at 10% level of significance (Table 103.4). The exchange rate has a positive impact on the gold prices.
- Stock Market Performance has turned out to be statistically significant at 5% level of significance (Table 103.4).

- Silver Price is also statistically significant at 5% level of significance (Table 103.4). Silver is considered as the alternative of investment in gold. The price of silver compared to gold is very low. It has more uses as compared to gold.
- Domestic Savings is another variable which has attained significance at 10% level of significance (Table 103.4). It has negative coefficient, indicating a negative effect on the gold prices.
- Per Capita Income is the last variable included in the model which is statistically significant at 5% level of significance (Table 103.4). The coefficient is positive indicating that the per capita income has a positive effect on the price of gold.

Table 103.2 Descriptive statistics

	GP	DS	FOREX	INF	INT	PCI	SMP	SP
I	4770.379	4213.299	34.12143	8.010345	5.755517	11679.31	641171.1	80.46552
II	3983.5	3891.394	30.1638	7.8	6.35	4138	259284.7	55.5
III	16665	9511.729	62.5465	13	10.66	33973	3980783	306
IV	1450.5	616.0294	9.9	3.1	0.95	675	6583	29
V	3498.615	2886.116	19.32412	3.269813	2.32641	12059.43	1091293	61.96297
VI	1.838383	0.386458	0.27	−0.01551	−0.40071	0.883855	2.139594	2.289638
VII	6.316591	1.789089	1.486405	1.545247	2.914731	1.907024	6.341502	8.057388
VIII	29.62638	2.493644	3.120607	2.558368	0.78486	5.219266	35.61814	56.24422
IX	0	0.287417	0.210072	0.278264	0.675414	0.073562	0	0
X	138341	122185.7	989.5214	232.3	166.91	338700	18593963	2333.5
XI	$3.43E+08$	$2.33E+08$	$1.05E+04$	299.3669	151.5411	$4.07E+09$	$3.33E+13$	107503.5
XII	29	29	29	29	29	29	29	29

Note: I: Mean; II: Median; III: Maximum; IV: Minimum; V: Std. Dev.; VI: Skewness; VII: Kurtosis; VIII: Jarque-Bera; IX: Probability; X: Sum; XI: Sum Sq. Dev.; XII: Observations.

Table 103.3 Correlation matrix

	GP	DS	FOREX	INF	INT	PCI	SMP	SP
GP	1	0.812244	0.815983	0.049771	−0.63642	0.836702	0.950006	0.983914
DS	0.812244	1	0.968354	−0.20007	−0.81738	0.913382	0.732476	0.736904
FOREX	0.815983	0.968354	1	−0.25274	−0.77737	0.890548	0.688756	0.74818
INF	0.049771	−0.20007	−0.25274	1	0.153654	−0.2968	0.091503	0.060569
INT	−0.63642	−0.81738	−0.77737	0.153654	1	−0.82045	−0.61302	−0.57012
PCI	0.836702	0.913382	0.890548	−0.2968	−0.82045	1	0.794563	0.80296
SMP	0.950006	0.732476	0.688756	0.091503	−0.61302	0.794563	1	0.951864
SP	0.983914	0.736904	0.74818	0.060569	−0.57012	0.80296	0.951864	1

Regression Equation: LS (GP) C LOG(DS) (FOREX) LOG(PCI) LOG(SMP) LOG(SP) INF INT

It is important to note that all the variables are being considered together when these values are computed. Therefore, if one of the insignificant predictor is dropped from the equation, it can affect the levels of significance for other predictors. "Adjusted R Square, the coefficient of determination, is the squared value of the multiple correlation coefficients". The model is able to explain approximately 95% variation in gold prices as the adjusted R^2 is 0.948 (Table 103.4) meaning that 94.8% of the

Table 103.4 Regression result

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	−26864.62	5129.164	−5.237621	0
LOG(DS)	−1378.476	738.0871	−1.867633	0.0758
FOREX	−79.7684	41.45195	−1.924358	0.068
LOG(PCI)	1112.745	386.9913	2.875374	0.0091
LOG(SMP)	1013.653	322.8408	3.139791	0.0049
LOG(SP)	5439.419	797.131	6.823745	0
INF	47.33219	68.75078	0.68846	0.4987
INT	46.65592	113.8055	0.409962	0.686
R-squared	0.961477	Mean dependent var		4770.379
Adjusted R-squared	0.948636	S.D. dependent var		4770.379
S.E. of regression	0.948636	Akaike info criterion		16.41825
Sum squared resid	13202869	Schwarz criterion		16.79544
Log likelihood	−230.0646	F-statistic		74.87596
Durbin-Watson stat	1.467431	Prob(F-statistic)		0.000000

Dependent Variable: GP; Method: Least Squares; Date:12/19/11 Time:14:44;
Sample (adjusted):1980 2008; Included observations: 29 after adjustments.

variation in gold prices can be predicted from inflation, Interest rate, Exchange Rate of US Dollar with Pakistani Rupee, Stock Market Performance, price of silver, per capita income and domestic savings combined.

The value of the F statistics (0.0000) is less than 0.01 (see Table 103.4), which indicates that variation explained by the model is statistically significant. It means that the model is overall significant. This shows the combination of the predictors significantly predict gold prices.

103.2.1 Economic Significance

Price of Gold represents the strength of the economy. High prices of gold depicts that the economy is not healthy. Investors prefer to invest in gold when they want to protect their investment from inflation or crisis. Decrease in gold prices indicates the healthy economy. It happens when investors prefer to invest in other investment options like stocks, bonds, real state etc rather than gold. People invest in gold to make up for stock market declines, hedge against inflation and counteract a declining dollar. That is why gold is often considered a safe investment [10].

Gold is used in very small quantities in electronic gadgets like computers and cell phones. It is also used in utensils, but again in very small quantities that the changes in the gold prices have a little impact on this economic sector.

Mining sector is the industry which can be affected directly with the fluctuations in the gold prices. Because gold miners generate their profit by selling gold, their profit margins are largely determined by the prevailing market value of the commodity. In past decades, miners used hedging in futures market to generate some

Table 103.5 Gold: consumer demand (tonnes) 1996-2002

	1996	1997	1998	1999	2000	2001
Gold price ($/oz)	387.9	331.3	294.1	278.6	279.1	271.1
India	511.2	688	774.4	730.7	723	726.7
Pakistan	52.2	78.1	54.8	67	58.1	49
Greater China	431	529.6	367.3	308.7	292.6	269.7
China	297.5	373.9	279.3	225	212.5	205.6
Hong Kong	40.3	62.9	22.6	17.6	23	21.6
Taiwan	93.2	92.8	65.4	66.1	57.1	42.5
Japan	126.9	109	109.6	160.5	105.1	113.9
Korea	58.5	82.2	5.5	66.1	69.7	67.8
SE Asia	296.5	218.3	63.2	243.8	251.4	264.3
Indonesia	124	102.5	19	120.8	95.2	106.3
Thailand	83	23.9	−24	40.8	65.4	64.7
Vietnam	42.8	46.5	42	49.3	55	57.6
Malaysia	26.2	22.6	15.6	21.6	232	23.5
Singapore	20.5	22.8	10.6	11.3	126	12.2
Middle East	360.3	502.7	464.1	459.1	455.5	438.2
Saudi Arabia	181.7	249.6	194.8	173.2	173.8	165.4
Egypt	75.8	138.4	135.8	138.9	129.9	117.4
Gulf States	102.8	114.7	133.5	147	151.8	155.4
UAE	50.1	46.9	59.9	82	96	97.6
Kuwait	31.8	37.7	42.8	34.5	27.2	28.6
Other	20.9	30.1	30.8	30.5	28.6	29.2
Turkey	137.2	169.9	160.4	113.9	177.4	114.1
Americas	378.2	461.8	528.3	554.4	473.1	510.6
USA	307	371.1	431.8	461.1	368.5	412.9
Mexico	30.5	35	40.2	52.6	60.4	57.2
Brazil	40.7	55.7	56.3	40.7	44.2	40.5
Europe	244.7	273.3	263.4	208.9	142.1	274.9
Italy**	106.3	113.1	112.4	100.7	92	91.2
UK**	43.5	54.2	63.7	65	75	81.9
France	13.2	19.8	29.1	32.4	19	30.3
Germany	89.6	92.4	74.5	41.9	15.6	61.3
Other invest	−7.9	−6.2	−16.3	−31.1	−59.5	10.2
world*	**3103.7**	**3765.1**	**34448.5**	**3508.2**	**3335.5**	**3403.4**

*Including non-specified countries. **Jewellery only.
Figures may not sum to totals due to rounding. Source: World Gold Council (http://www.gold.org).

stability and transparency, but that practice largely ended as the volatility of gold and its rising price made it unprofitable to do so [11].

103.3 Conclusions

In this research, the determinants of gold prices in Pakistan have been studied. We have used multiple regression model to estimate gold prices using inflation rate, Interest rate, Exchange Rate of US Dollar with Pakistani Rupee, Stock Market Performance, price of silver, per capita income and domestic savings. The model is able to explain the movement of the gold price as 94.8% variation in gold prices is explained by the variables included in the model. The change in gold prices is effected to large extent by the prices of silver which is considered as the close substitute. The other variables like per capita income and stock market performance are also affecting the prices of gold. Domestic savings and foreign exchange has a negative effect on the gold prices.

It is important to note that all the variables are being considered together when these values are computed. Therefore, if one of the insignificant predictor is dropped from the equation, it can affect the levels of significance for other predictors.

The reason for holding gold is guided by the individual sentiments. Like other developed countries, investment in stock market is not very common in Pakistan. Most of the people consider gold as the safe investment as the price of gold continues to increase. Gold has not lost its importance as a hedge against loss of wealth in times of crises.

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Chapter 104
A Dynamic Optimal Management on Economic Energy Efficiency in Developing Countries

Dong Wang and Kan Tao

Abstract This paper is based on the dynamic optimization methodology to investigate the economic energy efficiency issues in developing countries. The paper introduces some definitions about energy efficiency both in economics and physics, and establishes a quantitative way for measuring the economic energy efficiency. The linkage among economic energy efficiency, energy consumption and other macroeconomic variables is demonstrated primarily. Using the methodology of dynamic optimization, a maximum problem of economic energy efficiency over time, which is subjected to the extended Solow growth model and instantaneous investment rate, is modeled. In this model, the energy consumption is set as a control variable and the capital is regarded as a state variable. The analytic solutions can be derived and the diagrammatic analysis provides saddle-point equilibrium. A numerical simulation is also presented; meanwhile, the optimal paths of investment and energy consumption can be drawn. The dynamic optimization encourages governments in developing countries to pursue higher economic energy efficiency by controlling the energy consumption and regulating the investment state as it can conserve energy without influencing the achievement of steady state in terms of Solow model. If that, a sustainable development will be achieved.

Keywords Economic energy efficiency · Dynamic optimization · Energy consumption · Investment

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104.1 Introduction

Social planners and policymakers have been attracted by dynamic optimization issues for many years. Although a large quantity of researches have discussed on the optimal path of economic growth, energy consumption or pollution reduction, seldom economists have set their feet in the energy efficiency issues under the view of dynamic. In fact, the improvement of energy efficiency is a dynamic procedure in the development and it is always related to growth, investment, technology change and many other economic variables.

Energy efficiency can be defined in three dimensions. The first definition stems from the laws of thermodynamics in physics. It is defined as a ratio of best practice energy input over energy input, ceteris paribus, which refers to technical efficiency[1] by Jin and Arons [1], and cannot be greater than one. The second definition is based on economic concepts and named energy intensity[2], which is the ratio of energy input over aggregate output [2]. However, this definition only considers energy as a unique input with ignoring the other factors in the production such as capital and labor. David Stern [3] has developed this definition of economic energy efficiency under the multi-input framework. In his work, the economic technical efficiency is on the basis of Pareto principle and is associated with capital as another input. He stated that any economy has two inputs for production: the one is energy and the other is capital. People should utilize the input composition to attain the goal of output and growth. Thus, by this argument, there must be an optimal solution about the input combination in development, which can be seen as the economic energy efficiency. The things people need to do are to make the economy operating under the best energy efficiency condition. In this paper, I adapt the meaning of energy efficiency is based on the Stern's definition. In other words, I consider how to allocate and utilize energy and capital as two inputs efficiently for achieving the desired output and growth in development.

Apparently, advanced technology applications can increase energy efficiency. Besides that, the underlying drivers are capital, human resources and even energy itself. Firstly, increasing the quantity of investment and skilled labor can promote energy technology whether in exploitation or utilization, thereby increasing energy efficiency; secondly, different types of energy have different potential for energy efficiency promotion, as the modern energy contains more energy[3], meaning that higher energy efficiency could be achieved if people use more modern energy [4]. However, the transition from conventional energy to modern energy results from the increases of income, which is referred by 'energy ladder' theory. In other words, the modern energy consumption in developing countries also needs sufficient capital accumulation and adequate economic growth. Hence, the improvement of energy

[1] The thermodynamic definition of the energy efficiency η is $\eta = \frac{{W_{in}}^{min}}{{W_{in}}^{real}} \leq 1$.

[2] Energy intensity $= \frac{E}{Y}$ Where E is energy input and Y is total output of the society.

[3] Energy is available energy, which is the maximum useful work possible during a process that brings the system into equilibrium with a heat reservoir [4].

efficiency is interlinked with capital stock, investment capacity, labor force quality and economic growth stages.

This concept is of importance and inspiration on both theory and practice. In theory, if we can model the dynamic optimization of energy efficiency improvement linking with energy consumption and economic growth, we can introduce energy efficiency into traditional 'energy-economy-environment (3E)' analysis. In practice, the modeling could reveal the best choice of energy policy for developing countries on how to enhance energy efficiency given the limited capital stock and investment and achieve their goals of development.

The purpose of this paper is to model the dynamic optimization of energy efficiency improvement in development given the investment movement and production function. Firstly, a function is established for measuring the level of energy efficiency. Secondly, Solow growth is extended by adding energy consumption and deriving the instantaneous state of investment. Lastly, the steady-state solution can be solved by dynamic optimization method and furthermore, we can get the optimal path of energy consumption and investments under the condition of maximum energy efficiency over the periods in development. The paper is organized by five parts. The introduction is presented in Sect. 104.1, and then the methodology is introduced in the Sect. 104.2. Results and a numerical simulation are presented in the Sect. 104.3 followed by some discussions in the Sect. 104.4. The conclusion is arranged at the end of the paper.

104.2 Methodology

104.2.1 The Meaning of Economic Energy Efficiency

The economic energy efficiency is linked with energy itself and capital. Thus, economic energy efficiency can be defined as a function of capital stock and energy consumption under the multi-input framework. Denote economic energy efficiency is W, energy consumption is E and capital stock level is K. The basic mathematical expression on economic energy efficiency is $W = W(E,K)$.

Obviously, economic energy efficiency depends on energy use. For any given level of output, the more energy we use, the less economic energy efficiency is. The reasons that we encompass capital in the model can be explained from the views of stock and flow angles. For one thing, the level of capital stock determines the level of development and technology, which is the foundation in economic energy efficiency improvement. For another thing, the level of capital stock is directly associated with investment, which is the key driver of economic growth and technology progress in developing countries. Thus, capital is tightly related with the economic energy efficiency. In this model, technology is assumed exogenous and it is embodied by investment and capital stock level.

With energy and capital as two inputs, to some extent, economic energy efficiency is similar to production function. On the other hand, some certain levels of economic energy efficiency can be evaluated and compared with each other, similar to the methods used in the theory of ordinal utility. This definition is demonstrated geometrically in Fig. 104.1.

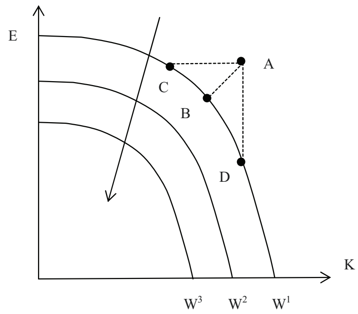

Fig. 104.1 The economic energy efficiency

In Fig. 104.1, the three curves represent three levels of economic energy efficiency with different input combination of capital and energy under the same output level. All points on the curves are efficient states. The direction of the arrow means the direction of increase of economic energy efficiency, implying that 'the less, the better' for inputs. Given the level of output, the less inputs use means the more efficient energy economic system is. W stands for economic energy efficiency, as a result, $W^3 > W^2 > W^1$.

The curves in Fig. 104.1 are concave rather than convex mainly because of diminishing marginal rate of substitution. That is how much capital input increase can substitute one unit of energy we reduce. It is similar to the production-possibility curve.

There are three ways can be used for increasing economic energy efficiency, which are demonstrated by both arrow and dotted line. A is on the right of curve W^1, meaning that A use more energy and capital relative to W^1, which is the most efficient level of the economic system indeed need given the output. So A is an inefficient point B, C and D on W^1 are all the efficient points. Now, we have three paths to haul the inefficient point A back to the efficient state W^1. The distances of AC, AB and AD are called energy distances; therefore the process of hauling A to curve W^1 is called diminishing the energy distance. If we reduce both energy and capital, we can get B; if we only reduce energy with holding capital input unchanged, we can get D; if we only reduce capital with holding energy input unchanged, we can get C.

The three curves W^1, W^2 and W^3 represents three scenarios when the economy achieves the best level of economic energy efficiency in different development stages separately. We assume that the most efficient level of economic energy efficiency is corresponding to the level of development directly. And the economy is developing all the time. That is to say, the capability that the economy can achieve the most energy efficiency given the level of development is increasing over time. To be more specific, at time t^1, the most economic energy efficient level is W^1 under the development level at t^1. And with time increasing, the economy approaches a higher level of development at time t^2, and it also can achieve the higher level of economic energy efficiency, say, W^2. Therefore, the economic energy efficiency is associated with development and time series.

The reason we set these assumptions is in the long term, the best economic energy efficiency is determined by the level of capital stock of the economy. While the capital stock stage determines the energy technology applications and different types of energy we use. And based on the neoclassical growth model, the capital level is increasing with the economic growth and development over time. In this paper, we consider the economic energy efficiency increase in the long term instead of at any certain time point. Put differently, we study the dynamic process that the economy climbing the economic energy efficiency curves along the direction of the arrow in Fig. 104.1 in the long time.

An equation for quantifying the level of economic energy efficiency W is:

$$W(K,E) = -E^2 - \alpha K, \quad \alpha > 0, \tag{104.1}$$

where W is the level of economic energy efficiency; K is capital stock and E is energy consumption. They are both inputs in Equation (104.1). Here, α is a parameter. The projection of W on the $E-K$ plane is a cluster of curves like Fig. 104.1.

104.2.2 The Extended Solow Model

As explained well in Sect. 104.2.1, the increase in economic energy efficiency is related to the development process which is from the view of Solow model. Thus, for linking energy with growth and capital, the neoclassical growth model should be extended and defined well before further discussion. Holding technology as an exogenous variable, Stern [5] developed the Solow model and discussed the role of energy in growth. However, his model is so complicated that it cannot be solved in mathematics. In this paper, we provide a simple extended model as follow.

$$Y = (1-\gamma)K^{\beta}L^{1-\beta} + \gamma E, \; 0 < \gamma < 1, \; 0 < \beta < 1. \tag{104.2}$$

Equation (104.2) embeds Solow model, which is a Cobb-Douglas function of value added, with adding energy (E), which produces gross output Y. The term of $K^{\beta}L^{(1-\beta)}$ is the traditional component of Solow model with capital (K) and labor (L). β and γ are parameters. γ reflects the relative importance of energy and Solow value added. Besides, we can get an equation on instantaneous investment state which reveals capital flow.

$$\dot{K} = s(Y-E) - \delta K, \; 0 < s < 1, \; 0 < \delta < 1, \tag{104.3}$$

where K is the growth rate of the capital stock which refers to investment. s is the rate of saving. The capital depreciates at a constant rate δ. The term $(Y-E)$ is different from Solow model. It implies that, under the energy constraint, the true accumulated capital should be adjusted by energy consumption. Hence, the instantaneous increment of capital is the proportion of gross output with subtracting the depreciation of capital stock from the net accumulative capital.

104.2.3 The Maximum Dynamic Problem

For a developing economy, in its developing periods, we can sum up all the levels of economic energy efficiency and maximize the value by the methodology of dynamic optimization which is raised by Pindyck [6, 7]. Under the assumption that different time points is associate with different levels of economic energy efficiency which is increasing over time. The maximum problem is over the whole development period T.

Modeling on the maximum dynamic problem of economic energy efficiency under the growth and energy constraints is expressed mathematically as follow.

$$\begin{aligned} &\max \int_0^T W(K,E)\mathrm{d}t, \\ &\text{s.t.} \begin{cases} Y = (1-\gamma)K^{\beta}L^{1-\beta} + \gamma E, \\ \dot{K} = s(Y-E) - \delta K, \\ K(0) = K_0 \quad K(T) \quad \text{Free.} \end{cases} \end{aligned} \tag{104.4}$$

The Equations (104.2) and (104.3) are two constraints and Equation (104.3) is state equation. Accordingly, capital (K) is the state variable and energy (E) is the control variable. The Equation (104.4) does not include discounting rate in terms of the specific problem of economic energy efficiency. As mentioned above, the main meaning of the Function (104.1) is for indicating the degree of economic energy efficiency and for comparing different levels of efficiency. Thus, it has little meaning in discounting.

Concerning about the boundary condition [8], the initial value of the state variable is given by E_0, and the terminal value is free. T is the ending time and it is flexible or $T \to \infty$. In this free ending point problem, the transversality condition of Hamiltonian approach is

$$\mu(0) = 0, \ \mu(T) = 0. \tag{104.5}$$

Substituting Equation (104.2) into (104.3) and integrating them as one constraint, the Hamiltonian is given by:

$$\begin{aligned} H &= U(K,E) + \mu[s(Y-E) - \delta K] \\ &= -E^2 - \alpha K + \mu\left[s\left((1-\gamma)K^{\beta}L^{1-\beta} + \gamma E - E\right) - \delta K\right]. \end{aligned} \tag{104.6}$$

The first order condition is $\frac{\partial H}{\partial E} = 0, \ \dot{\mu} = -\frac{\partial H}{\partial K}, \ \dot{K} = s(Y-E) - \delta K.$

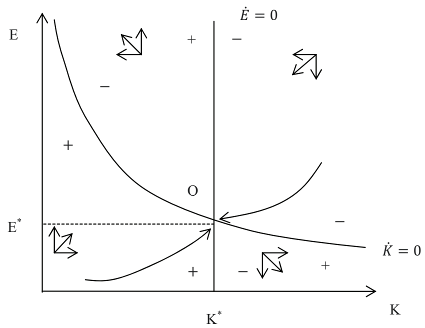

Fig. 104.2 The phrase-diagram analysis

104.3 Results

104.3.1 Diagrammatic Analysis

In this subsection, we use phrase-diagram to analyze the steady-state of this constrained problem (see Fig. 104.2). The purpose is to investigate whether the possible increase path of economic energy efficiency exists. Suppose that labor is constant, denoting $\bar{L}$. That is, during the observed years, the gross number of the labor force in the country should not change. Solving for the steady-state point, the first order condition can be rewritten as:

$$\frac{\partial H}{\partial E} = -2E + \mu\gamma - \mu = 0, \tag{104.7}$$

$$\dot{\mu} = -\frac{\partial H}{\partial K} = \alpha - \mu\beta s(1-\gamma)\bar{L}^{1-\beta}K^{\beta-1} + \mu\delta, \tag{104.8}$$

$$\dot{K} = s\left[(1-\gamma)K^{\beta}L^{1-\beta} + \gamma E - E\right] - \delta K = 0. \tag{104.9}$$

From Equation (104.7), we can get:

$$E = \frac{\mu}{2}(\gamma - 1). \tag{104.10}$$

The derivative of E is:

$$\dot{E} = \frac{(\gamma-1)}{2}\dot{\mu}. \tag{104.11}$$

Substitute Equation (104.8) into (104.11),

$$\dot{E} = \frac{(\gamma-1)}{2}\dot{\mu} = \frac{(\gamma-1)}{2}\left[\alpha - \mu\beta s(1-\gamma)\bar{L}^{1-\beta}K^{\beta-1} + \mu\delta\right] = 0. \tag{104.12}$$

From Equation (104.12), we can get the notation of K:

$$K=\left[\frac{\mu\beta s(1-\gamma)\bar{L}^{1-\beta}}{\alpha+\mu\delta}\right]^{\frac{1}{1-\beta}} \quad (\dot{E}=0 \text{ curve}). \tag{104.13}$$

Equation (104.13) is for $\dot{E}=0$ curve. It only depends on the parameters of the system and the scale of population. This is a constant in the $E-K$ space as illustrated in Fig. 104.3. Solving Equation (104.9), we can get the solution is:

$$E=\frac{\delta K}{(1-\gamma)}-\bar{L}^{1-\beta}K^{\beta} \quad \left(\dot{K}=0 \;\text{ curve}\right). \tag{104.14}$$

Equation (104.14) is for $\dot{K}=0$ curve as illustrated in Fig. 104.3. Consequently, the differential system of E and K in $E-K$ space is:

$$\dot{E}=\frac{(\gamma-1)}{2}(\alpha+\mu\delta)-\frac{(\gamma-1)}{2}\mu\beta s(1-\gamma)\bar{L}^{1-\beta}K^{\beta-1}, \tag{104.15}$$

$$\dot{K}=s(\gamma-1)E+s(1-\gamma)\bar{L}^{1-\beta}K^{\beta}-s\delta K. \tag{104.16}$$

The direction of movement depends on the signs of the derivatives $\dot{E}$ and $\dot{K}$ at particular point in the $E-K$ space. We can find by the differentiation from Equations (104.15) and (104.16).

$$\frac{\partial\dot{E}}{\partial K}=(\beta-1)\frac{(\gamma-1)^2}{2}\mu\beta s\bar{L}^{1-\beta}K^{\beta-2}<0, \tag{104.17}$$

$$\frac{\partial\dot{K}}{\partial E}=s(\gamma-1)<0. \tag{104.18}$$

The negative sign of Equation (104.17) implies that with K increasing, $\dot{E}$ should be decreasing. The negative sign of Equation (104.18) implies that with E increasing, $\dot{K}$ should be decreasing. The directions are denoted in Fig. 104.3 followed by drawing the possible path of their movement. The phrase-diagram analysis indicates that the equilibrium point Q is a saddle point. The mathematical solution is derived from Equations (104.13) and (104.14). Thus, the steady-state is:

$$\begin{cases} K^*=\left[\frac{\mu\beta s(1-\gamma)\bar{L}^{1-\beta}}{\alpha+\mu\delta}\right]^{\frac{1}{1-\beta}}, \\ E^*=\frac{\delta}{(1-\gamma)}\left[\frac{\mu\beta s(1-\gamma)\bar{L}^{1-\beta}}{\alpha+\mu\delta}\right]^{\frac{1}{1-\beta}}-\bar{L}^{1-\beta}\left[\frac{\mu\beta s(1-\gamma)\bar{L}^{1-\beta}}{\alpha+\mu\delta}\right]^{\frac{\beta}{1-\beta}}. \end{cases}$$

104.3.2 The Solutions of Dynamic Optimal Path

Firstly, we solve the co-state variable μ, from the Equation (104.8) and calculate the integral of $\dot{\mu}$ for time t. The Equation (104.8) can be rearranged as a regular linear differential equation of first order.

$$\dot{\mu} - \left[\delta - \beta s(1-\gamma)\bar{L}^{1-\beta} K^{\beta-1}\right] \mu = \alpha.$$

So, the analytic solution of μ is:

$$\mu(t) = e^{\int [\delta - \beta s(1-\gamma)\bar{L}^{1-\beta} K^{\beta-1}] dt} \left[C + \int \alpha e^{\int [\delta - \beta s(1-\gamma)\bar{L}^{1-\beta} K^{\beta-1}] dt} dt\right].$$

Combining with the transersality condition in Equation (104.5), we can get the particular solution is:

$$\mu(t) = \frac{\alpha}{[\delta - \beta s(1-\gamma)\bar{L}^{1-\beta} K^{\beta-1}]} e^{[\delta - \beta s(1-\gamma)\bar{L}^{1-\beta} K^{\beta-1}]t} \left[1 - e^{-[\delta - \beta s(1-\gamma)\bar{L}^{1-\beta} K^{\beta-1}]t+1}\right].$$

For simplicity, Let $\delta - \beta s(1-\gamma)\bar{L}^{1-\beta} K^{\beta-1} = A$, the solution of $\mu(t)$ can be simplified as:

$$\mu(t) = \frac{\alpha}{A} e^{At} \left[1 - e^{-(At+1)}\right]. \tag{104.19}$$

Secondly, the state variable K can be solved by substituting the Equation (104.19) into (104.13). The optimal time path of the capital stock optimal capital path is:

$$K = \left[\frac{\beta s e^{At}\left(1 - e^{-(At+1)}\right)(1-\gamma)\bar{L}^{1-\beta}}{A + \delta e^{At}\left(1 - e^{-(At+1)}\right)}\right]^{\frac{1}{1-\beta}}. \tag{104.20}$$

Furthermore, we substitute Equation (104.19) into (104.10) for solving the optimal path of control variable E.

$$E = \frac{\alpha(\gamma - 1)}{2} e^{At} \left[1 - e^{-(At+1)}\right]. \tag{104.21}$$

Note that Equations (104.20) and (104.21), in Equation (104.20), K does not depend on α, which is the parameter of capital in energy efficiency function (104.1). That is to say, whatever how important capital is in determining the energy efficiency, it cannot affect the optimal path of capital stock. While in Equation (104.21), α is a crucial multiplier in determining optimal energy consumption. That is, if capital plays an important role in energy efficiency, it will have a great influence on the optimal energy consumption given the maximum energy efficiency.

104.3.3 Simulation: A Numerical Example

In this subsection, some numbers will be assigned on the parameters on the basis of common economic practical knowledge. And then, the optimal paths will be plotted in the graphs for further discussion. Suppose that $\alpha = 10$, $\beta = 0.3$, $\gamma = 0.2$, $\delta = 0.1$, $s = 0.6$, $\bar{L} = 50$. This is reasonable for many developing countries.

Consequently, the economic energy efficiency function is:

$$W = -E^2 - 10K.$$

Next, we will simulate the optimal paths of K and E. Note that usually, the capital stock $K \gg 0$. Given the numerical example, $A \approx \delta$. Hence, the function of K is:

$$K = \left(\frac{2.23e^t - 0.82}{0.1e^{0.1t} + 0.063} \right)^{-0.7}.$$

The curve is drawn in Fig. 104.3.

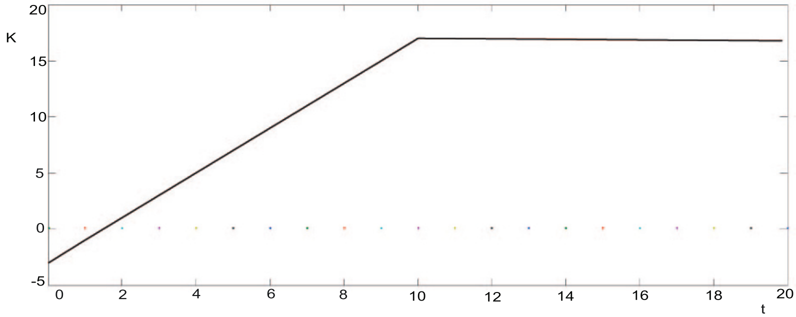

Fig. 104.3 The optimal path of capital stock

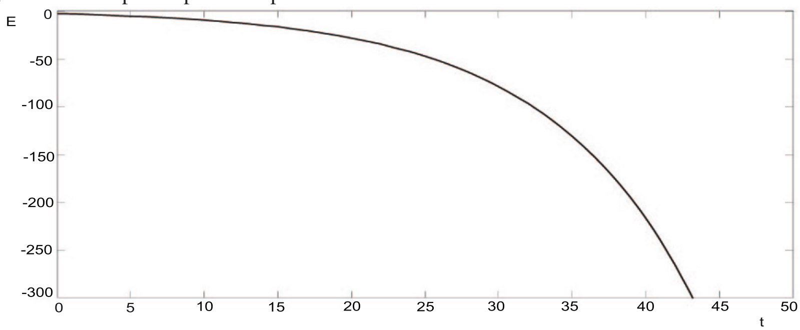

Fig. 104.4 The optimal path of energy consumption

As illustrated in Fig. 104.3, the path of capital stock increases at first, after ten periods, it will remain constant. On the side of energy consumption, the simulated function is:

$$E = -4e^{0.1t} + 1.47.$$

The path can be investigated in Fig. 104.4. As we can see, the energy consumption will always decline over time. Besides, its speed is slow at first but becomes more and more rapidly then. In theory, the curve in Fig. 104.4 can be zero. That is, the energy consumption is zero in the economy. In this case, the economy approaches the maximum economic energy efficiency. In other words, we can get the output without energy as an input. In practice, this situation indicates that we find something as a kind of perfect substitution of energy.

104.4 Discussion

The modeling and results reveal some interesting and profound policy implications. Firstly, under the neoclassical growth mechanism and investment constraint, we can get the maximum of economic energy efficiency continuously. In this paper, technology progress is assumed exogenous and it is an underlying reason, which is associating with capital stock and development stage directly, for energy efficiency improvement in long-run. In other words, the effect of technology does not be reflected direct but is embodied by investment in this model. For achieving the maximum economic energy efficiency, the economy should run according to the optimal investment state by energy consumption being controlled. In reality, the quantity of energy consumption is relative easy to control for many developing countries; however, the investment is a fluctuant variable in many circumstances.

The second important implication is about the state of equilibrium. The saddle-point equilibrium reveals that there is the only stable branch to reach the target point Q. If the economy gets onto the unstable branch unfortunately, it could never reach the optimization. Thus, the ‘path choice’ problem is still vital for social planners in developing countries. Additionally, the phrase-diagram indicates that the increase in investment is accompanying with an increase in the rate of energy consumption reduction. The evidence is proved by Figs. 104.3 and 104.4 in the numerical simulation. That is to say, a persistent investment can reduce energy consumption as the same time as increasing energy efficiency. And to some extent, the accumulative investment may reflect some scale effect in energy conservation.

Lastly, we discuss the two transition paths of state variable and control variable. The result in Fig. 104.3 is in accord with the statement of Solow model. After the steady state, the capital stock will not increase. At this point, the rate of investment increase is equal to the rate of capital depreciation. In other words, even though energy consumption is included in Solow model, it does not change the basic conclusion of neoclassical growth model. On the other hand, the curve in Fig. 104.4 is also easy to understand. With the continuous improvement of energy efficiency, the amount of energy consumption is decreasing all the time. Initially, the rate of decline is small. But with the accumulation of capital, the rate of decline becomes more faster. As capital will not change over ten periods, technology which is resulted from capital accumulation would be a key factor for energy conservation after ten periods and have an effect in long-run. Thus, the shift of slope can be explained by the scale effect of technology.

104.5 Conclusions

The modeling on the dynamic optimization of economic energy efficiency demonstrates some implications and inspirations. In development, the economic energy efficiency is a factor which is linking with other macroeconomic variables. On one hand, industrialization and modernization lead to the appetite for energy. The improvement of economic energy efficiency is essential for utilizing and conserving energy effectively. On the other hand, the improvement of economic energy efficiency largely depends upon the capital stock, investment and technology, which are key drivers in development. Pursuing the maximum economic energy efficiency is not contradictory with investing and consuming energy. In contrast, they can be harmonized in the economic growth and development. This fact could help the developing countries realize a sustainable development.

Moreover, the modeling provides specific methods for approaching a better and sustainable development. As the extended Solow model works well, governments can regulate the quantity of energy consumption effectively and make the optimal state of investment at any time. As a result, the levels of best economic energy efficiency could be attained in succession; the capital stock will increase until reaching the steady level of the golden rule which is illustrated in Solow model; while the energy consumption will decline continuously. Eventually, the sustainable development can be achieved automatically and optimally.

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Chapter 105
Research on Partner Selection for Technology Innovation Alliance in Knowledge Perspective

Qifeng Wei and Xin Gu

Abstract Technology innovation alliance is such an effective mode to form the knowledge advantage from inter-organizational knowledge transfer. It is significant and difficult to select the right partner for the technology innovation alliance. We specifically use the entropy method to make a study on the partner selection issue of technology innovation alliance in knowledge perspective. Firstly, we establish an evaluation index system. And then, Index importance weight and entropy weight are combined to get the comprehensive weight of indexes, based on that, one comprehensive evaluation method is given. Finally, the example analysis shows the method is strongly operable.

Keywords Partner selection · Technology innovation alliance · Knowledge transfer · Entropy method

105.1 Introduction

In the knowledge economy times, one single enterprise is difficult to carry out innovative activities by using its own resources. In response to market changes, many firms have been increasingly willing to participate in strategic technology innovation alliance, even with their main competitors, this kind of increase is motivated by combining their respective strengths in the area of intellectual property as well as each company's complementary distinct core competencies, so as to respond to the growing needs of customers with quick turnaround time and cost-effective manufacturing [1]. Comprised of various institutions such as enterprises, universities,

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scientific research institutions or some other organizations, technology innovation alliance is the main form of current R&D alliances, which is based on developing demands of enterprises and mutual interests of all parties. With goals to enhance the technological innovation ability and to bring out technical innovation achievements, it is also a kind of cooperation organization for technical innovation, formed under the principles of jointly developed, advantage complementary, benefits sharing and risk sharing, safeguarded by a legally binding contract. Research of technology innovation alliance has become a hot topic recently. We used the term "technology innovation alliance" to make a search on ISI. Fig. 105.1 shows the distribution of journal publications of this topic and citation per year from 2000 to 2012. It can be seen that the number of publications and citations increased rapidly from 2000.

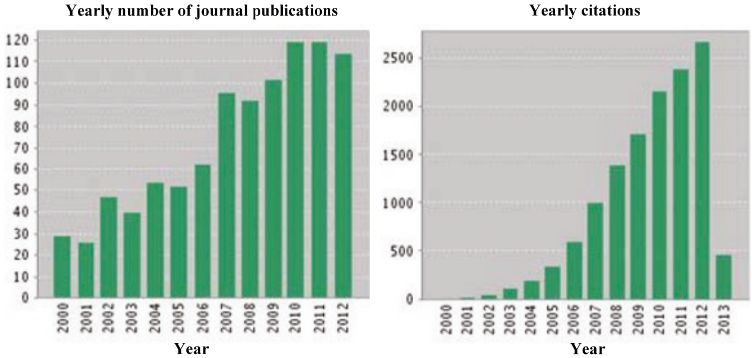

Fig. 105.1 The research trend from 2000 to 2012

In the context of this era, knowledge is one of the most important elements of core competence, and firms try to transfer and absorb it in each interaction with their environment, how to maximize grasp and use the knowledge has been the key to improve their core competitiveness, the essence of cooperative innovation in technology innovation alliance is the process of knowledge transfer, knowledge integration and knowledge creation, ability of knowledge transfer and integration is one important reason to decide whether a technology innovation alliance continues to exist [2]. Nevertheless, despite that the advantages of technology innovation alliance are obvious, many alliances have not brought out their expected benefits, some even collapse in the midway, say, since the 1990s, more than 800 U.S. businesses involved in the alliance, only 40% of the alliances can maintain more than 4 years, most of them generally are short-term disintegrated, that seriously dampened the enthusiasm of enterprises participating in the alliances [3]. There are many reasons for this result, and one of them is the poor matching in choosing partners, as Bronder and Pritzl [4] and Mason [5] considered, inappropriate partner selection is one of the most important reasons for the technology alliance failure, and Brouthers et al. [6] also believed that an inappropriate choice of alliance partners may face higher costs and risks than being alone. Partner selection for technology innovation alliance is the basic and key link of alliance formation, whose success is directly related to the performance of the alliance. There already have been some scholars made researches on a range of issues in partners-selection of technology innovation alliance.

105.2 Reviews and Propositions

Within the strategic alliances, only when two or more enterprises jointly committed to a series of goals the alliance can keep stable [7]. The inter-organizational innovation strategy being identity or not, is the first factor to be considered in the selection of innovation alliance partners, only when their innovation strategies are the same, knowledge share and transfer in the technical innovation process can be achieved, and thus the alliance may continue to create new knowledge, many more new products and technologies will be developed.

Proposition 105.1. *Strategic goal consistency is one criteria of partner selection for technology innovation alliance.*

In the research of partner selection for alliance, most have emphasized the complementarity and compatibility of cooperative members. First and foremost, resource complementarity plays an important role in the partner selection [8]. In addition, as Lewis [9] and Slowinski et al [10] emphasized, partner selection should more meet the compatibility. And besides, capacity complementary, cultural cooperation, target compatibility and risk proportionality are also included in the union allies selection criteria [11]. Wu et al. made a study on strategic alliance partner selection criteria with ANP method, which shows that the vendor complementary capability is the most important characteristic, and then the intangible assets, afterwards, the marketing knowledge and ability, two principles been valued least are the appropriateness and peculiarity, his study also indicated that the data analysis of different industries may draw different degrees of the selection criteria importance [12]. Beyond that, various organizations composing technology innovation alliance usually have heterogeneous culture, cultural heterogeneity between organizations may cause a conflict. In the perspective of the corporate culture, after staffs involved in the alliance have received lots of information from other culture, there will be a psychological reaction produced more or less, that is, the "culture shock". That is because alliance members lost their familiar social communication signals and symbols, and also being not so familiar with each other's social symbols, which leads to the confrontation and tension among the employees, even the open conflict with other organizations. Therefore, in order to avoid the cultural conflict in alliances, mutual cultural distance is also one big focus when the alliance is first established.

Proposition 105.2. *Resource complementarity is one criteria of partner selection for technology innovation alliance.*

Proposition 105.3. *Culture difference is one criteria of partner selection for technology innovation alliance.*

Parkhe [13] divided the partner selection channels for alliance into intermediary (Government introduced, peer recommendations), social networks and to gain by themselves. It is easier to establish a higher degree of trust between alliances which have intermediary channels, and form a strong coupling relationship. Bierly and Gallagher [14] explained the partner selection, trust and Strategic expediency, analyzed two partner selection strategies within the situations of full information and incomplete information, and summed up the advantage of trust-based and the problems caused by too much trust, thus put forward some suggestions to strengthen corporate strategic expediency by forming a formal partner selection criteria for alliance. Trust is recognized as essential for cooperative behavior, and the operation of network forms of organization, which is also perceived to have a complementary and supplementary role relative to the use of controls, Daellenbach and Davenport [15] argued that a firm will make a decision to enter into an knowledge-sharing technology alliance based on its assessment of the trustworthiness of the potential partners, that is, based on an attribute of other organizations and their representatives rather than an attribute of the future alliance relationship (trust).

Proposition 105.4. *Social capital match is one criteria of partner selection for technology innovation alliance.*

Proposition 105.5. *Mutual trust is one criteria of partner selection for technology innovation alliance.*

Knowledge transfer is an important means to promote organization interactive learning and to acquire external knowledge [16], and is also essential to maximize knowledge effectiveness. Conversely, technology alliance is a need to extend the knowledge base (knowledge accumulated by enterprises and knowledge flow into the enterprises) [17], and one goal of alliance members participate in the technology innovation alliance is to learn his requisite knowledge from partners by mean of alliances the intermediary, knowledge learning is thus closely related to the success of alliance cooperation [18]. Enterprises are able to integrate resources by building up the technology alliance, and make an effective and reasonable use of the resources. The alliance form also establishes a good platform for knowledge transfer among enterprises, which promotes effective sharing of knowledge and technology among businesses, all parties in the alliance achieve the prospect of win-win or even multi-win by continuous digestive absorption innovation.

Proposition 105.6. *Knowledge transfer capacity is one criteria of partner selection for technology innovation alliance.*

Then, we get the partner selection criterias for technology innovation alliance (see Fig. 105.2). In conclusion, partner selection should be based on the building targets of the technology innovation alliance, to seek or accept partners who are helpful to achieve objectives of the alliance, fill gaps of knowledge, information and technology. Actually, the partner selection process is a kind of multi-objective decision making problem. We use a conventional multi-objective programming method combines object weight and entropy [19] to select partners for the technology innovation alliance.

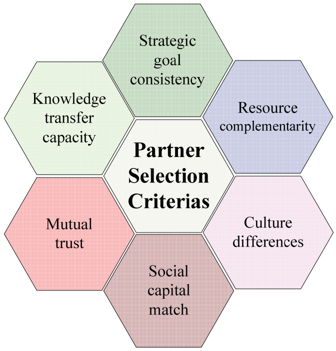

Fig. 105.2 The partner selection criteria for technology innovation Alliance

105.3 The Evaluation Model

For the partner selection for technology innovation alliance is a multi-objective decision making issue, based on the preceding analysis, we establish an evaluation model. Assuming that alliance chief is prepared to select one organization from n alternative organizations as his cooperative partner.

105.3.1 The Evaluation Index

We can get the evaluation form when alliance chief evaluates the six indexes of other n participants, see Table 105.1.

Table 105.1 The evaluation index

Index	Alternative 1	Alternative 2	······	Alternative n
Strategic goal consistency	r_{11}	r_{12}	······	r_{1n}
Resource complementarity	r_{21}	r_{22}	······	r_{2n}
Culture differences	r_{31}	r_{32}	······	r_{3n}
Social capital match	r_{41}	r_{42}	······	r_{4n}
Mutual trust	r_{51}	r_{52}	······	r_{5n}
Knowledge transfer capacity	r_{61}	r_{62}	······	r_{6n}

And the evaluation matrix is:

$$\begin{pmatrix} r_{11} & r_{12} & \cdots & r_{1n} \\ r_{21} & r_{22} & \cdots & r_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ r_{61} & r_{62} & \cdots & r_{6n} \end{pmatrix}.$$

r_{ij} means the evaluation value of index i on object j. Because most of these indexes cannot be quantified, we could use expert scoring method to get each index value (that is to quantify every index which could be quantified). Specifically, the scoring method goes as follows: according to the extent that alternative j meets the need of alliance chief to form an alliance on index i, assign an integer value to this index r_{ij} from 1 9, and these numbers mean: 1: strongly low meet, 3: low meet, 5: neutral, 7: high meet, 9: strongly high meet; 2, 4, 6, 8 are the mean between two adjacent judgments, they are used where need to compromise.

After the standardization, this matrix turns to: $R' = (a_{ij})_{6\times n}$.

Under the assignment rules above, here indexes can be considered as the effective indexes, and therefore we can define:

$$a_{ij} = \frac{r_{ij} - \min\limits_{j}\{r_{ij}\}}{\max\limits_{j}\{r_{ij}\} - \min\limits_{j}\{r_{ij}\}}, \quad i = 1, 2, \cdots, 6. \tag{105.1}$$

105.3.2 Determine the Weight of Each Index

To a specific index, if the difference of index values in alternative organizations is more significant, that means it is more effective in the comprehensive evaluation; and if all the index values are numerically equal, that means there is no effect in the comprehensive evaluation at all, and it also means that the indexes don't provide any useful information to solve the problem. In the information theory, information entropy is the measure on disorder degree of system, the greater the variation degree of index value is, smaller the information entropy is, and also the greater the information content the index provides, bigger the corresponding weight is, otherwise the weight is smaller.

We determine the index weights based on both the information content the index provide and its importance.

Assuming that based on the aims and demands, the chief enterprise defines the weights of index importance as a_i, $i = 1, 2, \cdots, 6$. According to the variation degree of each index value, use entropy weight method to calculate each entropy weight of various indexes. We define the entropy of the $i-$th evaluation index as:

$$H_i = -\frac{1}{\ln n} \sum_{j=1}^{n} b_{ij} \ln b_{ij}, \; i = 1, 2, \cdots, 6, \tag{105.2}$$

in formula (105.2),

$$b_{ij} = \frac{a_{ij}}{\sum\limits_{j=1}^{n} a_{ij}}. \tag{105.3}$$

Entropy weight of the $i-$th index is defined as:

$$\omega_i = \frac{1 - H_i}{6 - \sum\limits_{i=1}^{6} H_i}. \tag{105.4}$$

When the index i values of alternatives are identical, then the entropy value of this index reaches the maximum value 1, and meanwhile its entropy weight is 0, which represents this index provides no useful information to decision makers, that is under that index, all alternatives have no differences to the decision makers, the index could be discarded. Entropy weight does not mean the importance factor of indexes, but the discrimination of evaluation objects (the alternatives) under that index, namely the index ability to distinguish alternatives, the greater the entropy weight is, the index is more able to distinguish the alternatives.

After decision makers have determined the weight α_i of each index (weight represents the importance), combined with the entropy weight ω_i, we can calculate the comprehensive weight of index i:

$$\beta_i = \frac{\alpha_i \omega_i}{\sum\limits_{i=1}^{6} \alpha_i \omega_i}, \ i = 1, 2, \cdots, 6. \tag{105.5}$$

105.3.3 Comprehensive Evaluation

We use the distance from feasible solutions to the ideal point to sort these alternatives, the one who has the smallest distance is the optimal alternative. Here the ideal point is defined as $Q = (1, 1, L, 1)$, and the distance from alternative j to the ideal point is defined as:

$$L_j = \sqrt{\sum_{i=1}^{6} {\beta_i}^2 (1 - a_{ij})^2}, \ \ i = 1, 2, \cdots, n. \tag{105.6}$$

If there are two or more than two enterprises having the smallest value, then we can sort all alternatives based on the index importance.

105.4 Example Analysis

Assuming that the alliance chief is to select one organization as his partner from five alternatives, after a careful evaluation on these five organizations, we get the following matrix R:

$$R = \begin{pmatrix} 8 & 7 & 9 & 6 & 7 \\ 7 & 8 & 6 & 8 & 8 \\ 6 & 5 & 4 & 7 & 8 \\ 4 & 3 & 6 & 8 & 4 \\ 6 & 5 & 7 & 5 & 6 \\ 5 & 6 & 3 & 7 & 3 \end{pmatrix}.$$

Use formula (105.1), we get the standardization matrix,

$$R' = \begin{pmatrix} 2/3 & 1/3 & 1 & 0 & 1/3 \\ 1/2 & 1 & 0 & 1 & 1 \\ 1/2 & 1/4 & 0 & 3/4 & 1 \\ 1/5 & 0 & 3/5 & 1 & 1/5 \\ 1/2 & 0 & 1 & 0 & 1/2 \\ 1/2 & 3/4 & 0 & 1 & 0 \end{pmatrix}$$

and then we get b_{ij},

$$b_{ij} = \begin{pmatrix} 2/7 & 1/7 & 3/7 & 0 & 1/7 \\ 1/7 & 2/7 & 0 & 2/7 & 2/7 \\ 1/5 & 1/10 & 0 & 3/10 & 2/5 \\ 1/10 & 0 & 3/10 & 1/2 & 1/10 \\ 1/4 & 0 & 1/2 & 0 & 1/4 \\ 2/9 & 1/3 & 0 & 4/9 & 0 \end{pmatrix}.$$

From Equations (105.2) and (105.3), we can calculate the entropy of six indexes as follows: $H_1 = 0.794$, $H_2 = 0.840$, $H_3 = 0.79$, $H_4 = 0.726$, $H_5 = 0.646$, $H_6 = 0.659$.

And from Equation (105.4), the corresponding entropy weights are: $\omega_1 = 0.134$, $\omega_2 = 0.104$, $\omega_3 = 0.133$, $\omega_4 = 0.178$, $\omega_5 = 0.230$, $\omega_6 = 0.201$.

Assuming that the indexes values the alliance chief assigns are: $\alpha_1 = 0.202$, $\alpha_2 = 0.175$, $\alpha_3 = 0.133$, $\alpha_4 = 0.142$, $\alpha_5 = 0.161$, $\alpha_6 = 0.187$.

Then we get comprehensive weights based on Equation (105.5): $\beta_1 = 0.166$, $\beta_2 = 0.112$, $\beta_3 = 0.109$, $\beta_4 = 0.155$, $\beta_5 = 0.227$, $\beta_6 = 0.231$.

Based on Equation (105.6), we can get every distance from the index vector to ideal point of all alternatives, $L_1 = 0.225$, $L_2 = 0.313$, $L_3 = 0.286$, $L_4 = 0.283$, $L_5 = 0.306$.

For the value of L_1 is smallest, the alliance chief should select alternative 1 as his partner.

105.5 Conclusion

Knowledge has become the fundamental source of sustainable competitive advantage, and technology innovation alliance is such an effective mode to form the knowledge advantage from knowledge sharing and knowledge creation among enterprises and other organizations. Moreover, how the chief enterprise scientifically and reasonably selects the right partners is directly related to the success or failure of the technology innovation alliance. We make a study on the partner selection for technology innovation alliance. In the calculating of each index weight, we not only take the importance weight of each index into account, but also notice the amount of information indexes offer for partner selection, therefore, we believe that it is more comprehensive and reasonable to use this method to determine the synthetic index weight rather than to only take the importance weight into account. See from the example analysis, the method we discuss in this paper is strongly operable.

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Chapter 106
Strategic Development of Beibu Gulf Economic Zone of Guangxi: From the Perspective of Low Carbon Economy

Xiaoguo Xiong and Yongjun Tang

Abstract Low-carbon economy is an economic mode which features the reduction of CO2 emission in the process of production and consumption. Accelerating the development of marine low-carbon economy is a fundamental choice for future development. The Beibu Gulf Economic Zone of Guangxi (BGEZ) enjoys a long coastline and covers 123,000 sq km, which known as the last uncultivated coastal area in China. The current marine low-carbon economy in Beibu Gulf has limiting factors such as institutional building falls behind and shortage of technology and human resources, etc. However, there are also some unique advantages of BGEZ developing its low carbon strategies. Simply applying the inland development model to the marine economic development will bring new disasters to marine ecosystem as well as social and economic system. This article aims to develop a strategy of BGEZ's marine industry in the perspective of low carbon economy. Various strategic steps to improve the BGEZ's institutional systems and industrial structure and to introduce advanced marine technology of BGEZ are also being explored.

Keywords Marine economy · Marine economy · Beibu Gulf Economic Zone · Strategy

106.1 Introduction: The Present Situation of BGEZ Marine Economy

Currently, land resources of economic development are gradually being exhausted. As the most important bridgehead of China's reform and opening-up to Southeastern

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Asia, Guangxi sees increasingly close ties between its economic development and marine development. Guangxi is shifting its economic development from the Inland Development Model with Nanning-Liuzhou as the axis to the Marine Economic Development Model with the Beibu Gulf zone as axis. The proportion of marine economy's total output value in Guangxi's GDP is on the rise annually, and shows obvious acceleration of development. The Beibu Gulf Economic Zone of Guangxi (so-called BGEZ) enjoys a long coastline, while the Beibu Gulf sea area covers approximately 123,000 sq km. Boasting a low development density and little pollution, it is known as the last uncultivated coastal area in China. In the new century, China is accelerating its development and application of marine resources. The 2011 China Marine Economic Statistics Bulletin released by the State Oceanic Administration shows that total output value in the marine sector increased by 10.4% compared with 2010, reaching ¥4.557 trillion and accounting for 9.7% of GDP in 2011; 34.2 million people were employed in the marine industry, an increase of 700,000 over the previous year. For Guangxi Beibu Gulf, the total output value of the marine industry is expected to ¥70.8 billion, an increase of 24% over same time last year. This accounts for approximately 6% of Guangxi's GDP and takes up around 18% of the GDP in Beihai, Qinzhou and Fangchenggang, the three cities of Beibu Gulf Economic Zone (see Table 106.1). Guangxi Beibu Gulf's marine economy has a lower share of GDP than the national average, suggesting at its great potential for development (see Fig. 106.1).

Table 106.1 Marine economy data of cities of Beibu Gulf

Cities of BGEZ	Gross value of marine industry (billions of CNY)	Percentage of respective city's share in the gross value of marine industry of BGEZ
Beihai	14.45	42.30%
Qinzhou	11.26	32.96%
Fangchenggang	8.45	24.74%
Total	34.16	100.00%

The rapid growth of marine economy is of great importance to social economic development. However, under the backdrop of further global warming, simply applying the traditional model of land economic development to marine economic development will bring new disasters to the marine ecosystem and global climate [1]. As a relatively underdeveloped region in a developing country, Guangxi Beibu Gulf has many limiting factors in its current economic development, such as its relatively backward internal industrial structure, trade structure, energy structure and great external environmental pressure. Therefore, a low-carbon economy development pattern with low energy consumption, low pollution and low emission must be adopted in order to develop Beibu Gulf marine economy well.

Low-carbon economy is an economic operation mode which features the reduction of CO_2 emission in the process of production and consumption. Marine economy refers to the collection of economic activities which takes oceans as the activ-

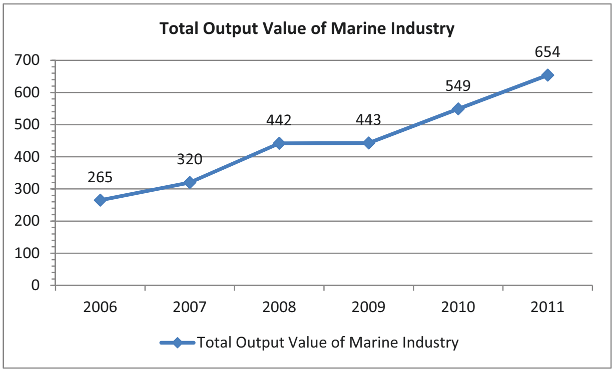

Fig. 106.1 Annual percentage of marine total output value in BGEZ's GDP based on 2011 Guangxi marine economic statistics bulletin

ity place and marine resources as the object to be developed. According to industry types, marine economy can be divided into fishery, marine cultivation, marine industry, marine transportation, marine tourism and marine financial industry. The essence of marine low-carbon economy is to reduce the carbon dioxide emissions in the process of marine production and consumption, curb climate deterioration and realize the sustained development of marine industries by efficiently utilizing marine resources and developing clean energy [2]. Oceans possess the natural attributes of low-carbon economy and the important function of absorbing greenhouse gases-carbon dioxide. The marine renewable energy and green energy are important resources to the improvement of energy structure and the development of marine low-carbon economy. The development of marine low-carbon economy is a complex and systematic project, involving the economic growth of coastal areas, technological innovation, consumption values and changing ways of life.

106.2 Challenges to the Development of Marine Low-Carbon Economy in BGEZ

Nowadays, the marine economy in Guangxi Beibu Gulf still follows the extensive development pattern with high energy consumption, heavy environmental pollution, huge cost and low industrial profit rate. The total output value of the major marine industries in Beibu Gulf increased by 21.53% annually over the past five years, but this achievement was gained at the cost of degrading marine environmental quality and exploitation of marine resources. The current marine low-carbon economy in Beibu Gulf has limiting factors in many aspects, such as institutional building, industrial structure, technology and personnel construction.

106.2.1 Deficiency in Institutional Building

In order to promote the stable development of marine low-carbon economy in Beibu Gulf Zone, we should build up a marine low-carbon economy with Beibu Gulf's characteristics by improving institutional environment, taking the long-term growth as the key link, adapting marine-low-carbon-industry-oriented preferential policies and attracting the investment of funds, technologies and talents helpful to marine low-carbon economy. The institutional building of the current marine low-carbon economic development in Beibu Gulf Zone has the following problems: First, a number of enterprises in Beibu Gulf Zone participate in carbon emissions-trading usually due to their social responsibilities. However, owing to the lack of government incentive system, such companies which actively promote low-carbon development fail to obtain the deserved rewards, and this in turn damages their enthusiasm. Second, certain enterprises fail to consummate their transactions efficiently due to the relatively backward level of domestic trading in the carbon trading platform construction, as well as the lack of unified and convenient services in transaction registration, authentication and settlement. Third, R&D in this field is still in its infancy, and such scientific research is characterized by the huge investments, little or even no profits and slow speed of capital recovery at the initial stage. Therefore, without support from the government, it is hard for enterprises to overcome the barrier of lack of funds at the initial stage of marine low-carbon development [4].

106.2.2 Imbalance of Industrial Structure

The current structure of Beibu Gulf marine low-carbon industry is unreasonable: The traditional industry, namely, the marine fishery retains a high share; the proportion of the secondary and tertiary industries is higher than that of the primary industry, however, tourism services hold the dominant position while the industrial services with high technological content scores a relatively low proportion in the tertiary industry (see Fig. 106.2). Overall, the marine economy in BGEZ has maintained an extensive economic growth model with high pollution, low benefits and excessive attention to output, thus seriously hampering the sustainable development of economy in BGEZ [5]. The current BGEZ marine economy still retains an extensive economic growth of high energy consumption and low benefits. It not only leads to environmental pollution, resource strain and other consequences in BGEZ, but also constricts the growth of new marine industries owing to the occupancy of its development resources.

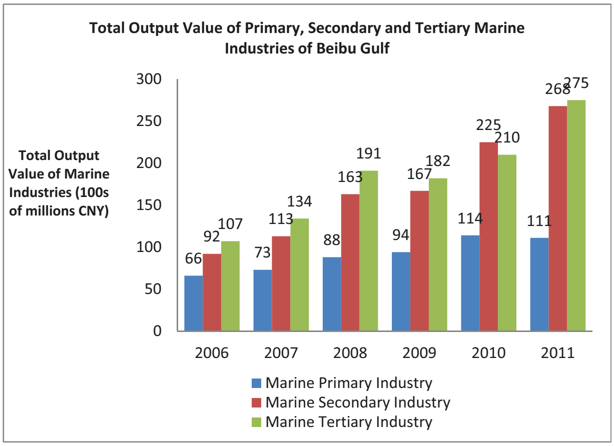

Fig. 106.2 Total output value of primary, secondary and tertiary marine industries of Beibu Gulf based on 2011 Guangxi marine economic statistics bulletin

106.2.3 Low-level of Technology

At present, the overall level of marine technology development in the BGEZ is low. The traditional marine industrial technology still holds the dominant position in marine economy while the emerging marine industry has not formed an effective-scale system. All these seriously impede the development of marine low-carbon economy in the BGEZ. The current development of Chinese marine low-carbon technology is relatively backward in the following aspects: First, the degree of investigation concerning marine resources in Beibu Gulf offshore areas which is under Chinese jurisdiction is low. Furthermore, information of marine resources regarding maritime and offshore areas is insufficient. These cause China to be at a disadvantage in the marine resources development of BGEZ. China and Vietnam only recently entered into the Beibu Gulf Demarcation Agreement. In addition, there is widespread overlapping of possession and access to Beibu Gulf resources between the both sides and abundant cross-border oil and gas resources. All these restrict our investigation of marine resources in BGEZ. Second, the technological equipment for research is relatively backward; accumulation of marine resources research historical data is inadequate and the co-administrative and sharing mechanism of marine investigation data has not yet been formed. For want of the above-mentioned research requirements, the technological research development and application required by medium- and long-term development of marine low-carbon economy in BGEZ has been seriously restrained. Independent technological R&D exhibits many disadvantages, such as long periods, high risks, high cost and inefficiency. Thus, technology required by the current marine low-carbon economy in BGEZ should not depend solely on traditional self-sufficient science and technology. Instead, we need to take the following path of developing science and technology by leaps and bounds: Proactively introduce advanced science and technology, as well as digest, absorb and convert it into real productive forces. However, the marine low-carbon economy in Beibu Gulf is hindered by the market environment, industrial system, financial system and lack of high-caliber talents and is lagging far behind in the transformation of scientific achievements. Consequently, marine science and technology takes up a low proportion of contribution to the marine industry; the Beibu Gulf marine low-carbon industry, including marine biological medicine, seawater desalination, tidal power generation, accounts for a relatively low share of the total marine output value. Thus, the BGEZ should establish the strategic marine low-carbon economy industry as its leading force, so as to boost the transformation and contribution rate of science and technology, enhance its core competitiveness, and propel the development of marine low-carbon model by leaps and bounds [3].

106.2.4 Deterioration of Ecological Environment

The BGEZ is a weak link in China's marine ecological environment. There is excessive exploitation of marine resources, certain rare marine species have become endangered, and certain waters have controversial ownership rights. Serious pollution of coastal and local waters caused by coastal industrial zone exists, and there is a lack of effective mechanisms to keep the marine ecological environment in Beibu Gulf from further deterioration due to various negative factors. The pollution discharge of coastal industrial production in Beibu Gulf has lead to increased pressure on offshore marine ecological environment. Beibu Gulf coastal industrial belt is an economic growth-pole of Guangxi and the accompanied industrial pollution is mainly distributed in the offshore areas of Qinzhou bay and Fangchenggang. Inorganic nitrogen and oil are the main pollutants and the offshore sediments are polluted by chemicals such as cadmium and petroleum. Consequently, the evaluated potential ecological risk is ranked at medium and has a trend to increase. Based on the 1997 to 2007 analysis of trends of pollutant residues levels in offshore marine shellfish bodies, the content of cadmium, lead, arsenic, petroleum hydrocarbon and total mercury level in Guangxi waters went up distinctly. As large-scale petrochemical, steel-making, paper-making, power generating and other projects are planned and distributed in BGEZ, the marine ecological environment will experience greater pressure due to the development orientation of Guangxi's major coastal industries and logistics.

106.3 Development Strategy of Marine Low-carbon Economy in BGEZ

As a new stage following the development of Bohai Rim area in China, the Beibu Gulf marine low-carbon economy features unique advantages. Accelerating the development of marine low-carbon economy is the fundamental choice for future development. From the perspective of system, industry and technology, an investigation of Bohai Rim area shows that various paths can be chosen to develop the Beibu Gulf marine economy.

106.3.1 To Improve Institutional Systems

A reasonable system arrangement can effectively regulate the initial condition of the decisive elements for marine economy development, and thus determine the track of economic development. Guangxi Beibu Gulf marine economy should establish a complete set of marine economic development systems based on the development strategy of serving Guangxi and eventually the entire southwestern Chinese economy. This is a potential advantage for Guangxi and a foundation stone for realizing the strategy of catching-up and surpassing.

Firstly, we should establish and implement a long-term planning system for Guangxi Beibu Gulf marine economic development from a strategic height. On one hand, we need to set up the legal system foundation for Beibu Gulf marine economy according to the International Law of the Sea. Beibu Gulf is an international gulf, thus its development cannot be separated from a relatively stable international and domestic environment and its success depends on China's ocean sovereignty maintenance and border stability. Nowadays, there are still some distinct controversies about demarcation issues on Beibu Gulf estuary waters. We should safeguard our sovereignty and respect the rights of bilateral territorial sea as well as exclusive economic zones according to the International Law of the Sea. We should properly solve the legal foundation problem in Beibu Gulf marine economic development. On the other hand, when we formulate policies concerning the Beibu Gulf marine economic development strategy, we should consider the two main goals of marine resources exploitation and marine ecological environmental protection. On the premise of ensuring the sustainable development of Beibu Gulf marine exploitation, we need to optimize the marine industry and boost marine economic gross value and quality.

Secondly, the BGEZ carbon-trading market should be established and improved. According to the legal foundation of carbon market establishment, the carbon-trading market can be divided into compulsory trading market and voluntary trading market. In the compulsory carbon-trading market, compulsory laws regulate the total greenhouse gas emission, as well as the carbon emission allocation to each economic body in a certain zone. Thus carbon trading should be done according to the regulated carbon emission allocation. Comparatively, in the voluntary carbon-trading market the participants carry out carbon emission trade based on their social responsibilities or brand-building needs. According to the United Nations Framework Convention on Climate Change, China, as a developing country, assumes no legally binding responsibility of reducing the absolute total greenhouse gas emission until 2020. As a result, the BGEZ cannot carry out compulsory carbon trade. Therefore, at present we should actively promote construction of the voluntary carbon-trading market and accumulate experience for future construction of compulsory carbon emission trading market. Meanwhile, BGEZ is relatively backwards and has more carbon-sink than carbon source. Thus, the authorities should positively formulate a system to help enterprises in BGEZ participate in the global carbon-trading business, acquire experience and obtain benefits. In 2006, the first forestry carbon sink project in the world was carried out according to the CDM (Clean Development Mechanism) at Huanjiang, Guangxi. It made profits and also serves as a model that promotes the enthusiasm of Guangxi Beibu Gulf enterprises, encouraging them to participate in the global carbon emission trade.

106.3.2 To Reform on Industrial Structure

Firstly, we should proactively popularize the marine low-carbon technologies in marine traditional industry and realize the optimization and promotion of the traditional marine industry. The 2010 Guangxi Marine Economic Statistics Bulletin shows that the current marine economy in BGEZ is mainly based on traditional industries, such as marine transportation, marine fishery, coastal tourism, marine oil-gas and marine chemical engineering. The traditional industry not only has high energy consumption, but also occupies rare resources required by the development of the emerging industry. Therefore, advanced marine low-carbon technologies should be actively promoted in the transformation of traditional industry. Thus it can realize the optimization and promotion of the traditional marine industry and avoid being limited at the end of value chain in marine industry. [8] In the case of marine transportation, we need to vigorously develop marine ports and shipping. For example, Japan's Mitsubishi developed the first ship to use solar panels as a source of energy. The "AURIGALEADER" can save up to 13 tons of fuel annually. Another example is the South Korean ecological ship named "The Green Dream Eco-Ship" with a fuel saving rate of 50%. In order to promote marine transportation in BGEZ and improve its overall competitiveness, we should proactively learn from progressive foreign energy management experience and introduce advanced low-carbon technology. We should also spread the application of low-carbon energy and low-carbon technology in the enterprises in BGEZ and curb carbon emission per output unit. By these means we can achieve development of marine transportation in Beibu Gulf by leaps and bounds.

Second, we should vigorously adjust marine industrial structure, and raise the share of marine tertiary industry in marine total output value. High-end marine tertiary industries enjoy relatively high levels of appreciation rates in its industry chain, as well as low energy consumption per unit of output value. Thus we can reduce the marine carbon unit of output value through improving the industrial structure. Currently, Beibu Gulf marine industries is still mainly based on the secondary industry, while the tertiary industry takes up around 40% of the total output value, and has been at this stable rate for some time. In 2008 the proportion was 43%, while in 2010 it dropped to 40.2%. In order to elevate the tertiary industry's share, we not only need to remodify traditional tertiary aspects such as coastal tourism, fisheries, shipping logistics, but also foster new and emerging marine services such as modern shipping logistics, marine information industry, marine finance and insurance sectors. Guangxi Beibu Gulf is situated at the southernmost part of China's Golden Coastline and enjoys abundant marine culture tourism resources; however it lacks necessary equipment and facilities for marine tourism. The Beibu Gulf cities cluster should join efforts to develop the marine culture tourism industry, and strengthen overall planning of culture, sports and tourism. Concerning marine sporting activities, we can build comprehensive marine sport and leisure centers and industry bases for sea based sports; concerning marine tourism we should avoid simply copying and repeating modes when designing places of interest, and put emphasis on bringing forth unique tourism choices that meet international standards and auxiliary recreational facilities. We should also build coastal leisure and holiday bases to meet the needs of consumers with varying levels of consumption demand. These coastal facilities should comply with the principle of low-carbon environmental protection, and ecological tourism resources such as the mangrove natural park should be encouraged. Thus we can achieve a positive development cycle of low-carbon economy in which the industries promote environmental preservation.

Third, we should attach importance to the long term results that marine ecological and environmental restoration brings to the development of marine industries. Marine ecological restoration is a way of restoring a polluted marine ecological system to a state of sustainability. This is achieved through grasping the patterns of marine ecological environment, utilizing its self-restoration ability, and providing appropriate measures of artificial support. Currently this has been piloted effectively to great success in cities such as Xiamen, Ningbo and other coastal areas in China. The BGEZ should also actively launch such restoration projects to recondition the marine ecological environment, by means of constructing man-made fishing reefs, restoring mangrove forests and cleaning beaches.

106.3.3 To Introduce Advanced Marine Technology

In order to avoid the traditional path of pollution first, treatment later, Beibu Gulf's marine low-carbon economic development should achieve key breakthroughs concerning marine low-carbon core technology. First, we should introduce low-carbon technology from the outside so as to close the gap between generations of technology. The United Nations Framework Convention on Climate Change bestowed an obligation upon developed countries to transfer low-carbon technology to developing nations. The marine low-carbon economic development of BGEZ should lay equal stress on the two paths of obtaining marine low-carbon technology: Introducing and absorbing from abroad and independent development at home. At the same time, we should emphasize the learning, understanding and re-innovation of such technologies. In the process of introducing marine low-carbon technologies, we need to tighten the feasibility inspection of the projects, so as to prevent the repeated bringing in of low-level information. The Guangxi Government can consider launching an authorization center for marine low-carbon technology of BGEZ. This center can take European, American and Japanese companies with such proficiency as the subjects for bringing in expertise, and trade market access rights to the BGEZ in the return for ownership or exploitation rights of such technology. Second, we should clearly establish the strategic direction for developing marine low-carbon knowledge, and target the independent R&D of key technologies. Third, we should set up a marine low-carbon supervision network system. This network can use comprehensive measures such as satellite remote sensing, aerial surveys and taking samples to monitor Beibu Gulf sea zone's carbon emission data. This provides statistical support for making policies concerning Beibu Gulf's marine low-carbon industries, and accumulates basic statistical data for carbon trading and related financial business.

106.4 Conclusion

The paper described the basic connotation of marine low-carbon economy; analyzed the predicament of development path of marine low-carbon economy in BGEZ; proposed the development path of marine low-carbon economy in the zone. The BGEZ enjoys a long coastline and covers 123,000 sq km, which known as the last uncultivated coastal area in China. Simply applying the inland development model to the marine economic development will bring new disasters to marine ecosystem as well as social and economic system, for instance high energy consumption, heavy environmental pollution, huge cost and low industrial profit rate etc. The development of marine low-carbon economy is a complex and systematic project, involving the economic growth of coastal areas, technological innovation, consumption values and changing ways of life.

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Chapter 107
Rescue System Construction for Sports Leisure and Outdoor Sports in Sichuan Province

Ming Xu

Abstract With the continuous and rapid development of sports leisure and outdoor sports, injury accidents also occur frequently in the course of sports activities. It is greatly needed to establish a rescue system of Sports Leisure and outdoor sports, especially for Sichuan. In this paper, we first analyze the current situation of Sports & Leisure and outdoor sports in Sichuan to find the problems in leisure and outdoor sports. Then, combined the advanced experience in the development process of foreign emergency rescue system with characteristics of Sichuan Province and the administrative, the advanced experience can be used in the management of sports leisure and outdoor sports rescue, we propose some suggestions for establishing sports leisure and outdoor sports rescue system in Sichuan.

Keywords Leisure sports · Outdoor sports · Rescue system · Emergency management

107.1 Introduction

Outdoor sports refer to a of group sports which are adventurous or aims at experiencing adventure in natural environment [1, 2]. There are no special protective measures in these venues, so the safety factor is relatively low. Nature brings human happiness and health, as well as a variety of risks [3]. As outdoor sports accidents occur frequently, outdoor sports security has become the problem that can not be ignored by the people in the process of participation in outdoor activities. The establishment of sports and leisure and outdoor sports rescue system is the insurance for sports leisure and outdoor sports can be implemented safely, smoothly and ordinarily.

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107.2 The Current Situation of Sports & Leisure and Outdoor Sports in Sichuan

Sichuan terrain is characterized by the Tibetan Plateau on the west, the Three Gorges on east the Bashan and Qinling on the north, Yunnan-Guizhou Plateau on the south. All these together form the world-famous Sichuan Basin. Sichuan has vast land and sufficient resources, a long history and many famous people, and been enjoying the “Land of Abundance” reputation from ancient times. Its special geographical environment resources make it an ideal place for a variety of sports leisure and outdoor sports such as hiking, river rafting, mountain climbing, skiing expedition etc. Sichuan is hailed as “paradise for outdoor sports” and one of the places in which sports leisure and outdoor sports are developing much faster.

Table 107.1 A statistics of accidents in mountain area in recent year

Time	Number of people	Place	Type
16-Oct-10	1 loss	Tian Haizi, Ganzi, Kangding, Sichuan	Slide pendant
29-Jul-09	1 dead	Sichuan Luotuo Peak	Exploration in mountain
26-Jun-09	1 loss	Siguniang mountain Changping Gou Po Miao Peak, 5413 meters in altitude	Climbing mountain
30-Dec-08	1 dead	Sacred Tree Ditch, Yala Snow Mountain, Ganzi Tibetan Autonomous Prefecture	Getting through mountain
2-Jan-06	2 dead	Tian HaiZi mountain	Lost
2-Jan-05	2 dead	Siguniang mountain	Avalanche
3-Nov-05	3 dead	Tian HaiZi mountain	Slide pendant
3-May-04	1 loss	Small Klang Valley bubble	Lost
4-May-03	1 loss	Songpanxue peak	Slide pendant

With the continuous and rapid development of sports leisure and outdoor sports, injury accidents also occur frequently in the course of sports activities. On January 29, 2009, nine college students from Jianyang City, Sichuan Province, dated to climb the Zhaogong Mountain in Du jiang yan City to take advantage of the occasion of the Chinese New Year holiday. As they were not familiar with natural climate changes of the mountain district in winter and did not know the terrain of mountain covered snow was difficult to distinguish, they went adventure to get through the Tai an town via Zhao gong mountain Peak. They got lost on their way because the anterior was covered by snow and lost. In may of the same year, the American Aide Jia peak climbing team planed to climb Aide Jia peak which is 6618 meters above sea level in Ganzi Tibetan Autonomous Prefecture, Sichuan Province. However, according to the original return plan, three people were not back to the base camp on time. Because there was no communication signal in the mountain area, the climbers in the base camp could not get contact with them. In the end, two were dead and one lost. A series of events has sounded the alarm for outdoor sports. Insufficient attention paid to the security problem will seriously affect the development of sports leisure and outdoor sports in Sichuan. In recent years, a statistics of accidents in mountain area are shown in Table 107.1.

The factors for mountain accidents can be classified into environmental factors and human factors. The latter include the participants in outdoor sports, outdoor sports organizers, and the rescue team. First, for the participants, the preparation is not sufficient and they are blindly confident, which is the common problem in sports leisure and outdoor sports. Most participants are inexperienced in outdoor sports, lack of awareness of the adventure and safety, and unfamiliar with the lines and weather. Second, as the participants in outdoor leisure sports are from very broad social backgrounds, and there is no limit of social status and professionals so every body can take part in outdoor sports if he likes, the complexity of participants in sports leisure and outdoor sports is a great challenge for organizing and arrangements without doubt. Many outdoor sports are initiated and organized via the network, rather than by specialized agencies, departments and organizations. What is worse, some organizers do not get professional knowledge and skills trained at all and aim only at sufficient profits.

107.2.1 The Current Situation of Rescue for Sports Leisure and Outdoor Sports

The outdoor sports rescue agencies should be an organized rescue system leaded by Sports Management Center of the State General Administration for Sport Climbing, implemented by local government and scenic areas. Sichuan Mountaineering Association (renamed as Sichuan Province Mountaineering Outdoor Sports Association later) was founded in 1979 with the approval of the People's Government of Sichuan Province. It is response for dealing with mountain and outdoor sports accidents. Mountain rescue Working Committee of the Sichuan Mountaineering Outdoor Sports Association is a branch of Sichuan Province Mountaineering Outdoor Sports Association, and consists of eight detachments (i.e. Luzhou, Yibin, Zigong, Nanchong, Leshan, Meishan, of Xichang and rescue dogs detachments) to cope with unexpected mountains and outdoor sports accidents. In 2009, Siguniangshan emergency detachment was set up in national scenic area Siguniangshan. Now there are 6 rescue dogs in the mountain rescue team and rescue dogs base in Luzhou. Leaded by People's Government of Sichuan Province and the Provincial Sports Bureau, Mountain rescue Working Committee of the Sichuan Mountaineering Outdoor Sports Association organizes and implements rescue plans for mountain accidents and a various rescue training courses in Sichuan Province. Since the association was established, it has disposed more than 20 mountaineering outdoor sports accidents including missing and dead events, and is recognized and approved by the Ministry of Foreign Affairs, the Mountain Sports Management Center of General Sports Administration, the People's Government of Sichuan Province, the community and the families of the missing victims.

107.2.2 The Problems in the Rescue of Sports Leisure and Outdoor Sports in Sichuan Province

It is very difficult for the rescue team to implement rescue plans due to the special location of Sichuan Province, in which the mountain scenic areas are mainly in Ganzi and Aba and most mountains are geographically isolated and inaccessible for the rescue team and equipment except for Emei, Qingcheng as the representative of the traditional mountains. During 2005 to 2010, the sports leisure and outdoor sports developed rapidly. Thus the, rescue demand is expanding. Today, the overall professional competence and rescue the scale of rescue agencies in the province is still more than far to meet the demand of huge groups of outdoor enthusiasts. Public institutions such as public security and fire are still the main implementation to search and rescue. However, there are more work that need improving when outdoor accidents occur, especially when adventure tourism accidents happen, for which the technology of searching needs improving. Besides, the equipment for rescue is in great lack so that the increasing number of outdoor accidents can not be coped with properly. In a survey of a few universities in and near Chengdu, and several clubs in Chengdu, which was based on the knowledge of the rescue mechanism of Sichuan sports leisure and outdoor sports, only 11.8% and 29.3% of the surveyed are very understanding and a better understanding of the mechanisms, 51.3% said they did not know, 7.6% said they had never heard of or did not know. 48.3% of the surveyed thought the equipment configuration of the rescue teams could not meet the needs of the rescue, and related equipment needed renewing and complementing.

Nowadays, the lack of rescue linkage mechanism, security awareness of outdoor sports participants, relevant laws and regulations, rescue supporting infrastructure and relief funds is the main problem in rescue. Besides, the rescue related organizations, medical institutions, armed public security departments, and insurance companies, which have been existed for a long time in society, only play a role in their own fields. Thus the convergence between various departments is blocked, which causes a serious impediment to the accident rescue, for Sports leisure and outdoor sports rescue involves many factors. How to connect the resources of rescue organizations in society, medical and bus fire department, and how to establish the government coordination and management mechanism in order to resolve to a series of complex issues such as emergent rescue, funds advanced, dealing with the aftermath, etc smoothly, and integrate different departments into an integrated rescue system are of great importance to Sichuan Sports Leisure and outdoor sports rescue.

107.3 The Rescue System of Sichuan Sports Leisure and Outdoor Sports

(1) Improve the policies and regulations of sports leisure and outdoor sports

With the continuous and rapid development of sports leisure and outdoor sports, we urgently need to speed up the legal construction of sports leisure and outdoor sports in order to guarantee the outdoor industry's healthy and sustainable development and perfect the unified market order. With the development of the outdoor sports industry, some of the negative impact followed by can not be ignored, such as the Nanning Damingshan traveling friends deaths event, Guangzhou traveling friends killed by flash floods event, Qinling Wanhuan Peak falling event etc. In addition to a policy to guide, the enhancement of outdoor sports legislation and the formulation and improvement of relevant laws and regulations are effective means to avoid these events. At present, China outdoor sports regulations include the notice for the organization and security work of mountaineering outdoor sports, provisional regulations on management of mountain guides, mountaineering outdoor sports clubs and related practitioners qualification marks. A safety management system shall be developed and implemented to protect the developing outdoor sports together with laws. Related complaints management departments should be founded to deal with the problems timely and effectively. A special mechanism for arbitration of disputes and litigation should be established so as to resolve complaints and disputes within the legal scope. Improving the legal system for sports leisure and outdoor sports is the fundamental guarantee for the healthy development of the outdoor sports industry. Enhancing the construction of outdoor sports legal system and promoting the development of outdoor sports towards the legal system healthily are not only the responsibility of the legislative department, but also the obligations each participant shall perform.

(2) The establishment of emergent funding guarantee for sports leisure and outdoor sports

Establish the funding guarantee mechanism consistent with the economic growth and social needs, make the annual government budget expenditure ratio clear in form of laws and set up a special fund in order to be used in projects as prevention, disposal, compensation, facilities recovery etc. In addition, call social agencies, power from all sectors, such as civil affairs departments, insurance companies, charities etc to denote money on a regular basis so as to meet the urgent daily need, form a comprehensive, multi-channel rescue funding and bear certain expenses for the government.

(3) Research and development of sports leisure and outdoor sports security network monitoring system

Related scientific research units have developed a number of information systems and management systems which are related to the emergency platform [4, 5], such as the American national emergency management information system (NE-MIS), the federal emergency management information system(FEMIS), the computer aided management system of emergency and operation etc [6, 7]. Remote sensing image generation and 3D-GIS map are also included. The support of a large number of real remote sensing data, highly realistic three-dimensional topography and 3G multimedia transmission [8] of the remote mobile audio and video data play an important role in on-site rescue, monitoring and visual guidance, which provides a convenient way to for rescue teams to find out where the accidents take place, Thus, the opportunities for persons in distress to be rescued are greatly enhanced.

(4) Strengthen the early warning system of the sports leisure and outdoor sports

The complexity and particularity of outdoor sports safety warning system require the administrative organization structure in the system be the coordination of the various government departments systems. Sports Bureau, the Bureau of Meteorology, the Public Security Bureau, Health Bureau and the information release institute etc should be integrated, so it is with the information and communication command system. Besides, the construction of the emergency command information network should be enhanced [9]. When it comes to safety information release, the development of mobile network technology and the popularity of mobile communications tools, such as mobile phones etc, should be taken full advantage of. Therefore, information such as weather, disease, disaster, geological conditions etc can be released in advance in order that the participants in outdoor sports get the information in time and adjust their roads and plans quickly to reduce the occurrence of injury and death events due to no access to information.

(5) To establish the sports leisure and outdoor sports rescue linkage mechanism

The rescue linkage mechanism is established for implementation of outdoor rescue, which involves in the division of labor and collaboration of the relevant aspects of the outdoor security organization. Branches can be set up in the Emergency Committee, and other relative departments can be contained as permanent branches. The joint meeting should be organized and held on a regular basis, and the respective responsibilities should be clarified. The plans can be modified and improved at any time so as to be more consistent with the reality, according to thee analysis of the accidents. Thus, each department will play its role better. Facing an accident, forces from all aspects will be organized and guided urgently to cope with the affairs.

(6) Set up the sports leisure and outdoor sports insurance system

With the gradual increase of the risk of accidents, personal safety of the participants becomes the focus of the organizers, amateurs of outdoor mountain climbing sports, relative management departments and different social classes. The establishments of outdoor sports insurance will provide a guarantee for the healthy development of the outdoor mountain climbing sports, reduce the worries of amateurs, and provide a guarantee for the rescue work of the rescue team, which will definitely promote the development of outdoor sports and benefit the implement of rescue work. In recent years, with the support of China Mountaineering Association, Dazhong Insurance Co., Ltd cooperated with Zhongti Insurance Brokers Ltd. to provide the special mountaineering and outdoor sports insurance, which fills the gaps in the field of China and becomes the unique insurance product in mountaineering and outdoor sports [10]. The sports leisure and outdoor sports insurance is far from perfect and must more fully protect the personal safety of the insured.

(7) Strengthen the sports leisure and outdoor sports safety education

The popularity of safety knowledge situation of sports leisure and outdoor sports is shown in Fig. 107.1. 57% of people believe that safety knowledge has not gained popularity, while only 5% of respondents believe that the safety knowledge of sports leisure and outdoor sports gains popularity, suggesting that relevant expertise has not been widely disseminated, which is one of the main reasons of accidents in outdoor mountain climbing sports. Fig. 107.2 shows that 64.6% of people think that it is necessary to carry out the sports leisure and outdoor sports safety education.

Fig. 107.1 The safety knowledge situation of sports leisure and outdoor sports

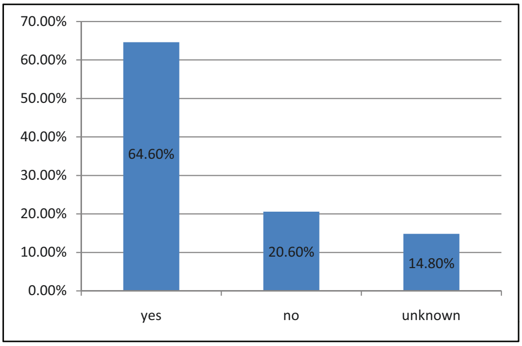
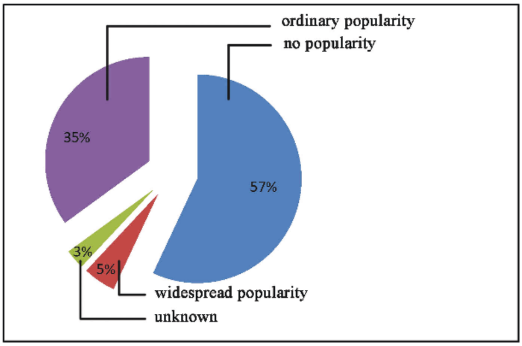


Fig. 107.2 The survey for sports leisure and outdoor sports safety education carried out



Lectures and courses related to the sports leisure and outdoor sports should be made within the schools to bring the popularity of the basic knowledge about outdoor sports. Besides, colleges should offer courses in professional theory courses, professional skills courses, management courses, and training courses of related skills and knowledge regularly to enhance the awareness about safety risk of students, cultivate better habits of outdoor sports in order to reduce the occurrence of unexpected accidents. As for the propaganda education, it should make full use of television, radio, newspapers, Internet and other media. For the professional rescue teams, the government should set up different training requirements and assessments for different positions, and perfect the identification mechanism.

In a word, the advanced experience in the development process of foreign emergency rescue system should be learned from. Combined with characteristics of Sichuan Province and the administrative, the advanced experience can be used in the management of sports leisure and outdoor sports rescue in order to establish sports leisure and outdoor sports rescue system, improve the management level, prevent and deal with various deaths and injuries scientifically and effectively, and promote the development of sports leisure and outdoor sports. Only the perfect sports leisure and outdoor sports rescue system is built, can the personal safety of the participants in the outdoor sports be guaranteed, and can the sports leisure and outdoor sports develop healthily and harmoniously.

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Chapter 108
Application of RFID Based Low-carbon Scenic Integrated Management System in Jiuzhaigou Area

Maozhu Jin, Di Zheng and Peiyu Ren

Abstract The development objective of ecotourism should be sustainable development as well as optimization of comprehensive benefits. Jiuzhaigou scenic region is located northwest Sichuan Province and more and more researchers from all research areas have paid their attention to the protection of the environment of this region for the scarce resources including water and species which have been affected by more and more tourists entering into this magnificent area. Therefore, to protect this area as well as keep the development rate of local economy, we introduce the concept of management entropy and with the application of RFID technology extend our existing space-time navigation method. Performance simulation results show our system can use proposed low-carbon scenic integrated management to achieve our goal of ecotourism.

Keywords Ecotourim · Jiuzhaigou · Management entropy · Low-carbon · RFID

108.1 Introduction

We usually describe some of the western China National Nature Reserves (nation-levelled scenic spots) by the terms such as natural scenic, economic underdevelopment and fragile natural ecological environment. Most of these spots are often ecologically fragile areas and it will be difficult for them to restore the origin conditions once destroyed. The restore process may exhaust thousands of years. However, the key point associated with these Reserves is natural landscape based eco-tourism. So the conflict between tourism development and ecological environment protection

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has become one of the most important questions in recent years. For example, the Tibetan Plateau and its periphery (Sichuan Aba Songpan prairie, Ganzi Hailuogou Glacier, Qiangtang prairie etc.). Therefore, development of tourism economy while protecting the natural ecological environment is an inevitable tradeoff for the sustainable development of the western scenic spots [1–6]. Furthermore, the western region is the ghetto of lots of minorities in China and it is also the main poverty-stricken area. So there is an urgent need to develop the economy for the reason of national stability and strategic purpose. The western zone is also main source of the healthy ecology of China and its ecological conditions have a tremendous impact on China's ecological security patterns, water resources and atmospheric environment.

So more and more researchers have pay attentions to the Low-carbon scenic integrated management mode to find a solution for efficient environmental protection as well as the development of economy. In our opinion, it should be a combination of new information technology with integrated management theory. Traditional scenic system just use some kind of wireless technology to improve the information and communication performance of the system [7–21]. Based on these works, we introduce the concept of management entropy and with the application of RFID technology extend our existing space-time navigation method. Therefore, we have finally constructed a complete architecture by using RFID based information process and management theory so as to monitor and control the entropy variation of the scenic spots to form orderly and being controlled management dissipative structure. By using this architecture we can solve the contradiction between the tourism based economic development of western area and eco-system protection as well as promoting the formation of management mode for sustainable and harmony development of the region's economic, social and environmental systems.

108.2 RFID Based Scenic Integrated Management System for Jiuzhaigou Area

108.2.1 Data Architecture of the RFID Based Scenic Integrated Management System

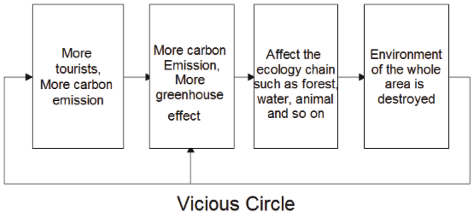
As depicted in Fig. 108.1, if we do not manage the tourists of the region in some certain way, the vicious circle will happen in a magnificent speed. So we have constructed the RFID based low-carbon scenic integrated management system as in Fig. 108.2.

In fact, the core goal of the management is balancing the number of the tourists and reduces the usage of the vehicles and avoid occurrence of overloaded of the scenic spots. We divide the system into three layers.

(1) Management decision level

This level is the so-called top-level design and it is composed of Environment Management System (EMS), Spatial-temporal Splitting Navigation Manage-

Fig. 108.1 Vicious circle



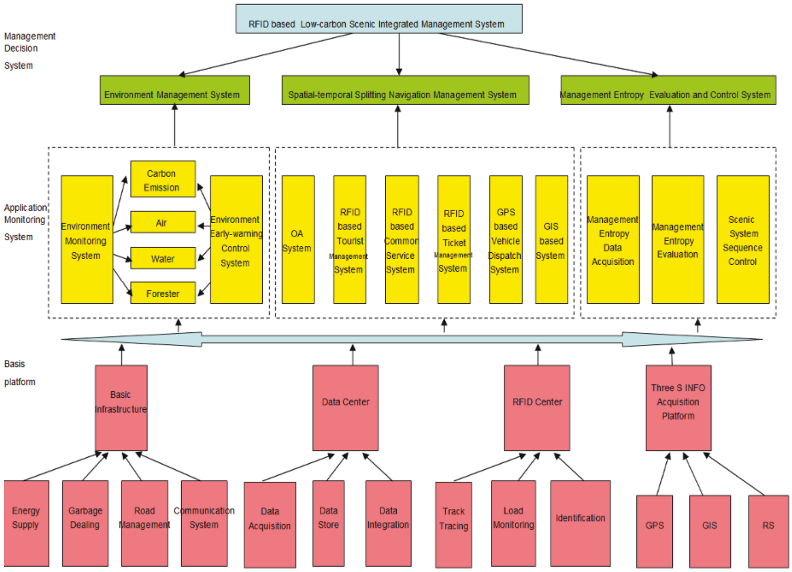


Fig. 108.2 Application architecture of the RFID based scenic management system

ment System (STSNMT) and Management Entropy Evaluation and Control System (MEECS). These systems work together to solve the problems such as contradiction between the peak tourists and the insufficient structural capacity of the scenic spots as well as according security risks and ecological damage to the environment.

(2) Application monitoring system level

This level is the middle level of the whole architecture and it is in charge of the core functions providing.

• Subsystem of EMS

The core components of EMS are the environment monitoring system and the environment early-warning control system. They manage the variation of environment resources including carbon emission, air degree, water quality and forester fire alarm.

• Subsystem of STSNMT

The core components of STSNMT are RFID based tourist management system, RFID based common service system, RFID based ticket management system, GPS based vehicle dispatch system and GIS based system coordinating by the OA system. All these sub-systems are the key parts of the whole system. Based on the management entropy theory, RFID, GPS/RS/GIS and environmental monitoring technology, they can monitor the scenic area tourism scale, tourist's behavior and ecological environment to collect and analyze data. By these data, we can improve the efficiency of decision-making; provide scientific use of resources and technical support for scenic temporal and spatial separation scheduling, control and energy saving management.

• Subsystem of MEECS

The core components of MEECS are management entropy data acquisition, management entropy evaluation and scenic system sequence control. These subsystems merge the management technologies and computer technologies. They regard the whole system from the point of management entropy. The value of management entropy is computed by the information from the RFID sensors. And once the entropy is above the threshold they will lead the according subsystems to make reactions.

• Basis Data System Level

From the point of data acquisition. This level is the bottom level of the whole architecture and it is in charge of basis information providing. This level can be divided into the data provides as follows:

• RFID info acquisition platform

This subsystem is in charge of the real RFID information dealing. It is like the context-aware system in pervasive computing. It gets the origin RFID information from the sensors and refines them to provide useful info.

• Three S info acquisition platforms

The three S here means GPS, GIS and RS. All these are common services for the whole system and they may provide kinds of electrical info for the reason of locating and so on.

• Safety info management platform

This subsystem is in charge of the safety management of the whole system such as info safety and infrastructure safety.

(3) Furthermore, from the point of applications, as depicted in Fig. 108.1, the bottom level is the basic platform including the supporting platforms as follows:

- Data center and three S info acquisition platforms. Both of these are used to provide data supporting and is the core parts of the data architecture.
- Basic infrastructure. The core components of it are energy supply, garbage dealing, road management and communication system. These components work together to provide common service for the whole system.
- RFID center. The core components of it are track tracing, load monitoring and identification. These components are the basis of STSNMT and they are in charge of the whole tourist condition with the help of the RFID information.

108.2.2 Using Management Entropy

Time and space based navigation of the tourists in peak time is based on management Entropy and dissipative structure theory. Management entropy is the diminishing law of the management efficiency in the enterprises' structure. It is in fact the organization, systems, policies and methods for any kind of management. In the process of the movement of a relatively closed organization, it always shows irreversibly the gradual reduction of the valid energy as well as constantly increasing of invalid energy. Jiuzhaigou valley can be seen as a relatively closed system. When the original procession of the organization in the region and the management of tourists are controlled by several uncertain and interactive elements, the management efficiency will decrease in a fast way. These elements are much complex for they may be composed of the number of tourists, psychological, behavioral, fixed scheduling program, organizational strategy, original policy and natural or cultural factors. Once barriers occur in the co-ordination between these elements, management agencies will be difficult to control the system according to original goals. Then some extent disorder will occur and the system may have the problems such as weakening and increased disorder of the scenic tourist flows.

In our system, we use RFID based information technologies to complete space-time based navigation. Then we can promote and strengthen the flowing among management organizations, tourists and environment. So the negative entropy can be introduced to space-time based navigation and make the whole system be balanced and highly ordered conditions.

108.2.3 Space-time Navigation Mathematical Model

In fact, the focus of this management is distribution of the tourists among spots in the scenic region and examination of overloaded spots. Then we can set up mathematical model aiming at balanced load distribution among different spots and complete tasks schedules with dynamic prediction of the load of every spots. Therefore, we can eliminate the overload condition of every spot in one hour field and get the whole region's load balancing. Under this mode, we can guide several tourists to travel A routine firstly while the others B routine firstly with the help of RFID information monitoring and tourists dispatching. And then exchange the routines with each other in order to distribute the tourists to different spots in time dimension and space dimension.

As follows are the mathematical model used to solve the problem.

(1) Problems

The tourists in the scenic region in different time period will form some kind of distribution. If the time period be reduced to a point, the spatial distribution remains. Ideally, if the load of every spot is balanced in any time t, we can think the load of every spot is balanced in the whole period composed of several continuing time point t. Therefore, our main problem is set up the model that makes the load of all the spots be balanced in any time point t.

(2) Suggestion

The model is based on the suggestions as follows:

- The capacity of every spots and the ways around these spots are large enough;
- The capacity of the other resources such as travelling bus and resting place are large enough;
- The travelling time of every tourist in the same spot is same.

(3) Parameters

In this model we use the parameters as follows:

A : Assembly of the scenic spots;
B : Assembly of the tourists;
C : Assembly of the vehicles;
n : Number of the scenic spots;
c_j : Capacity of the scenic spot j;
x_j : Capacity of passengers accommodated by spot j;
t_j : Staying time in the scenic spot j;
s_{jh} : Distance between spot j and spot h;
l_{kh} : Distance between the dispatching vehicle k and spot h;
p_{jh} : The probability that tourist will choose spot h in spot j;
r_{ij} : The probability that tourist i will take travelling bus in spot j;
$t_i j$: The entering time into the scenic spot j of tourist i;
v : Speed of vehicles.

(4) Variables

In time t, we define the variables as follows:

$$x_{ij} = \begin{cases} 1, \text{ tourist } i \text{ at spot } j, \\ 0, \text{ no.} \end{cases}$$

$$y_{kjh} = \begin{cases} 1, \text{ vehicle } k \text{ take tourist in spot } j \text{ spot } h, \\ 0, \text{ no.} \end{cases}$$

$$q_{ij} = \begin{cases} 1, \text{ tourist } i \text{ complete travelling in spot } j, \\ 0, \text{ no.} \end{cases}$$

(5) Mathematical model

$$z = \min \frac{1}{n-1} \sum_{j \in A} (R_j - \bar{R})^2, \tag{108.1}$$

$$\bar{R} = \frac{1}{n-1} \sum_{j \in A} R_j, \tag{108.2}$$

$$R_j = \frac{\sum_{i \in B} x_{ij}}{c_j}, (0 \leq R_j \leq 1, j = 1, 2, \ldots, n), \tag{108.3}$$

$$\sum_{j \in A} y_{kjh} \leq 1 (h \neq j), \tag{108.4}$$

$$0 \le p_{jh} \le 1, \tag{108.5}$$

$$0 \le r_{ij} \le 1. \tag{108.6}$$

Equation (108.1) presents minimizing the variance of the load of different scenic spots to act as the goal function. Equation (108.2) presents the average load of all the spots. Equation (108.3) presents the load of spot j. Equation (108.4) presents one vehicle can only take one way in some certain schedule. Equation (108.5) and Equation (108.6) present the probability of tourists' choice. In fact, for the variation of x_{ij} and the scale of the variations' value, this model can not be solved use precise algorithm. So we transform the question into find the best schedule plan as balancing as most at any time point.

108.2.4 RFID Based Space-time Navigation Schedule

In our system, the entrance distribution use hierarchical clustering method to get several kinds of distribution plans.

The system will simulate the results of these plans and compute the average usage and variance of these spots (If these two variables have lower value means the spot has lower load and load fluctuation). Then the system will choose the best plan. Exit point distribution can start from any spot and it can reduce the amount of the tourists in the region and resource configuration such as traveling buses. So we use the same evaluation method to choose the best plan.

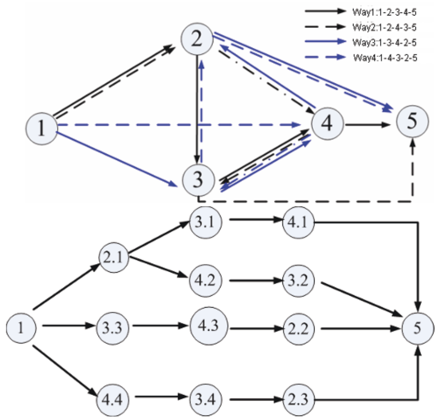


Fig. 108.3 Application Architecture of the RFID based Scenic Management System

To realize the schedule strategies, we use the RFID information managed by our system to automatically generate next day's tourists' distribution plan according to the number of tickets booking number in the e-commerce systems. And the according administrative departments of traveling bus, plank road, toilets and restaurant will form their working plan according the distribution plan and start the daily work in order.

Furthermore, we divide three kinds of schedule strategies into five schedule subsystems including tickets booking distribution subsystem, access shunt distribution subsystem, plan distribution subsystem, emergency distribution subsystem and price distribution subsystem. Tickets booking distribution subsystem use the tickets booking e-commerce platform to realize distribution before tourists begin their travel. And then we can avoid the conditions including the tourists are rejected around the entrance of the region and the tourists are crowded in the region. Access shunt distribution subsystem identify the time when the tourist groups or single tourist enter the region with the help of their RFID card. And the subsystem will determine the tourists can be allowed to enter the region or not. Plan distribution subsystem has been discussed before and it produce the relative best scheduling plan according to history tourists' information and it extend existing three-steps distribution to multiple-steps distribution. Emergency distribution subsystem is used to deal the special condition such as the unpredictable excessive concentration of the tourists not matching with the time-space navigation management plan or the crowed circumstance for the reason of accidence. Price distribution subsystem uses the price to balance the diversion of the tourists. For example, better touring time will have higher price as well as lower at general time.

108.2.5 RFID Based Management

For supporting the five distribution strategies, we used the RFID based management as follows:

(1) RFID based ticket management

Traditional Jiuzhaigou scenic spot ticket management use the inside touring as well as outside living feature and the access control ticketing subsystem use bar code as well as computer network to implement tickets selling, tickets inquiring, summary statistics and reports, tickets control and so on. However, these may lead to concentrated recount time and peak tourist flow. So the tourists are usually distributed into different spots unbalancing and some spots may be burdened with excessive pressure.

Furthermore, with the development of RFID technology, more and more spots have use RFID tags tickets management systems. And this kind of systems may have the features such as: support for special information writing and reading, support for tickets recycle to meet the environmental protection and cost reduction requirements. At the same time, UHF technology has a penetrating, fast reading speed and can help obtain data to achieve efficient user-friendly ticket checking without aiming by laser/read light. It also can support group reading, tile reading and large flow identification. The recognition distance can reach about 10 m to meet the management of the vehicles and the tourists in the scenic spot.

So, according to the status of Jiuzhaigou scenic spot, to raise the management efficiency we have used RFID technology as well as software, network and wireless communication to transform traditional tickets management system into RFID based tickets management system to provide basis for the whole scenic integrated management system.

(2) Real-time monitoring of the scenic region

The goal of the whole system is protecting the environment as well as supporting better service for more tourists. Then we should know the distribution of different areas. So we use RFID technology to solve this question to serve as the basis of the spatial and temporal shunt navigation.

As we have discussed before, we divide the scenic region into relatively independent small areas and set RFID readers in the key places such as tourists' focal point or necessary crossing etc. At the same time, the readers have several pairs of antenna and the antennas are configured in the gates or other key points to cover most key areas. While the tourists go through the key points, he RFID reader will get ID number of the tourists by different antennas and all the RFID tags through the place will be get by the readers. And the data will be sent to the control center in the first time. Then the system can determine whether the tourists are coming into the region or going out to know the distribution of the tourists among different areas to complete the real monitoring of the system.

By the way, a high-performance RFID reader can handle hundreds of e-tickets per second to so as to fully meet the needs of a large number of tourists' data processing.

108.3 Performance Results

By using the RFID based management system, we have simulated the time-space navigation based distribution according to the peak data of the tourists about twenty-four thousand. The simulation results show we will get 59.73 percent average usage of the spots and get 0.095 average variance. While old management system has got the results that average usage of the spots was 72.35 percent and average variance was 1.47. So the RFID based time-space navigation has lower usage fluctuate and can realize the low-carbon scenic management more effect.

As depicted in Fig. 108.4, the average load of different spots will be balanced in simulation results.

As depicted in Fig. 108.5, simulation results show the conditions that most of the tourists go inside the region in the peak time have been alleviated by used RFID based time-space navigation. The time span of the tourists enter the region are lengthen and less tourist enter the region in the peak time.

As depicted in Fig. 108.6, by the use of space-time navigation, the peak number of the tourists leaving the plank road will be put down efficiently.

As depicted in Fig. 108.7, by the use of space-time navigation, the peak number of the turbid degree of the water in the region will be put down efficiently.

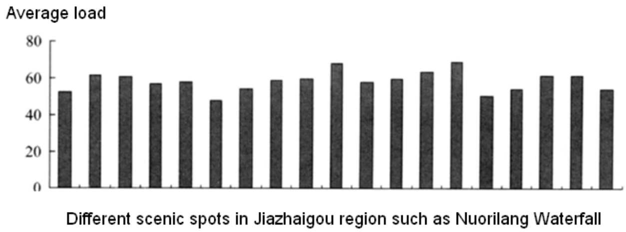


Fig. 108.4 Average load of different spots by simulation

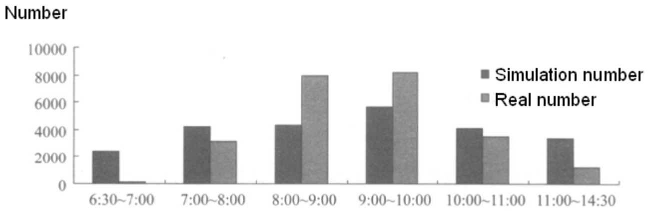


Fig. 108.5 Comparation between simulation number and real number

Fig. 108.6 Comparation of the number of the tourists leaving the way

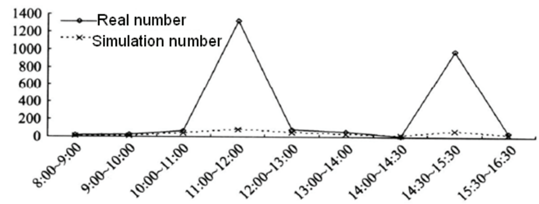
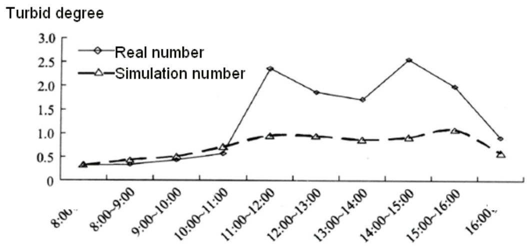


Fig. 108.7 Comparation of the turbid degree



As depicted in Fig. 108.8, by the use of space-time navigation, the peak number of the noise level in the region will be put down efficiently and most of the noise value will be under noise quality standard I of the city region.

As depicted in Fig. 108.9, by the use of space-time navigation, the lower level of the satisfaction degree in the region will be improved efficiently in the peak time and the whole satisfaction degree will keep about 90 percent.

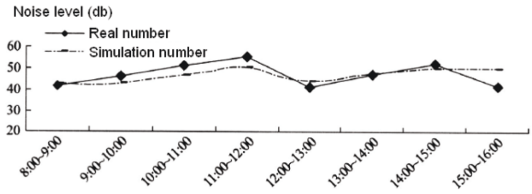


Fig. 108.8 Comparation of the noise level

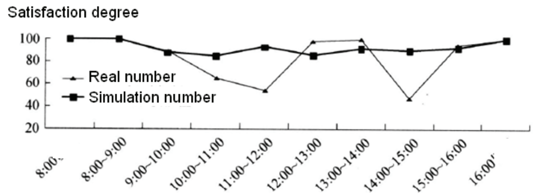


Fig. 108.9 Comparation of the satisfication degree

108.4 Conclusion

In many famous scenic places, the development of economy is usually at the cost of destroying of the environment. To avoid the developing way like this, we have completed the RFID based low-carbon integrated management system in Jiuzhaigou Area. Based on the guidance of the Management entropy and the RFID based time-space navigation, we have set up the whole system. We embed the RFID tag into tickets and make the system can trace the tourists exactly. Then we can use this RFID information to know the load of different scenic spots and complete the adjustment by different strategies. Therefore, Jiuzhaigou Scenic Area can make use of its advantageous tourism resources, and rely itself on income and expenditure through moderately developing tourism industry with the help of our system. Part of its income can be returned to the nature reserve as protection fund, and meanwhilelocal residents can benefit from the development and then devote themselves spontaneously into the environment protection and tourism development.

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Chapter 109
Improving Competitive Level of Elite Woman Tennis Doubles Players in China

Qing Liu and Ying He

Abstract Through technical statistics and analysis, observation and comparison at site, this paper points out the difference between basic technique, playing characteristics and main structure of score losing and gaining of our elite woman double players with that of foreign players. It suggests that we should focus on program assaulting fortified position in Olympic Games, following the law to win, finding the effective way against the tactics of net ball for players, strengthening communication between partners, elaborately setting the tactics against different kinds of serve, catch, break and attack in order to improve competitive level of our double players. Based on mission of Olympic Games, correlative measures are put forwarded.

Keywords Tennis · Woman · Double · Competitive ability · China

109.1 The Purposes and Tasks of the Research

Guided by the spirit of our Olympic strategy that the development of women sports should be given higher priority [7], to meet the actual needs of the tennis women double tennis training, regarding the 2008 Olympic Games as an opportunity, this paper aims at improving the scientific level of tennis training in China and the competitive level of women double tennis, and providing scientific and technological support and services for the 2004, 2008 Olympic Games. The main tasks: analyze the current technology state of in China, find the gap between China's elite woman double tennis players and elite woman double tennis players in the world, determine the development direction and technical style of China's double tennis projects further, and identify specific measures to achieve a breakthrough on the Olympic Games in 2004, 2008.

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109.2 Objects and Methods

109.2.1 Objects

The objects include Chinese women double players Li Ting/Sun Tiantian, Zheng Jie/Yan Zi who are the highest-ranked in the world from the point of our country, as well as some excellent double players in the world.

109.2.2 Methods

(1) Literature research

We had a broad review of literature about the double tactics, training methods etc in and abroad systematically in order to get a comprehensive understanding of the current development of the field and the latest study trends, grasp the technical and tactical characteristics and development trend of today's world tennis elite female double players [1].

(2) Survey

According to the research needs, experts and coaches relevant to the topics in this paper have been invited to attend the symposium three times during the national team and domestic training period. According to related issues, 38 athletes, 16 coaches and experts who were participating in 2003-2004 winter training-cum-training camp, preparing for the Athens Olympic Games, were consulted through questionnaires (recovery rate and efficiency were 98%, 100%).

(3) Observation

We have a watch of the live video data of Australian Open in 1999, 2003 Polo Tennis Open in Shanghai (a total of 16 games, 37cds) [2], and get a full technical statistics of International Women Tennis Challenge in Changsha, and Shenzhen during November-December 2003 (14 games, 32cds), the matches between Chinese women doubles player and foreign elite athletes (3 games, 7cds) in the French Open, in May 2004, and the matches of French Open top 8 world's elite double players (5 games, 13cds). Besides, we track and observe the national tennis women team's training in the country to gain a comprehensive understanding of the current training situation of China's women tennis.

(4) Computer statistics and logical analysis

SPSS for Windows 10.0 is used to process a variety of raw data for statistical analysis. Valuable regularity conclusion is extracted from a number of complex data for quantitative analysis, and the use of induction, comparison, analogy logic methods are also applied. The expected results are interpreted, analyzed, reasoned and argued.

109.3 The Main Statistics and Analysis

109.3.1 The Comparison of Basic Skills

According to the characteristics of double tennis, we main do statistics and analysis of Chinese elite women double tennis players'five basic skills, including serving a ball, serving and catching, ripping a ball up from the baseline, positive intercept in front of the net, midfield interception etc [4].

(1) Serving skills

In double tennis match, the serve quality directly determine whether the players get positive rights in the first four beats to create offensive opportunities in front of the net. Serving skill is one of the key skills to winning the game [5, 6]. From Table 109.1, we can know that all the first serve success rate of players in our country is lower than that of foreign players, that the first serve success rate of Li Ting/Sun Tiantian is only 62.3%, 5 percent points lower than that of foreign players, 10 percent points lower than that of the world's top athletes. From the spot observation, we find that not only the first serve success rate of our players is low, but also the serve speed, strength, placement change are poor. As a result, it is difficult for a player to give the opponents a certain pressure and create offensive opportunities for partners.

Table 109.1 The serving situation of women double tennis players (per beat)

	Serve attempts	First serve failure times	First serve success rate	Double failures
Li Ting/Sun Tiantian	29.3	11	62.3	3
Zheng Jie/Yan Zi	38.5	12	68.8	1.5
Foreign athletes	35.4	11	68.9	1.4
The world's top athletes	22.7	6.2	72.7	1.5

(2) Serving and catching skills

In double tennis match, the serving and catching skill whose requirements are higher is more difficult than singles. Thus, the serving and catching skill has significant importance [8]. From Table 109.2, we know that the direct scores got rates of serve and catch of our two pairs of players are higher than that of foreign players, lower than that of the world's top athletes. The failure rates of serve and catch of Li Ting/Sun Tiantian, Zheng Jie/Yan Zi are 17.6% and 15%, higher than that of foreign players, 6 percent points higher than that of the world's top athletes, which means a certain gap of serve and catch existing between Chinese players and the world's top athletes. From the spot observation, the proactive awareness, efforts to attack, pressure and force the net with the ball etc in serve and catch of our athletes have significant deficiencies, compared with the world's elite athletes.

(3) Ripping a ball up from the baseline

Table 109.2 The scores of serve and catch of women double tennis players (per beat)

	Serve & catch times	Direct scores got	%	Direct scores lost	%
Li Ting/Sun Tiantian	32.3	0.5	1.5	5.7	17.6
Zheng Jie/Yan Zi	40	0.3	0.7	6	15
Foreign athletes	33	0		4.8	14
The world's top athletes	26.2	0.9	3.4	3.1	11.8

As shown in Table 109.3, the scores of ripping a ball up from the baseline of all players in China are higher that of foreign player and the world's top athletes. The positive score rate of Chinese players is 38.5%, lower than foreign players' 42.9%, and the world's top athletes' 55% again. The no forced scores lost rate of Chinese players is 68.3%, higher than foreign player' 57.1% and the world's top athletes' 45%. From the spot observation, China's athletes often compete with their opponents in. However, their awareness to take the initiative to the net and to "grab" is not strong, and they can not reach the net timely. The overall performance is that the scores got or lost in the net is few, the pros and cons of the bottom line, while that in the bottom line is many, take Zheng Jie/Yan Zi for example.

Table 109.3 The scores of ripping a ball up from the baseline (per beat)

	Balance	Positive scores got	%	No forced scores lost	%
Li Ting/Sun Tiantian	6.3	2	31.7	4.3	68.3
Zheng Jie/Yan Zi	19.5	7.5	38.5	12	61.5
Foreign athletes	4.2	1.8	42.9	2.4	57.1
The world's top athletes	4	2.2	55	1.8	45

(4) The positive intercept in front of the net

The interception in front of the net skill is an important manifestation which implements the attack mainly and is fast guided by fast winning. As shown in Table 109.4, Chinese players seldom use this skill, for the times is small, and their success rate is lower than that of foreign players and the world's top athletes. The success rate of Chinese players is 61.5%, but the success rate of foreign players and the world's top athletes are 14 and 10 percent points higher respective. For the failure rate, the Chinese players' is 38.5%, higher than foreign players' 25%, much higher than the world's top athletes' 4.5%. We can come into the conclusion that there is a great gap of the positive intercept in front of the net between Chinese players and the world's top athletes. From the spot observation, the world's top athletes' utilization rate of the positive intercept in front of the net skill is higher than that of our athletes, and their ability to capture attack opportunities is stronger, and make less mistakes and have score higher rate. China's athletes have a small range of movement in the net, and can not seize the opportunity in time to attack, which is the fatal weakness of before and after the formation skill.

Table 109.4 The scores of positive intercept of women double tennis players (per beat)

	Times	Scores got	%	Scores lost	%	Balance	%
Li Ting/Sun Tiantian	2.6	1.6	61.5	1	38.5	0	
Zheng Jie/Yan Zi	2	1	50	0.5	25	0.5	25
Foreign athletes	4	3	75	0.8	20	0.2	5
The world's top athletes	3.6	2.6	72.2	0.16	4.5	0.84	23.3

(5) The midfield interception

The front and middle positions are focal points of both sides of the Tennis Doubles, for who occupy the midfield who will grasp the initiative of the game. As shown in Table 109.5, for the score rate in midfield, the Chinese players' is 41.1%, 6 percent points lower than foreign players', 14 percent points much more lower than the world's top athletes'. Besides, the lost score rate is 10 percent points higher than that of foreign players and the world's top athletes. Thus, there is a great gap of the midfield interception between Chinese players and the world's top athletes. From the spot observation, China's athletes make more mistakes in the frontcourt intercept, especially from the baseline to the net during which the move interception capability is worse. For Chinese players are not good at midfielder skills enough, they have not enough confidence in the net, resulting in lost the opportunity to force pressure to score in the game.

Table 109.5 The scores of midfield interception of women double tennis players (per beat)

	Times	Scours	%	Lost scores	%	Balance	%
Li Ting/Sun Tiantian	5.6	2.3	41.1	2	35.7	1.3	23.2
Zheng Jie/Yan Zi	5	2	40	2	40	1	20
Foreign athletes	7	3.3	47.1	2	28.5	1.7	24.4
The world's top athletes	12.6	7	55.5	3.6	28.5	2	16

109.3.2 The Comparison of the Double Nets and Skills

Tennis strategies are the technical, tactical and competitive characteristics based on one or two frequent used and maturing skills by the players in the competition. At present, the basic strategy for Tennis doubles include double net access, a net and a bottom and double bottom lines. According to the statistics, the number and ratio of foreign athletes and the world's top athletes using double net access were higher than that of China's elite athletes (see Table 109.6), and the difference was significant. From the spot observation, the main strategy used by woman double tennis players in China is a net and a bottom. In other words, tackling from baseline to create favorable conditions for the net closing down and force the pressure on the double, while the other stalemates are waiting for the opportunity to attack. The strategy of double attack after the serve and volley is rarely used. The statistical results shows that the success rate of double attack is relatively high, reaching 53.5% (see Table 109.6). This shows that China's athletes still has some two-on ability, especially the Li/Sun pair, but they lack confidence in the game, for not daring to use the strategy.

Table 109.6 The scores of two-on strategy of women double tennis players (per beat)

	Total scores	Using rate (%)	Scores	%	Lost scores	%	Balance	%
Li Ting/Sun Tiantian	4.3	13.4	2.3	53.5	1.3	30.2	0.7	16.3
Zheng Jie/Yan Zi	2	4.1	1	50			1	50
Foreign athletes	12.2	40.9	4.8	39.3	4	32.8	3.4	27.9
The world's top athletes	14	54.6	7	50	3.2	22.9	3.8	27.1

109.3.3 The Comparison of Main Gains and Losses Structure and Distributed Strategy

As shown in Table 109.7, Chinese players Li Ting/Sun Tiantian score mainly in positive intercept & middlebar, 32.3%, and Zheng Jie/Yan Zi score mainly in baseline stroke, 37%. While the foreign players score mainly in positive intercept and two-on, 35.3%, and the world's top athletes score mainly in two-on, 46.8%. This shows that the front net is the key to win in double tennis. The two-on score rate of Chinese players is only 18.1%, and that of foreign players is 35.3%, the world's top 46.8%. A statistical result of the average lost and gained scores from the first four shots and stalemate (5 shots later) shows that, major gaps between our athletes and foreign athletes, the world's elite athletes mainly exist in the first four shots, while the difference in stalemate is not significant, which means the Chinese double tennis players have certain ability of scoring in stalemate.

109.4 The Features and Skill Trends of the World's Outstanding Double Tennis Players in Match

(1) Serve pays more attention to the rotation and placement changes rather than simply pursuits strength

Table 109.7 The scores of main strategy of women double tennis players (per beat)

	Using times	High pressed balls	%	Baseline stroke	%	Serve, catch & serve	
Li Ting/Sun Tiantian	13.3	2.3	17.3	2	15	1.3	
Zheng Jie/Yan Zi	23	4.5	19.6	8.5	37	1	
Foreign athletes	13.6	2	14.7	1.6	11.8	0.4	
The world's top athletes	12.4	1.2	9.7	1.3	10.5	0.5	

	%	Positive intercept & middle bar	%	Two-on	%	Other	%
Li Ting/Sun Tiantian	9.8	4.3	32.3	2.4	18.1	1	75
Zheng Jie/Yan Zi	4.3	7	30.5	1	4.3	1	4.3
Foreign athletes	2.9	4.8	35.3	4.8	35.3		
The world's top athletes	4	3.3	26.6	5.8	46.8		

Now the players in women double tennis pay more attention to changes in rotation and placement than singles on the basis of the serve strength. They do not simply pursuit strength, but the organic combination of strength, rotation and placement, of maintained effectively serve speed during the race and change, accuracy and stability, and of offensive tactics after serving and serve skills. Maintaining a high first serve success rate and the driving position after serving is the main purpose of the service strategy and one of the basic laws of winning women double tennis [9].

(2) The serve and catch is more active and the sense of attack is stronger

With the level of serve and catch skills continues to improve, the high-level athletes are no longer satisfied with looking for an opportunity to fight back in a stalemate. Their attack and defense conversion is in advance. The point of attack turned on the serve and catch, especially the second serve and volley. Once the second serve is weak, the player will seize the opportunity to force sights. Therefore, the serve and catch has gradually transferred to the aggressive force attack from the robust defense in the past, and their awareness of attack is stronger, backing to the ball is in higher quality, and the catch is more initiative in order to keep "serve is the beginning of the attack, the catch and serve is the beginning of the attack two" in mind.

(3) Skills develop towards the direction of more fine and comprehensive

Skill is the basis of strategy, and skill comprehensiveness determines the variability of strategy. The double tennis is no exception. Attack and defense converse frequently, and many tactical changes in the game are completed on the basis of comprehensive skill. The requirement of skill is more sophisticated and more comprehensive than singles. Technical refinement mainly reflects on the precise and just right of hitting the ball, rotation, amplitude over the net, angle and placement etc. Comprehensive skill mainly manifested in two ways: first, the offensive and defensive technology must be comprehensive and no loopholes, and there is no obvious weaknesses in serve and catch, intercept the net, front interception, forehand and backhand baseline stroke, high pressed ball etc [10]. As the tennis game is held in a different climate and site conditions, athletes must have a more comprehensive technology and skills to adapt to change of venue and climate and maintain the competitive level of sustainable development.

(4) The active offensive philosophy is more clear

Proactive in the doubles match is more prominent than that in the singles. This offensive philosophy includes not only the active grab of network in midfield, net access to force pressure, but also vigorously pumping hit in the bottom line, accurate small-angle pumping the ball nets, offensive lob etc. Even if in a passive defense, attack thinking should be integrated in the defense so that defense is also attack. Players should try to attack as many as possible on the basis of the defense except for serving. Therefore, in the women doubles competition, regardless of the kind of play, whether in the front or in the bottom line, athletes must have a proactive awareness, and strive to use the most specialized skill with relatively high score rate to take the initiative to attack. Mastering the skill of how to take the initiative to attack in all situations, adhering to the guiding ideology of aggressive attack strategy is the inevitable development trend of the world women doubles.

(5) The strategy is flexible and the two-on strategy is mainly used

Confrontational sports need a change of tactics. Women double tennis change in tactics is more colorful than singles. For example, the serve and grab tactics in women doubles competition, during which companions serve net horizontal intercept or force the pressure on the net should change and different tactics should be applied according to different opponents game situation. Fast, flexible, adaptable, surprise and unexpectedly features are the common characteristics of all confrontational sports that rely on air superiority to win the net separated competition. Change, strain and flexibility are the basic law of the tennis doubles match tactics. Change is still one of the elements to win women doubles tennis competition. Excellent doubles player in the world play in diverse styles, but two-on strategy is still an advanced in the modern women double tennis to win. As a survey shown, the majority of the world's top athletes in the game adopt the two-on strategy. In the game, they are good at capturing every opportunity, accessing to favorable location quickly, implementing the various means of attack at the net to win the victory.

(6) Mutual communication and operation is an important guarantee of winning

Doubles beat their opponents through the close cooperation and coordinated operations. For an excellent doubles players, mutual understanding, trust, mutual assistance, tolerance, and feelings of harmony are the basis for the tacit understanding and acting in concert in the field. For high level of women double players, interaction and communication almost be carried out for every score of every game in the ball field. Strengthening the emotional communication tactical communication and technology exchange between the pair has become an important guarantee for the victory of the modern tennis doubles match.

In short, the world's elite women double tennis athletes highlight the strengths technical on the comprehensive technical basis, and pay attention to the changes in rotation and the coordination of the two on the basis of strength and speed. Guided by the idea of striving to take the initiative and aggressive attack, their strategy is more comprehensive, more clever tactics and more flexible on the basis of two-on net access. Comprehensive technology, rapidly changing, active net access and coordination is the major trends of the world women double tennis.

109.5 The Major Disadvantage of the China's Tennis Doubles Players

(1) The ability of two-on net access is weak and the confidence is in short

Two-on net access strategy is the inevitable trend of the development of the women doubles competition. However, for China's women's doubles players, two-on net access strategy is seldom used low in the game, and volley and serve and catch net access is rare. there is a considerable gap between Chinese players and the world's elite athletes. For the reasons, first, the lack of confidence in the technology of the middle column, results in not daring to access the net; second, the awareness is not strong, without a profound understanding of the doubles match net is the focal point of contention between the two sides. So, their awareness of initiative attack is not strong in the game, and they lack courage to access the net and lose a lot of favorable opportunity to attack.

(2) Serving, receiving and first 4 beats' attack need to strengthen

Excellent doubles player in the world attaches great importance to the rotation and placement changes, especially in the second rounds based on a pro-serve rapidly after the net or 3 shot attack. The success rate of our athletes first shot is not high, and the rotation and placement is of little change, which seldom creates opportunities to beat offensive for the third shot. For serve and catch, the rate of mistakes is high and in poor quality, which has a direct impact on the smooth implementation of the various means of attack after the fourth beat and shot.

(3) Proactive awareness and control of the ball in the net need to be improved

Our athletes' average net active intercept success rate is lower than that of the world's top athletes. From the observation of the spots, the sense of the world's elite athletes to take the initiative to grab is strong, and the scope of activities is large, which puts powerful pressure and interference to opponents' bottom line, causing the opponent to return the ball in lower quality, thus to create their own opportunities to attack. For Chinese athletes the net active awareness is not strong, the range of activities is small, which can not form pressure and interference to opponents, and the opponent can arbitrarily pumping strike back, thus loss more opportunities to grab in game for Chinese athletes, the ability of controlling the ball in the confrontation before net is poor.

109.6 Countermeasures and Suggestions

Improve the women double tennis competitive level and establish the direction of skill development:

- The importance should be emphasized and players should concentrate on the Olympic crucial project.
- Follow the tennis doubles winning law, and comply with the development trend of the world.
- Find out an effective means to deal with two-on net access tactics through training and simulation.
- Strengthen the tacit understanding and exchanges between the pair in training on purpose, and well-designed sets of serve and grab tactics and sending and receiving attack tactics.to deal with all types of athletes.
- The proportion of speed and strength, sensitivity and coordination and footwork should be increased in physical training.

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Chapter 110
Low-carbon Economic Structure Evolution for Sustainable Development of Western China

Yanfei Deng and Lei Xu

Abstract With economic development and the change of economical structure, structural evolution of economical system is an inevitable trend especially in low-carbon environment.This paper study the economical structure considering the environment, economic and social requirements in order to implement low-carbon development combining multi objective planning techniques, chance-constrained model under fuzzy random environment. Then setting energy-saving, economic growth, and laborer's employment as the goals. After comparing the simulation result of three different schemes, we conclude that the type of economical structure directly determine carbon dioxide emissions. It will significantly reduce the energy consumption and environmental pollution through adjusting the economic structure using our model. Finally, we proposed policy recommendations according to the situation based on the research results of our model.

Keywords Industrial economic system · Regional economics · Low-carbon Developing country · Sustainable development

110.1 Introduction

Environmental issues have increasingly become the focus of world attention especially in the urban areas, with the risks of climate change, and associated unreasonable economical structures being two of the important considerations. As many countries' economical production has increased rapidly over the last decades, they have become known as newly industrializing countries. In these countries, econom-

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ical growth has been much higher than economic growth in agriculture over the past 15 years and the share of industrial production in their GNP is rapidly increasing [10]. Economical activities in general have however never been without environmental problems and therefore it is not surprising that the accelerated industrialization, entailing a dramatic transformation of the industrial sector, included some serious environmental problems [1, 4, 9].

Detailed theories of economical structure have been proposed for a couple of years [3, 5, 6]. Clark [7] summarized the changing law of economical structure and testified its importance to economic development. Chenery [2] standardized the open economical structure theory and put forward the development type theory. However, there is little research on the relationship among low-carbon economy, economical structure in the development mode. More importantly, these current research could not apply to our actual situation without considering the fuzzy random environment.

The chapter is structured as follows. Sect. 110.2 provides the problem background in this study. Sect. 110.3 discusses the research methods and describes a new model, the multi objective planning techniques, chance-constrained model, which is designed to analyze the economical structure of environment and development choices. Sect. 110.4 presents a case study. A city in China is presented as a case and three scenarios based on our model are proposed to reach the aim of reducing environmental damage. Sect. 110.5 presents the empirical results, and Sect. 110.6 presents a summary and concluding remarks.

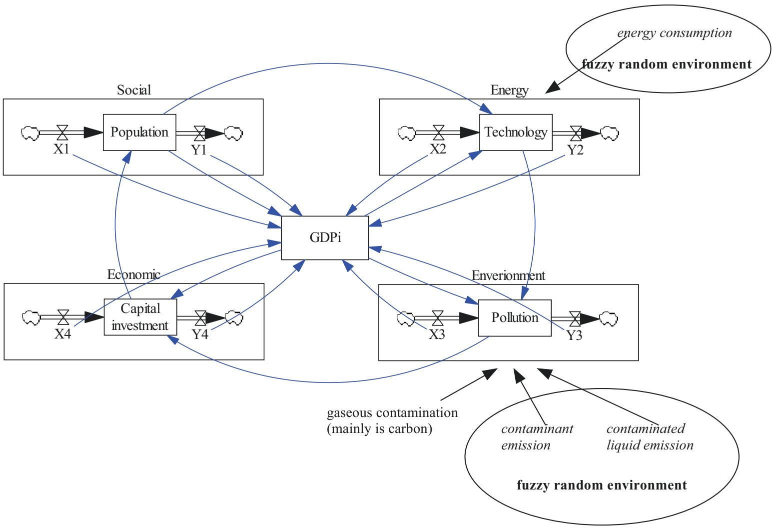

Fig. 110.1 The SD model of low-carbon industrial structure system

110.2 Problem Background

In this section, we will describe the economical system studied in our paper. The low-carbon development system is described by the diagram in Fig. 110.1. We will define the parameters used to describe and analyses the system. The model is composed by four subsystems which are population, capital, resource and environmental subsystem which represent the social, economy and environment system respectively.

These issues are highly interrelated, not only among each other but also with a variety of social, economic, political, environmental and technical factors. How to achieve the goal of economic growth and emission reduction as well maintaining economic growth is the chief task of a low-carbon economic development.

110.3 Modelling

110.3.1 FRCCP Model

In this section, we set up the universal form of the SD-FRCCP (system dynamics-fuzzy random chance constraint program) model. Factors affect each other, which means the system can keep developing. By the analysis above, we observed that complex interactions between inherent components must drive the growth of the system: steering and governance are limited by knowledge of these interactions.

We let G express the polyclinics set, X be the scheme set, Z be the product value set, C be the fuzzy variables and F be the objective set. G expresses the input values or named as the raw data, there are M years to be forecasted $\{G_1, G_2 \cdots, G_M\}$; $X = \{X_1, X_2, \cdots, X_N\}$ is the set of all schemes. Z is the set of all products values and is decided by X. So if there are K products in all the schemes, Z can be expressed as $\{Z_1, Z_2, \cdots, Z_K\}$, and K may be equal to N or not. C_K is the value of the fuzzy variables, and if there are K products, there must be K fuzzy variables in the model. $F = \{F_1, F_2, \cdots, F_K\}$ are the set of all objectives that the decision-maker look forward. Actually, we get the optimal value of fuzzy variables C_K through the process of objectives F_K in order to run the SD system.

Thus, the economical system includes G_m $(m = 1, 2, \cdots, M)$; X_n $(n = 1, 2, \cdots, N)$; $F_k, Z_k, C_k,$ $(k = 1, 2, \cdots, K)$. This dynamics model can be described mathematically as:

Level: level parameter is controlled by the raw data G_m $(m = 1, 2, \cdots, M)$ and rate parameter X_n $(n = 1, 2, \cdots, N)$.

$$Z_k = f(G_1, G_2, \cdots, G_M, X_1, X_2, \cdots, X_N), \ k = 1, 2, \cdots, K. \tag{110.1}$$

Objective: objective function is affected by level parameters and fuzzy variables.

$$F_k = f(Z_1, Z_2, \cdots, Z_K, C_1, C_2, \cdots, C_K), \ k = 1, 2, \cdots, K. \tag{110.2}$$

Fuzzy: fuzzy variables are the price of products and affected by many other factors.

$$C_k = (\mu_k, \alpha_k, \beta_k),\ k = 1, 2, \cdots, K. \tag{110.3}$$

The general SD-FRCCP modelling may be described mathematically as follows:

$$\max F_k = f(G_1, G_2, \cdots, G_M, X_1, X_2, \cdots, X_N, C_1, C_2, \cdots, X_K),$$
$$\text{s.t.} \begin{cases} g_i(X_1, X_2, \cdots, X_N) < 0, \\ C_k = (\mu_k, \alpha_k, \beta_k), \\ i = 1, 2, \cdots, I,\ k = 1, 2, \cdots, K. \end{cases}$$

110.3.2 Solution Method

In order to solve the uncertain model, we must convert it into a deterministic model. We take multi-objective as the example to illustrate the solution method.

$$\max\{f_1(x), f_2(x), \cdots, f_m(x)\},$$
$$\text{s.t. } x \in X.$$

Solving method can be summarized as:

Step 1. solve programming problems $\max_{x\in X} f_i(x)$ and $\min_{x\in X} f_i(x)$, maximum $f_i^{\max}$ and minimum $f_i^{\min}$ function $f_i(x)$ in the feasible region $x \in X$, $i = 1, 2, \cdots, m$.

Step 2. we will build new dimensionless function for the objective function $f_i(x)$:

$$H_i(x) = \frac{f_i(x) - f_i^{\min}}{f_i^{\max} - f_i^{\min}}. \tag{110.4}$$

Step 3. we will make the target weighted, then we make the multi-objective programming problem into single objective optimization problem:

$$\max_{x\in X} \left[\sum_{i=1}^{m} \omega_i H_i(x)\right], \quad \sum_{i=1}^{m} \omega_i = 1.$$

110.4 Optimization and Simulation

110.4.1 Analysis of Data

In this section, Leshan is used as a typical case to study. A system simulation is performed using the simulation software VENSIM and data from 2010 marked as the initial condition.

Situation of Leshan

Leshan has been one of the most representative cities in China and faces considerable pressures and challenges. Leshan aims to build the first demonstration of a low carbon economy and strives to reduce carbon intensity by 20% by 2020.

(1) Industrial structure situation

The share of industrial added value for the three major industry sectors in GDP is 11.0:46.5: 42.5. Even though the industrial structure has changed considerably due to the decade long rapid development, there is still a certain disparity with what is considered to be a reasonable standard.

(2) Pollution and energy situation

The carbon intensity of leshan has increased from 0.6 in 2001 to 0.71 in 2008. Energy consumption is twice as high as the national average and the new/renewable energy proportion is too low with coal being the primary source. The structure changes of pollution and energy is shown in Fig. 110.2.

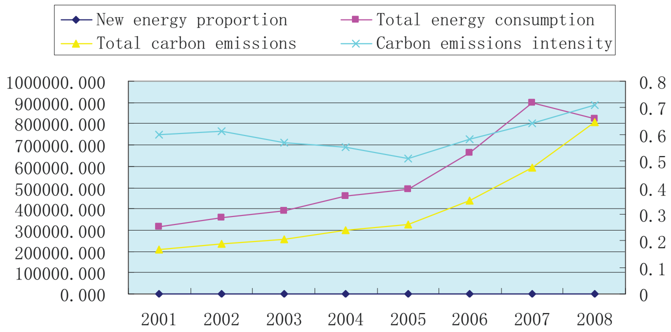

Fig. 110.2 Structure changes in trends of pollution and energy

110.4.2 Three Different Scenarios for Low-carbon Development

To choose the optimum strategy for the the low-carbon development of Leshan, this paper examines three different scenarios to test and analyze the simulation results.

- Inaction scenario. The economical sector proportions remain the same as at present without any readjustment or upgrade.
- Industrial structure adjustment scenario. The economical sectors will be adjusted according to the ideal proportion predicted by the SD-FRCCP model with the proportion being 10.7: 43.8: 45.5.
- Industrial structure adjustment+carbon reduction scenario. This is considered the optimal scenario and follows the assumption of scenario 2 but with higher weights for pollution abatement and energy consumption reduction because of higher environmental investment.

110.5 Simulation Result

Carbon intensity refers to the carbon dioxide emissions per unit of GDP which fluctuates with technology progress and the growth or decline in the economy. Thus, as the table shows, though both the carbon emissions and GDP are growing, the carbon intensity of all three scenarios declines as the GDP growth rate is at a higher rate than for carbon emission. The comparison of carbon intensity of three scenarios is shown in Table 110.1.

Table 110.1 Comparison of carbon intensity of three scenarios

	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Scenario 3	0.53	0.49	0.46	0.44	0.43	0.41	0.40	0.39	0.39	0.37
Scenario 2	0.54	0.52	0.51	0.49	0.48	0.46	0.43	0.41	0.39	0.39
Scenario 1	0.56	0.59	0.64	0.69	0.73	0.78	0.84	0.87	0.90	0.94

There is a bigger gap in carbon intensity in scenario 3 and scenario 2 compared with between scenario 2 and scenario 1. Different from the other two scenarios, the aim to reduce carbon intensity by 20% in Leshan is reached in scenario 3. This is a result of the implantation of low-carbon measures and higher environmental investment.

Through a comparison of data between scenario 2 and scenario 3, we find that industrial structure adjustment takes longer to affect carbon intensity than to affect environmental investment. Therefore, it is better to put more investment into the environment rather than in the adjustment of the industrial structure if an area wants to change its carbon intensity in the short term.

110.5.1 Policy Proposal

(1) Increase the number of related policies to encourage environmental investment

It is now important to implement more environment protection policies including a reduction in carbon emissions. Policies should encourage the development of an environmental protection industry and should have severe penalties for enterprisers with illegal emissions or other actions which lead to environmental degradation. Further, environmental protection investment need to be increased and the introduction of new energy technologies needs to be strengthened. This is critical in reaching the aim of realizing low-carbon development.

(2) Construct integrated chain of industrial tourism

The tourism resource is an important driving force for economic growth, so it should also be an important force in dealing with the associated environmental problems. Generally, there are a lot of tourist arrivals in Leshan. Thus, the government should exploit some other places such as a sightseeing tours of the city for the tourists' entertainment. Also the exploitation of the precious natural and cultural resources in these areas needs to be conducted positively.

(3) Establish the social security system

A perfect market system and social security system create a good external environment for industrial structural adjustment. A strong social security system is the inevitable requirement for economic development and industrial structure adjustment. Whether the social security system is sound and safe or not is the key sign for rational secondary industry structure in the area or in the country. A perfect social security system is helpful for the development of the industrial structure adjustment.

110.6 Conclusion

This paper built an SD-FRCCM model for research into adjusting to a low-carbon economic structure and compares three different scenarios. The simulation result shows that: all three scenarios show a clear reduction in carbon intensity, but only in scenario 3 is the aim to decrease it by 20% achieved. These results conclude that scenario 3 is the best of the three scenarios for lowering carbon intensity and protecting the environment with GDP growing normally. In a word, the established SD-FRCCM model simulates the real system precisely and offers directions for changes to the system. Further, the model is useful for the analysis of low-carbon economic structure adjustment in world natural and cultural heritage areas. It is possible to add more indicators to this model for a more complex analysis and a more comprehensive result in future.

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Chapter 111
Applying STIRPAT Model to Identify Driving Factors of Urban Residential Building Energy Consumption: A Case Study of Chongqing in China

Yahui Zhu and Weiguang Cai

Abstract In this articlepopulation, urbanization, construction area and the level of urban consumption are selected as the key factors of driving the growth of urban residential building energy consumption. At the same time, STIRPAT model is adopted to research quantitatively on the influence of these factors. Ridge regression is adopted to set up the driving factors regression model of urban residential building energy consumption. According to the results of the regression analysis, it is concluded as follows that firstly, the level of urban consumption has much more influence on the growth of urban residential building energy consumption than other factors, secondly increase of urban construction area directly drives the growth of urban residential building energy consumption, and thirdly the structure of population has much more influence on the growth of urban residential building energy consumption.

Keywords Building energy consumption · Urban residential building · STIRPAT model · Driving factors · Regression analysis

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111.1 Introduction

Building energy conservation is an inevitable choice for sustainable development in China. And it is an important measure to reduce greenhouse gas emissions and ensure national energy security. With the accelerating urbanization and the improvement of people's living standards, the proportion of building energy consumption will be up to 40% of general national energy consumption based on the experience of developed countries, though at present it is less than 30% [1].

Cai [1] divided the life-cycle building energy consumption into three parts, which are energy consumption of building materials production, construction of new buildings and running of existing buildings. Based on the statistics analysis from 1980 to 2009, it was concluded that energy consumption of existing buildings in the running stage is the main body of building energy consumption. For example, in 2009, it was up to 47 percent of total building energy consumption, and up to 23.4 percent of national energy consumption.

According to energy consumption statistics in China, energy consumption of existing buildings can be divided into energy consumption of public buildings, energy consumption of residential building and energy consumption of heating in the northern area. Chongqing is located in southwest of China and the centralized heating is not implemented. Therefore energy consumption of existing buildings includes energy consumption of public buildings and residential building. Especially energy consumption of urban residential building is the main part based on the statistics analysis [1].

With the urbanization acceleration, energy consumption of urban residential building will keep the continual growth. Therefore, it is helpful for the government to carry out the effective policy and measure and promote the building energy efficiency if the key influencing factors can be identified and the impact of these factors can be determined quantitatively. In this article, the qualitative and quantitative methods are adopted o study the impact of population, urbanization, construction area and living standards on urban residential building energy consumption.

111.2 Theory of STIRPAT Model

In the past, the impact of population, economic development and technological progress on the environment were studied deeply and many mathematical models were set up.

111.2.1 IPAT Model

In order to reveal the impact of population, economic development and scientific and technological development on the environment, Ehrlich and Holden [2, 3], the famous American demographers set up the IPAT model in 1971.

The equation is showed as follows:

$$I = PAT, \tag{111.1}$$

where I = the environment impact or impact, P = the population, A = affluent degrees, and T = technical progress.

The IPAT model revealed that the three major driving factors on environment change are population, economy and technology, the relationship among which is independent and relative each other, and environment change is the result caused cooperatively by these factors. For example, during a certain period for a given country, if variable P and variable T keep constant, but variable A is increasing continuously, it is not reasonable to consider the environment change caused by variable A totally. The reason lies in the influence from variable P and variable T are reflected in the change of variable A [4].

Based on IPAT model, many scholars revised further. Waggoner and Ausubel [5] set up IMPACT model, which is showed as follows:

$$I = PACT, \tag{111.2}$$

where variable T in IPAT model is divided into variable C and variable T. Variable C is the consumption per unit GDP, and variable T is the influence caused by the consumption per unit GDP. Schulze [6] introduced variable B into the IPAT model, and set up IPBAT model, which showed as follows,

$$I = PBAT, \tag{111.3}$$

where variable B = human behavior. Schulze believed that there were many other effective ways to reduce the environment change, such as human behavior, except relying on effective technology or reducing GDP. However, there is still controversy about it. Mark believed that the variable B has been included into the population, per capita GDP and technology, therefore variable B should be the other factors which exclude population, per capita GDP and technology [7]. It is very difficult to distinguish them.

111.2.2 STIRPAT Model

Dietz and Rosa [8] set up STIRPAT (Stochastic Impacts by Regression on PopulationAffluence and Technology) model to revise IPAT model further, which is showed as follows,

$$I = aP^bA^cT^de, \tag{111.4}$$

where I = the environment impact, P = the amount of population, A = per capita GDP, T = technical progress, a = model coefficient, b = index of population, c = index of per capita GDP, d = index of technical progress, and e = model deviation.

Equation (111.4) can be expressed with the form of logarithm, which is showed as follows,

$$\ln I = \ln a + b\ln P + c\ln A + d\ln T + \ln e. \tag{111.5}$$

Equation (111.5) can not be directly used for multiple linear regression analysis. According to IPAT model, the regression result of all indexes should be 1. Therefore, York et al [9] pointed out that variable T in STIRPAT model should not be estimated separately but be also included into model deviation when analyzing regressively. The revised model is showed as follows,

$$\ln I = a + b\ln P + c\ln A + e, \tag{111.6}$$

where a = constant, and e is the residual value.

At the same time, York et al [9] introduced the concept of Ecological Elasticity (EE) in order to analyze the problem further and deeply. Ecological Elasticity (EE) refers to the proportion of environmental impact caused by any crucial factor.

111.3 Qualitative Analysis on Influencing Factors

In this article, the factors directly influencing on building energy consumption are selected to analyze further, which are total population, urbanization rate, per capita residential floor space of urban residents and index of resident consumption expenditure.

111.3.1 Population

With the continuous expansion of the population, the demand for energy and resources is rapidly growing, and the pressure on the environment keeps increasing. In Chongqing, total population was up to 3329.81 ten thousand persons in 2011, while total population in Chongqing was 3072.34 ten thousand persons in 1999. According to Fig. 111.1, it can be concluded that in the past ten years, population kept continuously increasing and total population increased nearly 260 ten thousand persons.

The influence of population on energy consumption lies in many aspects. Firstly, energy demand always increases with the increase of total population, resulting in the increase of greenhouse emissions. York et al [9] believed that the elasticity coefficient between population and carbon dioxide emissions was close to 1. Secondly,

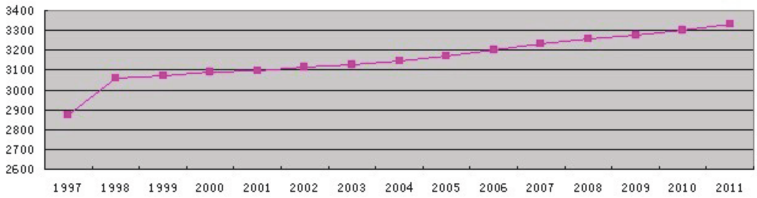

Fig. 111.1 Total population in Chongqing from 1997 to 2011

with the urbanization, the proportion of urban population increases, and energy consumption also increases significantly. Thirdly, the age structure of the population will influence on carbon dioxide emissions. Liu [10] believed that the proportion of the persons whose age is from 15 to 64 will influence on carbon dioxide emissions greatly. Fourth, the family size will influence the per capita energy consumption. The larger family size, the smaller per capita energy consumption. Chen et al [11] believed that in recent years, there is a trend of smaller family size, and the number of households increased faster than the growth of the total population, which resulted in the carbon emissions growing rapidly.

111.3.2 Urbanization

After reform and opening up, urbanization in China has entered into a new stage and kept fast growth, especially in the recent twenty years, which is showed in Fig. 111.2.

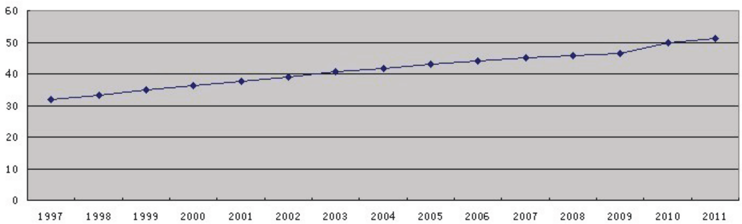

Fig. 111.2 Urbanization rate in China from 1997 to 2011

In 1997, Chongqing became China's fourth municipality directly under the central government, the only one in west China. Since 1997, urbanization in Chongqing kept rapid growth. In 2011, the total population in Chongqing was 3329.81 ten thousand persons, and urbanization rate is 55 percent. Urbanization rate in Chongqing from 1997 to 2011 is showed in Fig. 111.3.

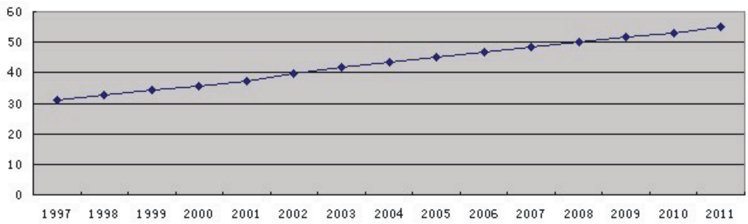

Fig. 111.3 Urbanization rate in Chongqing from 1997 to 2011

The influences of urbanization on building energy consumption mainly lies in three aspects. Firstly, with the urbanization, large-scale urban construction occurs and the construction area grows rapidly. Secondly the tertiary industry is drove to develop fast with the accelerated urbanization, which results in the increase of public buildings energy consumption. Thirdly, usually per capita energy consumption in urban area is higher than that in rural area, and the increase of urban residents will result in building energy consumption increasing fast.

111.3.3 Floor Space of Building

Load of devices will be larger with the increase of building floor space. For example, load of lighting systems, air conditioning and heating system is designed according to building floor space. The greater the building floor space, the load larger, building energy consumption larger.

The proportion of residential buildings in buildings under Construction was always above 50 percent in the recent ten years, and the Per capita residential floor space in urban area was increasing rapidly. In Chongqing, the Per capita residential floor space in urban area increased from 9.21 Square meters in 1998 to 31.77 Square meters in 2011. The increase of per capita residential floor space in urban area in Chongqing from 1998 to 2011 is showed in Fig. 111.4.

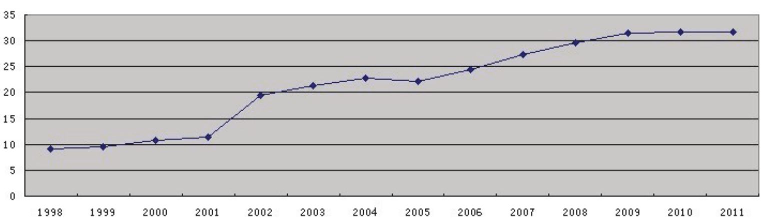

Fig. 111.4 Per capita residential floor space in urban area in Chongqing from 1998 to 2011

111.3.4 The Consumption Level

The level of resident consumption reflects the degree of products and service meeting the demand of survival, development and enjoy for people. The main indices are the amount and quality of the products and service consumed.

After basic demand is met, people will begin to pursue to more comfortable living environment. For example, in China, the amount of air conditioner kept increasing rapidly in the recent twenty years. The change of number of air conditioner owned per 100 urban households in Chongqing from 1998 to 2006 is showed in Fig. 111.5 and that from 2006 to 2011 is showed in Fig. 111.6.

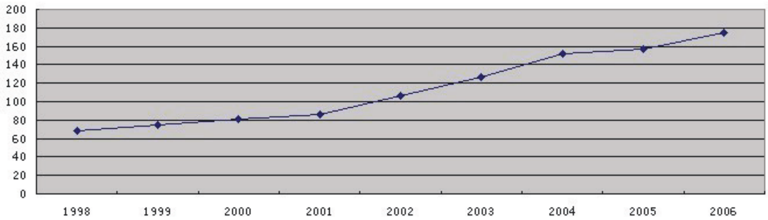

Fig. 111.5 Number of air conditioner owned per 100 urban households in Chongqing from 1996 to 2006

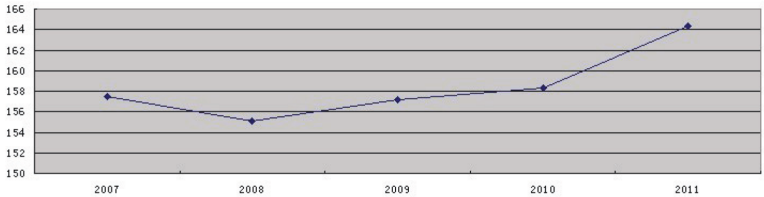

Fig. 111.6 Number of air conditioner owned per 100 urban households in Chongqing from 2007 to 2011

From Fig. 111.5 and Fig. 111.6, it can be concluded that the number of air conditioner owned per 100 urban households in Chongqing was increasing continuously with different increase rate in the above two stage. From 1998 to 2006, the increasing rate was higher than that from 2007 to 2011. The significant change in the first stage reflected the improvement of people demand with the economy development and increase of people income. The number of air conditioner owned by urban households always keeps continuous growth though the ascent was slow in the second stage, because the number of urban household increases rapidly with fast urbanization.

As a result, energy consumption in air conditioning will become larger and larger, which drive building energy consumption increase further.

111.4 Empirical Analysis

111.4.1 STIRPAT Model for Analysis on Building Energy Consumption

According to IPAT model and the qualitative analysis on driving factors for energy consumption of urban residential building, in this article, population and the affluence in IPAT model are divided. Population is divided into total population and population distribution between urban and rural area which is expressed with urbanization rate. And affluence is divided into per capita urban residential floor space and consumption expenditure index for urban household. With the progress of technology, building energy consumption will decrease. In this article, those factors driving the energy consumption increase are mainly analyzed. Therefore, when building up the STIRPAT model for building energy consumption, the factor technology is not considered.

$$\ln E = \ln a + b_1 \ln P + b_2 \ln U + c_1 \ln A + c_2 \ln C + \ln e, \qquad (111.7)$$

where P refers to the total population, U refers to the urbanization rate, A refers to per capita urban residential floor space, C refers to consumption expenditure index for urban household.

Why consumption expenditure index for urban household is selected as the index of consumption level lies in three aspects. Firstly, comparing with the index of per capita disposable income, consumption expenditure index for urban household can demonstrate the improvement of living standards of the people much more. Secondly, consumption expenditure index excludes the influence of price fluctuation, which makes the index in different year comparing. Thirdly, although the increase of that can reflect that people have higher and higher demand for thermal comfort of living environment, the number of air conditioner owned per 100 urban households change large, which is not helpful for the regression analysis.

111.4.2 Data Resources

In this model, all the data are from 1998 to 2011, including building energy consumption, the total population, urbanization rate, per capita residential floor space in urban area and consumption expenditure index for urban household. The explanation of variables in the model is showed in Table 111.1.

The data of Energy Consumption for urban Households is from table of overall energy balance in Yearbook of Chongqing (1999-2012). The data of total population is from table of Total Households and Total Population in Yearbook of Chongqing (1999-2012). The data of urbanization rate is table of Resident Population and Rate of Urban Population in Yearbook of Chongqing (1999-2012). The data of per capita

Table 111.1 The explanation of variables

Variable	Explanation	Unit
Energy consumption of urban residential building	Energy Consumption for urban Households	10 000 tons of SCE
Total population	Total population in Chongqing	10 000 persons
Urbanization rate	The proportion of urban population in total population	%
Per capita residential space in urban area	Per capita residential floor space in urban area	Square meter (Sq.m)
Consumption expenditure index for urban household	Value of the index in 1978 = 100	

Table 111.2 Relative data in the model

Year	A	B	C	D	E
1998	111.83	3059.69	32.6	9.21	527.1
1999	118.74	3072.34	34.3	9.51	523.4
2000	121.22	3091.09	35.6	10.72	506.1
2001	123.08	3097.91	37.4	11.47	514.7
2002	119.47	3113.83	39.9	19.56	512.6
2003	120.15	3130.10	41.9	21.29	515.7
2004	121.78	3144.23	43.5	22.76	534.8
2005	277.32	3169.16	45.2	22.17	539.1
2006	322.73	3198.87	46.7	24.52	552.0
2007	322.31	3235.32	48.3	27.31	577.9
2008	353.13	3257.05	50.0	29.68	610.3
2009	394.69	3275.61	51.6	31.42	600.5
2010	401.23	3303.45	53.0	31.69	619.8
2011	496.75	3329.81	55.0	31.77	652.6

A: Energy Consumption of Urban residential building (10 000 tons of SCE); B: Total Population (10 000 persons); C: Urbanization Rate (%); D: Per Capita Residential Floor Space in Urban Area (Sq.m); E: Consumption Expenditure Index for Urban Household.

residential floor space in urban area is table of Material and Cultural Life of Urban & Rural Residents in Yearbook of Chongqing (1999-2012). The data of consumption expenditure index for urban household is from table of General Indices of Consumer Price and Retail Price in Yearbook of Chongqing (1999-2012). All are showed in Table 111.2.

111.4.3 Regression Analysis

(1) Judgment on variable multi-collinearity

The important hypothesis to adopt ordinary Least Squares (OLS) to regress linearly is that there is not high linear relationship among variables [12]. For the multiple linear regression matrix $Y = X\beta + \varepsilon$, the ordinary least squares estimate of parameter β is showed as follows:

$$\widehat{\beta_{LS}} = (X^T X)^{-1} X^T Y. \tag{111.8}$$

When the relationship among variables is highly correlative, if adopting Ordinary Least Squares regression model, the standard error of regression coefficient parameters estimate will become larger, confidence interval become wider, the stability of the estimated value will reduce, and t test of the coefficient can not be passed or the correct coefficient estimates can not be gained [13].

After correlative analysis on the variables, it can be found that there is significant correlativity between any two variables, and the correlation coefficient is above 0.9, which is showed in Table 111.3. Therefore, Ordinary Least Squares can not be applied to regression analysis.

Table 111.3 Variable correlations

	I	II	III	IV	V
I	1				
II	0.911	1			
III	0.934	0.963	1		
IV	0.964	0.969	0.952	1	
V	0.975	0.966	0.993	0.985	1

I: Building Energy Consumption (InE); II: Total Population (InP); III: Urbanization Rate (InU); IV: Per Capita Living Space (InA); V: Consumption Level of Urban Household (InC).

(2) Ridge regression

In order to eliminate the effect of multi-collinearity, Ridge Regression is adopted to fit the model. Ridge Estimates was put forward by Hoerl and Kennard [14, 15]. When there is multiple correlative among the variable, the more stable estimate can be gained with this method, and the standard deviation of the regression coefficient will be smaller. Therefore, an unbiased estimator can be found out, which can have significantly higher accuracy than the unbiased estimator though there is slight deviation [16].

When there is multiple correlation among variables, with Ridge Regression method, a normal matrices kI will be added up to the determinant $(\mathrm{X}^T\mathrm{X})$. The parameters estimate of Ridge Regression is showed as follows.

$$\widehat{\beta_{\mathrm{Rid}}} = (\mathrm{X}^T\mathrm{X} + kI)^{-1}\mathrm{X}^T Y. \tag{111.9}$$

Adopting Ridge Regression to regress analysis, the bias coefficient k is added to increase the estimate stability and reduce the variable variance. Usually the value of k is determined based on research experience. In this article, k is determined as 0.12. Ridge Regression result is showed in Table 111.4.

Significance test shows that the coefficient of determination is greater than 0.90. The result of F test is acceptable. Variance inflation factor (VIF) of all variables stan-

Table 111.4 Ridge regression result

	Regression coefficient	Standard regression coefficient	VIF
Total population (InP)	0.056328	0.010164	1.12
Urbanization rate (InU)	0.301167	0.166281	0.885
Per capita living space (InA)	0.293286	0.185666	0.5996
Consumption level of urban	0.326861	0.356274	0.527
Household (InC) constant	4.460603		
R	0.95		
R^2	0.90		
Correction R^2	0.88		
Standard error	0.14		
F	49.5		
F significance	0		

dard regression coefficients are less than 1.12 and the regression coefficient symbols meet with the economic meaning. The fitting equation of Equation (111.7) is showed as follows.

$$\ln E = 4.460603 + 0.056328 \ln P + 0.301167 \ln U + 0.293286 \ln A + 0.326861 \ln C.$$

According to the regression result, the elasticity for each factor, which is ratio of change rate between dependent variable and independent variable, is gained. The elasticity of total population is 0.056. And that of urbanization is 0.301, that of Per Capita Living Space is 0.293 and that of Level of Urban Household is 0.327.

111.5 Conclusion

In this article, the driving factors on the growth of urban residential building energy consumption are analyzed. According to qualitative analysis, population, urbanization, residential floor space and consumption level are selected as the crucial influence factors. Adopting STIRPAT model, the influence of all factors is analyzed quantitatively, and the regression model is built up. Based on the regression result, it can be concluded:

- Comparing with other factors, the increase of consumption level can drive the energy consumption of urban residential building much more. The influence of that lies in two aspects. Firstly, with the increase of consumption level, the consumption amount of durable consumer goods will increase, which results in the number owned and running time increase. Secondly, for people, the requirement of living comfort become higher and higher with the increase of consumption level, which results in the energy consumption on air conditioning and heating increasing continuously, which can be found from the increasing of number of air conditioner owned per 100 urban households in Chongqing from 1996 to 2011.

- The increase of residential floor space in urban area is an important factor to drive the energy consumption of urban residential building growth.
- Urbanization has relatively higher influence on the energy consumption of urban residential building growth. With the acceleration of urbanization, the amount of urban resident kept continuous increase. The increase of urban resident directly drives the energy consumption in urban area growth.

In the future research, the influencing factors of urban residential building energy consumption are needed to extend to find potential important factors. And relative energy conservation policy of urban residential building is anticipated to analyze.

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Chapter 112
Birth and Death: Modeling Optimal Product Sampling over Time for Nondurables

Wei Lu, Bing Han and Zhineng Hu

Abstract To confirm the idea of sampling over time under the framework of Bass model, this paper builds a diffusion model based on the idea of birth and death process, systems dynamics. The basic results show that the model can include the results of previous models as a special case or reduced case. It is assumed that the total amount of potential consumers remain unchanged, and the effect of repeat purchase is consider, so as to build the Optimization model group. The analysis showed that product diffusion entered a stable period in the late and the amount of diffusion is maintained at a certain level. As part of potential customers don't purchase the product, the amount of diffusion must be less than the total potential customers' purchases and the diffusion continues as long as the product exist in the market. No matter the change of potential customer is static or dynamic, sampling promotes the diffusion and the best time to carry out the activity is first period. If sampling rate is limited, and the limit value is reduced to a certain extent, it will appear continuous sampling. With the reduction of the limit value, the sampling rate decreases, which causes the reduction of the amount of final product diffusion, eventually lead NPV of enterprise lower.

Keywords Product diffusion · Potential consumer · Birth and death process · Product sampling

112.1 Introduction

For a long time most of the domestic and international research and application on the diffusion of new product is the new product growth model proposed by Bass in 1969 [1] (often referred to as Bass model), which forms the Bass family or flexible

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diffusion model by changing the assumed conditions of Bass model and adding new meanings to the original indexes and new influence factors.

During the product diffusion, free sample, pricing strategy and repeat purchase behavior will influence diffusion. Researches mostly focus on the situation after market launch. Hu [2–4] pointed out that free sample can promote the diffusion of new product and also analyzed the influence of individual product diffusion caused by free sample in different price strategies. And Lammer [5, 6] stated that small samples of packing can promote the sales. Besides, Heiman [7] also indicated that the effects of sample: increasing the probability of consumers' purchasing and promoting communication with customers. As for sample given to individual product, Jain [8] and other experts studied the optimized proportion of the durable new product and sample by the Bass model. However, all of these studies are based on a same assumptions that potential customer amount is a fixed parameter without any change. In reality the potential customer keeps changing all the time, for that each period will have new consumers, but also some potential customers disappear, no longer buy or wish to purchase the product.

Mahanjan and Peterson [9] pointed out external influences factor diffusion model, internal impact factor diffusion model and mixed impact factor model. Although these have a different focus, potential consumers in the model is set as a fixed constant. Liu [10] stated that potential consumers of internet product diffusion model is based on a function of time, and the increase of internet users had an impact on the number of internet products' potential customers. In product diffusion study, the change of potential customers has four situations as follows: (1) potential customers is a fixed constant, such as that in Bass model; (2) the amount of potential customers increase as diffusion increases; (3) the amount of potential customers decrease as diffusion increases; (4) potential customer is affected by some factors, then potential customer function can be created in the light of exponential growth correction pointed by Rai et al [11].

In a summary, most previous researches based on the assumption that amount of potential consumer is a fixed constant. Some researchers pointed out that the function of potential customer is a time series functions which always related to the features of product. This paper talks about independent new product which only considered the impact of external factors and external factors. In this paper, there is a assumption that the potential market is a dynamic process, namely in each period some potential customers disappear and some new come into being while in the entire process the amount of potential market is unchanged. According to the above, this paper comes to a conclusion that the diffusion of new product plays an key role in dynamic potential market, which is based on Bass model establishing optimization model group, centering around determining the optimal proportion of sample with dynamic potential market.

112.2 Model Building

112.2.1 Problem Statement

In the presence of diffusion, some customers are attracted by advertisement to purchase the product, and factors such as oral communication may make the others who know the product but haven't decided whether to purchase it or not to become the adopters. This paper focuses on the undurable product whose price isn't high for most people. As cost of sampling is so high for expensive product, enterprise don't prefer this behavior. Sampling can express the features of product to people, make persistence of memory and consumption for people.

In this paper, consumers can be divided into two parts. One part is non-adopter include the people who have ever purchase the product but now decide don't buy it and the people never purchase it. The other is adopter. Both part of the populations into each other, forming a dynamic process of potential market. Combine with this process, this paper analysis the effect of sampling to diffusion.

Model assumptions:

- The geographic boundaries of the social system do not change over the diffusion process.
- Nature of a product does not change over time.
- The diffusion process is divided into non-adopter and adopter.
- There is no supply constrain.
- Sample is given only once to one customer, but customer can repurchase.
- The diffusion of a new product is independent of the other products.

The notations are shown below:

t : Time (from 1 to T);
$\overline{N}$: The upper limit of potential consumers;
a : External influence rate (innovative coefficient);
b : Internal influence (model coefficient);
$N(t)$: Cumulative number of demanders by time t;
$N_f(t)$: Cumulative number of consumers by time t who get the free sample but never adopted it before;
$U(t)$: Cumulative number of loss demanders by time t;
$s(t)$: Sales volume at time t;
$n_f(t)$: Number of consumers who get free sample at time t;
τ : Product life cycle;
$r_n(t)$: Non-adoption ratio of the consumers who get sample;
r_b : Ratio of potential consumers of new product among the whole consumers;
R : Repeat purchase rate;
i_r : Discount rate.

112.2.2 Model Development

In recent years, a lot of mathematical models have been proposed to describe the relationship of the innovation diffusion process and the S-shaped nature of its adoption curve since the publication of the Bass model [1]. The basic Bass model is:

$$N(t+1)-N(t)=(a+bN(t))(\overline{N}-N(t)). \tag{112.1}$$

In Equation (112.1), traditionally, the value for $N(0)$ has been assumed to be zero which is an initial condition.

(1) Impact of potential market dynamic changes

As potential market is a dynamic process, it assumed that each period new potential consumer increase as a certain percentage of $\overline{N}$, and the loss is the same percentage of $N(t)$. Although some people become the potential customer, they haven't purchase product before they change to be non-potential customers. So this paper discusses it with net inflows. The net outflow equals to a certain percentage of total potential market amount minus the amount of new potential consumers. The model describe the first time purchase behavior, so the net inflow and outflow express as follows:

$$\begin{cases} n(t+1) \triangleq N(t+1)-(1-\gamma_u)N(t)=(a+bN(t))U(t), \\ u(t+1) \triangleq U(t+1)-(1-\gamma_u)U(t)=\gamma_u\overline{N}-n(t+1), \end{cases} \tag{112.2}$$

where if $0<\gamma_u\leq 1, U(t)=\overline{N}-N(t)$, and if $\gamma_u=0$, the model retrogrades to the Bass model we had ever discusses.

(2) Impact of product sampling

Jain [5] pointed out that free sample can be an effective way to create an initial pool of "adopters", and this pool along with the regular group of innovators would influence other potential adopters via word of mouth. So potential market affected by sampling expressed as follows:

$$\gamma_b\gamma_n(t+1)n_f(t+1)=N_f(t+1)-N_f(t). \tag{112.3}$$

And Equation (112.1) changes to:

$$n(t+1)=N(t+1)-N(t)=\left[a+b(N(t)+N_f(t))\right](\overline{N}-N(t)-N_f(t)), \tag{112.4}$$

where $\gamma_n(t+1)=1-(N(t)+N_f(t))/\overline{N}$, $\gamma_n(0)=1, N_f(0)=\gamma_b n_f(0)$. $N_f(t)$ is effective sample which means the people who get free sample minus the non-potential customers and adopters. Especially, $\gamma_n(t)=1$ means accurate sample. Inflow and outflow potential market with sampling can be express as follows:

$$\begin{cases} n(t+1)=\left[a+b(1-\gamma_u)(N(t)-N_f(t))\right]U(t), \\ u(t+1)=\gamma_u\overline{N}-n(t+1)-\gamma_b\gamma_n n_f(t+1). \end{cases} \tag{112.5}$$

Potential consumers amount is the upper limit of adopters. So cumulative diffusion volume of product plus number of potential buyers among those who accepted samples should be less than potential consumers, which means:

$$N(t)+N_f(t)\leq \overline{N}. \tag{112.6}$$

(3) Impact of the repeat purchase

If every product has a life cycle, especially for non-durable products, repurchase rate of new product: $\gamma \leq 1$. Besides company hope consumers make a run-ahead consumption of products in order to gain benefits and to reduce uncertainty of future sales volume. So it's necessary to spread diffusion by sampling.

When $t \geq \tau$, number of adopters in period $t-\tau$ minus number of repurchasing consumers form $t+1-\tau$ to $t-1$ is potential repurchasing consumers in period t:

$$R(t)=\begin{cases} N(t-\tau)+N_f(t-\tau)]-r\sum\limits_{j=1}^{\tau-1}R(t-j), & \tau>1, t>\tau, \\ N(t-\tau)+N_f(t-\tau)], & \tau=1, t>\tau, \\ 0, & t\leq\tau. \end{cases} \tag{112.7}$$

The number of sales volume is:

$$S(t+1)=N(t+1)-N(t)+\gamma_b\gamma_n(t)n_f(t)+rR(t+1). \tag{112.8}$$

(4) Objective function

One may also argue that product sampling is expensive for the firm, so it may not be economical to give free samples to every potential adopter. As a result, serious consideration must be given to the question of how many samples should be distributed. In addition, offering too many free samples will cost the firm's resource. The firm needs to determine the "right" amount of sampling. Then one can get the objective function to maximize of net present value (NPV) of the firm given by:

$$\pi=\sum_{t=1}^{T}\frac{1}{(1+i_r)^{t+1}}\left[(p(t)-c)S(t)-(h+c)n_f(t)\right]-(h+c)n_f(0), \tag{112.9}$$

where h is the cost of unit sampling include labor, packaging cost, transportation costs, handling costs, etc. c is unit cost of product.

(5) Model group

Taking all the factors above into consideration, a model group can be established to provide an analytical framework for incorporating explicitly the effect of marketing mix variables on product diffusion. That is:

$$\begin{aligned} &\max\ \pi, \\ &\text{subject to Equations (112.2) - (112.9),} \end{aligned} \tag{112.10}$$

where the decision variables are $n_f(t)$, $U(t)$, $N(t)$, $S(t)$.

112.3 Numerical Analysis and Results

Model group (112.10) is a nonlinear optimization problem. We assume that total potential market is constant. Considering dynamic changes of potential market, enterprises should develop marketing strategies in line with diffusion trend, and this paper focus on sampling marketing strategy. Firstly, this paper talks about effect of sampling rate to product diffusion. Then repeat purchase is considered to find the most favorable sampling rate.

112.3.1 Impact of Product Sampling

(1) Static potential market

When new product is put on the market, enterprise will carry out a few marketing strategies such as sampling which is practical, simple to operate and effective. How to play role of sampling policy, how enterprise determined sampling rate to achieve the maximizing profits according to the actual situation will be discussed in this paper. To facilitate comparative analysis, some parameters, which reference the literature of Jain et al and Ho et al, are defined as follows: $a = 0.02$, $b = 0.35$, $\overline{N} = 54$. $c = 1$, $c_f = 1$, $h = 1$, $r = 0.5$, $\tau = 2$, $\lambda_b = 0.1$, $\lambda_u = 0.02$, $p = 10$, $i_r = 0.008$. During the diffusion, potential market assumed to be constant and enterprise goal to maximize profit, on this basis, analysis of sampling's affect to diffusion will be made.

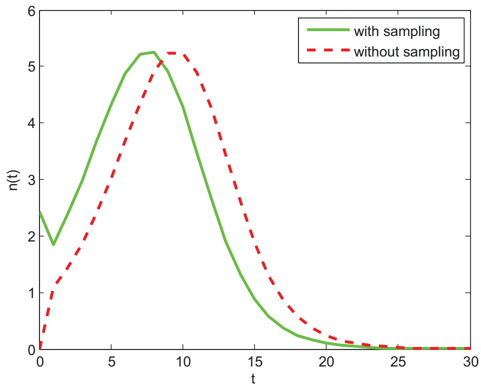

Fig. 112.1 Impact of sampling to diffusion while potential market is constant

When potential market is constant, sampling can promote the diffusion. As shown in Fig. 112.1, the diffusion which corporate take sampling strategy is faster than that which don't take the strategy and the peak is two periods in advance. Table 112.1 express the data, from which we know that although sampling maybe need more cost, the enterprise can get more profit, so sampling strategy is a effective

Table 112.1 Impact of sampling to the peak period

	With sampling	Without sampling
NPV	729.1	713.3
Peak	5.247	5.239
Peak period	8	10
Sampling rate	4.5%	0

marketing strategy. In the current parameter setting, the best time to carry out the strategy only in a certain period is at first period. Peak of diffusion will be two period in advance and peak is higher when sampling strategy is carried out. Above all, impact of sampling is very significant, mainly to accelerate the diffusion of new product, so as to increase corporate profits.

(2) Dynamic potential market

Actually, during the diffusion of new undurable product potential customers change each period. In one period, potential customers not only disappear by a certain percentage of adopters, but also generate by the same percentage of total potential market. At the final of diffusion, the adopters less than total potential market as some potential customers disappear each period, that's the difference with previous study which assumed potential market to be constant while at the final of diffusion adopters equal to total potential market. Considering dynamic potential market, this chapter focuses on impact of sampling to the diffusion, and how about the sampling rate and implementation period to make maximum profit.

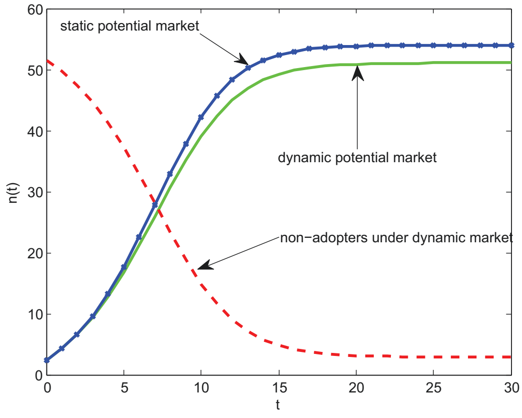

Fig. 112.2 Diffusion under dynamic potential market

With the assumption that potential market is dynamic and total potential market is fixed, non-adopter is divided into two parts, one is that who have ever buy it but now stop purchasing it, and the other is that who haven't purchased the product result from they aren't affected by external effect and internal effect. As the Fig. 112.2 shows, with propulsion of diffusion non-adopters decrease while adopters increase.

About 20 period amount of adopters and non-adopters become stable, namely a few periods after product put on market, product sales will remain at a certain level. While potential market is static and potential consumers will purchase product once they know it, at the final of diffusion adopters' amount equal to the total potential market. However, if potential market is dynamic, there is always some non-adopters which combination adopter form potential market (Fig. 112.2).

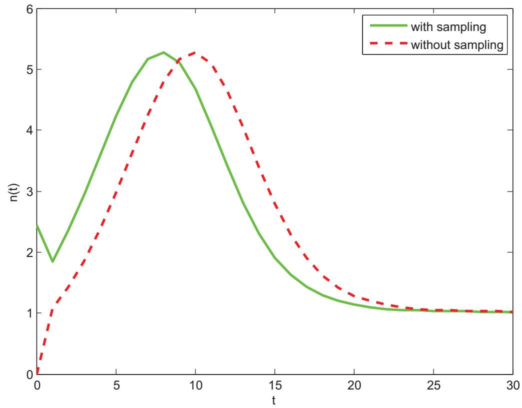

Fig. 112.3 Impact of sampling to adopters

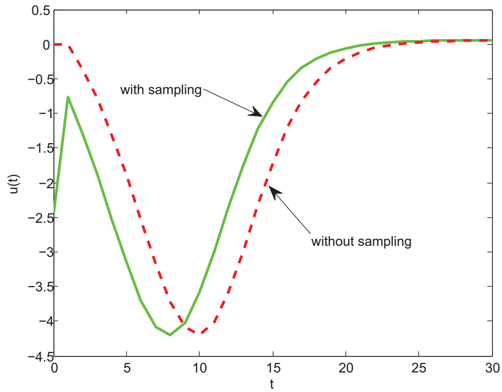

Fig. 112.4 Impact of sampling to non-adopters

Under fixed potential market, sampling promotes the diffusion and advances peak period, thus increasing the corporate profit. As well as potential market is dynamic, sampling speed up the changes in the amount of potential customer, quicker number of product adopters tends to a certain value. As shown in Fig. 112.3 and Fig. 112.4, diffusion and number of adopters tends to a certain value more quickly and peak period significant advances. With sampling, number of adopters and non-adopters almost stable at 25th period, however without sampling the two can stable after 25th period. At the final of diffusion, adopters will be more with sampling, so sampling not only promote the diffusion but also increase the sales. Compared with situation that potential market is static, sampling have a greater role in promoting.

Table 112.2 Impact of sampling to diffusion

	With sampling	Without sampling
NPV	685.8	671.3
adopter	51.0871	51.0831
Non-adopter	2.9129	2.9169
Sampling rate	4.51%	0
Peak period	8	10
Peak	5.279	5.278

112.3.2 Impact of Sampling under Different Change Rate of Potential Market

(1) Sampling under different potential

After product put on market, it assumed that potential market is floating around a certain value which can't remain unchanged in reality. The potential market is dynamic or not, how it affect the diffusion and how to develop a accurate sampling strategy is discussed in this chapter.

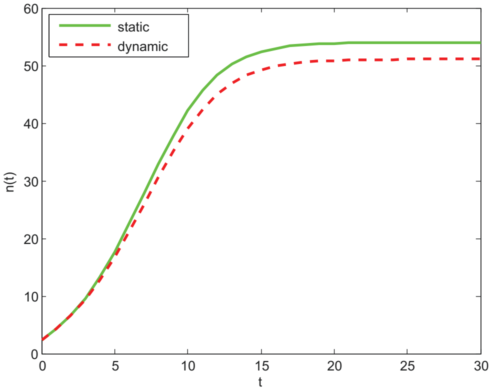

Fig. 112.5 Diffusion under different potential market

As shown in Fig. 112.5 and Fig. 112.6, diffusion and sales can be stable at about 15th period. As potential market is dynamic, it divided into adopters and non-adopters, for that diffusion and adopters is less than that of static potential market.

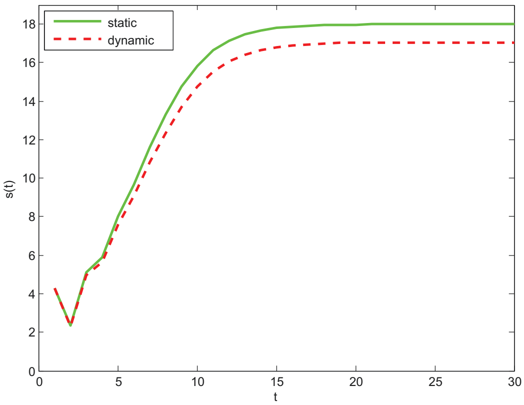

Fig. 112.6 Sales under different potential market

Amount of adopters increased gradually from first period, while non-adopters decrease gradually, and both will be stable at 15th period. When potential market is static, at final of diffusion the total potential consumers purchase product, so the diffusion and sales is more than that of dynamic potential market. Compared the diffusions, the previous period diffusion and sales of dynamic potential market is higher than that of static potential market, result from the higher sampling rate (Fig. 112.5). As Fig. 112.6 shows, in the previous five periods the two sale curves almost coincide. It assumed that product life cycle is two periods long, so repeat purchase begin at 3ed period, result in growth isn't upward trend. Above all, adopters under dynamic potential market must be less than that of static potential market, so as the NPV. However sampling rate have little difference and the strategy should be carry out at first period.

Table 112.3 Impact of sampling under different potential market

	Dynamic	Static
NPV	685.9	729.1
Diffusion	51.09	54.00
Sampling rate	4.51%	4.50%

(2) Sampling under different loss rate of consumers

This paper focuses on impact of sampling under dynamic potential market. Above analysis shown that sampling not only promote diffusion but also increase the sales. Under different loss rate of consumers, how sampling rate changes and the effect to NPV will be discussed below.

Cumulative amount of adopters gradually increase with diffusion process. As shown in Fig. 112.7 higher loss rate of consumer is the less cumulative adopters will be. When loss rate is 0.05, amount of final adopters is about 47; when loss rate is 0.01, amount of final adopters is near total potential market. As well as, higher the

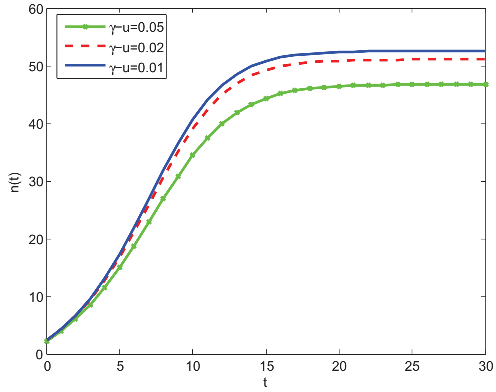

Fig. 112.7 Diffusion under different loss rate

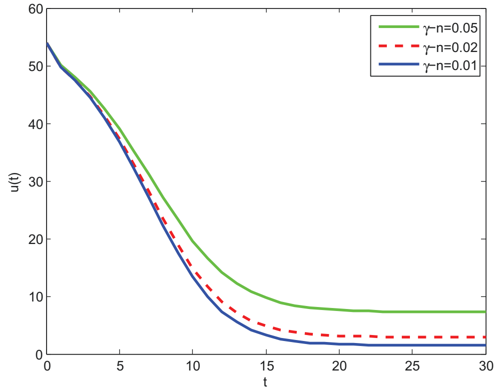

Fig. 112.8 Non-adopters under different loss rate

loss rate of consumer is amount of non-adopters will be more (Fig. 112.8). As Table 112.4 shows, with loss rate decreases sampling rate increase, and sampling still increase corporate profit. So in the management of production activities, enterprise should investigate the change rate of potential market to make accurate production plan.

Table 112.4 Impact of sampling under different loss rate

	$\gamma_u = 0.05$		$\gamma_u = 0.02$		$\gamma_u = 0.01$	
	With sampling	Without sampling	With sampling	Without sampling	With sampling	Without sampling
NPV	620.9	609.7	685.9	671.3	707.5	692.2
Sampling rate	4.15%	0	4.51%	0	4.54%	0
Non-adopter	7.24	7.25	2.91	2.92	1.46	1.46
Adopter	46.76	46.75	51.09	51.08	52.54	52.54

112.4 Conclusion

Most of marketing strategy and diffusion of new product research which based on Bass model always assumed potential market as a constant or a time function according to product features, and lack of product diffusion under dynamic potential market research. This paper focus on a optimization model group about sampling comprehensive integrate marketing strategy and consumers' behavior. Numerical simulation of sampling in each period and analysis of potential market come to instructive conclusion for enterprise: (1) when potential market is dynamic, the diffusion will not end, but it enters a stable phase at later stage that amount of loss consumers equal to that of new consumers. Amount of adopters keep around a certain level less than total potential market as non-adopters never disappear which is different from static potential market. (2) no matter potential market is dynamic or not, sampling can promote the diffusion and advance peak period result in increasing corporate profit. The best time to carry out the strategy is first period the same as previous studies. Sampling also can increase sales under dynamic potential market. (3) while potential market is dynamic, final amount of adopter is affected by loss rate of consumers. The higher loss rate is, the more non-adopters are and the less NPV enterprise can achieve. In this situation, sampling rate is reduced, and even sampling strategy may decrease the profit.

This paper considering dynamic potential market focus on promotion effect of sampling to diffusion based on Bass model. Model discrete into a multi-period dynamic model to be dynamic and flexible, such that every situation can be predicted. Then discuss loss rate of consumers to find the best sampling rate and period. However, for the study new undurable product's definition is too ideal to limit the discussion. Besides, as it's difficult to obtain enterprises' realistic data, there isn't reference data to do empirical analysis, such work will be complete in future.

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Chapter 113
A Decision Making Analyzing Mode for Opportunity Factors from Major Environmental Risks in an Enterprise's Sustainable Innovation Process

Yujiao Shi, Yunlong Duan and Gang Xiang

Abstract Based on the opportunistic characteristic of major environmental risks in an enterprise's sustainable innovation (ESI) process, this paper makes an effort to establish a decision making analyzing mode for opportunity factors derived from ESI major environmental risks. System identification, experts evaluation, dual-criteria assessment matrix and lattice fuzzy nearness method, are used for the identification, assessment and judgment of opportunity factors of ESI major environmental risks. This decision making analyzing mode has been applied to identifying, assessing, and judging opportunity factors of major environmental risk in XX Bio-tech Company's ESI process. Responding suggestions are proposed to XX Bio-tech Company according to the model's analysis results.

Keywords Decision making · Analyzing mode · Enterprise's sustainable innovation (ESI) · Environmental risk · Opportunity factor

113.1 Introduction

Enterprise's Sustainable Innovation (ESI) is a process that an enterprise has (had) continuously implemented innovative projects (introducing new products/new process techniques/developing new markets/acquiring new materials sources/realizing new organization and/or their inside diffusions), which suffice for the sustainable development requires, in a long period (generally in 10 years or more), and continuously gain economic benefits [1]. ESI is a great yet arduous process full of risks [2].

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Among all kinds of risks enterprise being exposed to, major environmental risks put significant influences on the process of ESI. International financial crisis in 2008 and its subsequent global impacts, for example, had and will have profound and generally negative influences on the ESI.

Nevertheless, an increasing amount of researches in risk management has showed that, risks can present as opportunities as well as threat to an entity [3–5]. Some even argues that taking “upside” risks (where some risk relevant opportunities derived from) is important and necessary to the enterprise’s survive and thrive [6, 7]. Exploiting enterprise’s risks and making use of their advantage side is an important research branch of enterprise risk management. When it comes to major environmental risks whose positive as well as negative potentials are significant, enterprise’s ability to identify, assess, judge and exploit opportunity factors from major environmental risks, turning major environmental risks from threats sides into opportunities sides, plays a vital role in enterprise’s successful sustainable innovation. Research on this topic would be of great practical and theoretical value, yet few studies have been published on it.

This paper clarifies the opportunistic characteristic of major environmental risks in an ESI process. In order to exploit this characteristic, a decision making analysis model for identifying, assessing and judging opportunity factors of major environmental risks in an ESI process is then established, by using system identification, expert evaluation, dual-criteria assessment matrix and lattice fuzzy nearness method. The model is applied to XX Bio-tech Company. According to the mode’s analysis results, specific suggestions are proposed to XX Bio-tech Company.

113.2 Major Environmental Risks in an ESI Process and Their Opportunistic Characteristic

113.2.1 Major Environmental Risks in an ESI Process

Major risks in an ESI process are risks that may have severe negative impacts on ESI, whose potential harm may cause violent losses, resulting in discontinuity or failure of ESI. Major risks in an ESI process involve operator man-made risks, innovation strategy risks, major projects risks (Fig. 113.1a) and major environmental risks [8]. Major environmental risks in an ESI process, is defined in this paper as risks derived from enterprise’s environment, whose potential harm may cause discontinuity or failure of ESI. In fact, ESI major environmental risks involve the external parts of operator man-made risks, innovation strategy risks, and major projects risks (Fig. 113.1b). Categories of ESI major environmental risks are presented in Table 113.1.

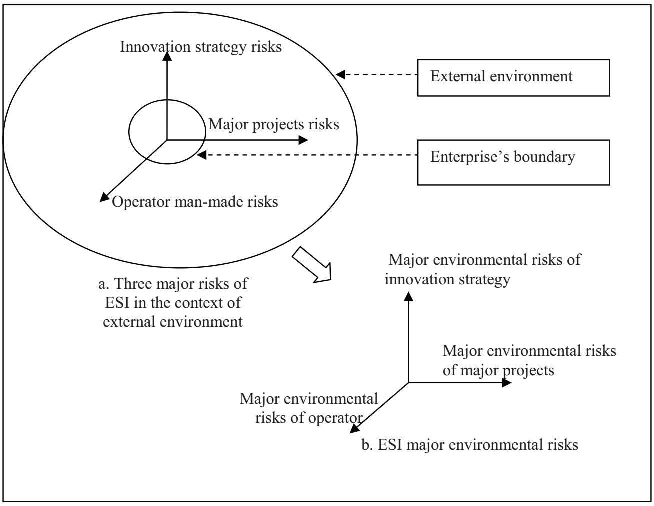

Fig. 113.1 ESI's three major risks in an ESI and their relationship with major environmental risks

Table 113.1 Categories of ESI major environmental risks

Categories	Sources of risk factors
Economy and finance risks	Adverse change in exchange or interest rate; economic or financial crisis, etc.
Market risks	Adverse change in product price, market share; vicious competition, etc.
Energy and raw material resources risks	The shortage of or inferior energy, raw material, etc.
Regulation and law risks	Adverse change in regulation and law
Technical environment risks	Unforeseeable trend; unavailable assess for tech acquisition, etc.
Natural and ecological risks	Natural disaster, ecological pollution, etc.

113.2.2 Opportunistic Characteristic of Major Environmental Risks in an ESI Process

Major environmental risks in an ESI process have the characteristics of objectivity, externalities, dynamicity, hierarchy and complexity, etc. It is also worth noting that major environmental risks in an ESI process are not the "pure" risks which only present negative possibilities, but "opportunistic" risks which present both negative and positive possibilities at the same time.

Investigating characteristics mentioned above from the perspective of basic principles of innovation theory such as Schumpeter's "creative destruction" and "new combination of production elements and production conditions", can present opportunistic characteristic of ESI major environmental risks. Firstly, the characteristics of objectivity and externalities make major environmental risks influencing creative enterprises as well as their competitors. The possible failures of competitors due to their improper responding to major environmental risks can results in competitive opportunities to those who can handle the major environmental risks excellently. Secondly, the characteristics of dynamicity, hierarchy and complexity suggest that external influencing factors of major environmental risks have dynamic and complicated correlations and interactions, and they can have interactions with enterprise's internal factors too. A sequence or combination of external factors related in major environmental risks or/and some special internal factors within the enterprise may lead to synergistic and positive effects and thus present as opportunities. In other words, ESI major environmental risks may accompany with or stimulate opportunity factors. If the potential opportunity factors can be identified and exploited by enterprise effectively, great rewards may follow subsequently, making major environmental risks present opportunistic characteristic.

The opportunistic characteristic is an important aspect of ESI major environmental risks. The traditional way of enterprise risk management, by identifying, assessing and responding to risks passively, is not sufficient for managing ESI major environmental risks excellently. Decision making theory and methods for identification, assessment and judgment of opportunity factors deriving from ESI major environmental risks is urgently demanded. Operational methods and tools for grasping opportunity factors deriving from ESI major environmental risks is important for enterprise to exploiting major environmental risks positively, turning risks from threat sides into opportunity sides.

Definition, substance, and characteristics of ESI major environmental risks mentioned above can compose an integrated and clear concept on ESI major environmental risks. The concept, especially the opportunistic characteristic it points out, provides theoretical basis for establishment of decision making analyzing mode for opportunities of ESI major environmental risks.

113.3 Decision Making Analyzing Mode for Opportunity Factors from Major Environmental Risks in an ESI Process

113.3.1 Identifying Opportunity Factors from Major Environmental Risks in an ESI Process: Opportunity Factors Analytic Tree Method

Identifying opportunity factors from ESI major environmental risks is the first step of our decision making analysis mode. ESI major environmental risks may leads to or associated with precious opportunity factors. By using system analysis method, combined with investigating ESI practice, we established opportunity factors analytic tree (Fig. 113.2) for identifying opportunity factors from different sources.

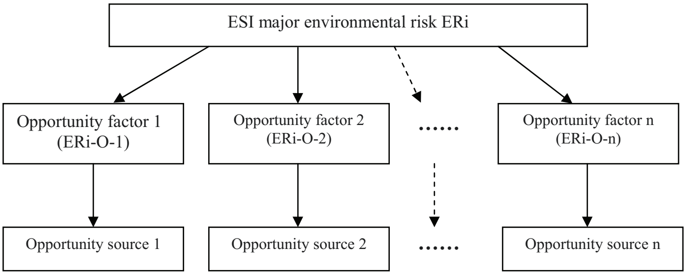

Fig. 113.2 Opportunity factors analytic tree

113.3.2 Assessing Opportunity Factors Derived from Major Environmental Risks in an SEI Process: Expert Evaluation, Probability and Benefits Fuzzy Matrix

After the identification of opportunity factors derived from SEI major environmental risks, assessment of them can subsequently be done by using expert evaluation and probability and benefit fuzzy matrix.

Probability (which describe the likelihood of an opportunity factor occurring during a certain period) and benefit (which describe the rewards the enterprise would benefit from an opportunity factor) of a certain opportunity factor need to be assessed by experts. Linguistic evaluations and corresponding fuzzy intervals of opportunity factor's probability (presented in Table 113.2) and benefit (presented in Table 113.3) will help the experts evaluate the opportunity factors derived from SEI major environmental risks.

Table 113.2 Linguistic evaluations and fuzzy intervals of opportunity probability

Probability	Low-low	low	Medium	High	High-high
Fuzzy intervals	$[0, 0.2]$	$[0.2.0.4]$	$[0.4, 0.6]$	$[0.6, 0.8]$	$[0.8, 1]$

Table 113.3 Linguistic evaluations and fuzzy intervals of opportunity benefit

Benefit	Medium	High	High-high
Fuzzy intervals	$[4, 6]$	$[6, 8]$	$[8, 10]$

The combination of probability and benefit evaluations determines the opportunity factor's Opportunity Level through probability and benefit fuzzy matrix (presented in Table 113.4). According to the Matrix, Opportunity levels are defined and classified into five levels: A, B, C, D, and E, by probability and benefit dual-criteria.

Table 113.4 Probability and benefit fuzzy matrix

Benefit	Probability				
	High-high $[0.8,1]$	High $[0.6,0.8]$	Medium $[0.4,0.6]$	Low $[0.2,0.4]$	Low-low $[0,0.2]$
High-high $[8,10]$	A	A	B	C	D
High $[6,8]$	A	B	C	D	E
Medium $[4,6]$	B	C	D	D	E

The multiplication of each probability and benefit fuzzy interval in matrix will result in corresponding intervals belonging to a certain Opportunity Level. The union of the intervals belonging to the same Opportunity Level will then result in the fuzzy intervals of Opportunity Levels, as presented in Table 113.5.

Table 113.5 Linguistic evaluations and fuzzy intervals of opportunity probability

Opportunity level	$\tilde{A}$	$\tilde{B}$	$\tilde{C}$	$\tilde{D}$	$\tilde{E}$
Fuzzy intervals	$[4.8,10]$	$[3.2,6.4]$	$[1.6,4.8]$	$[0,3.6]$	$[0,1.6]$

The distinctions between different Opportunity Level sets, as showed in Table 113.5, however, are not crisp but unambiguous. A numerical value of the multiplication of values of a certain opportunity factor's probability and benefit (from the experts evaluation), may belongs to more than one level at the same time. Thus, more effective fuzzy theory method is required in order to determine a certain opportunity factor's Opportunity Level.

113.3.3 Determining Opportunity Factor's Opportunity Level: Lattice Fuzzy Nearness Method

Lattice fuzzy nearness Method (by well-known Chinese fuzzy mathematician Wang PZ) is introduced in this paper in order to determine opportunity factor's Opportunity Level.

Definition 113.1. Let $\tilde{A_1},\tilde{A_2} \in U$, Lattice fuzzy nearness between $\tilde{A_1},\tilde{A_2}$ is defined to be $(\tilde{A_1},\tilde{A_2}) \cong (\tilde{A_1} \circ \tilde{A_2})^c$. Lattice fuzzy nearness between normal fuzzy sets $\tilde{A_1}(a_1,b_1)$, $\tilde{A_2}(a_2,b_2)$ is defined by:

$$(\tilde{A_1},\tilde{A_2}) = e^{-\left(\frac{a_1-a_2}{b_1+b_2}\right)^2}. \tag{113.1}$$

Definition 113.2. Assuming known standard fuzzy sets $\tilde{A^1}, \tilde{A^2}, \cdots, \tilde{A^m} \in U$ and undetermined fuzzy set $\tilde{A} \in U$. If

$$(\tilde{A^{(i)}}, \tilde{A}) = \vee_{k=1}^{m} (\tilde{A^{(k)}}, \tilde{A}). \tag{113.2}$$

$\tilde{A^{(i)}}$ is called the most approaching fuzzy set (among $\tilde{A^1}, \tilde{A^2}, \cdots, \tilde{A^m}$) of $\tilde{A}$, while Definition 113.1. is called Approaching Principle of Lattice fuzzy nearness.

According to Equations (113.1) and (113.2), the opportunity level of a certain opportunity factor (opportunity factor i) can be determined by an operation of Lattice fuzzy nearness between the opportunity factor i's fuzzy set $\tilde{O}_i$ (containing quantitative evaluations from different experts) and five Standard Opportunity Level fuzzy sets $\tilde{A}, \tilde{B}, \tilde{C}, \tilde{D}, \tilde{E}$, respectively, then, choosing the most approaching Standard Opportunity Level fuzzy set's representing level as the opportunity factor i's final Opportunity Level.

113.3.4 Decision Making Analyzing Mode for Opportunity Factors from Major Environmental Risks in an ESI Process

A framework of operational decision making analyzing mode for opportunity factors from ESI major environmental risks can be presented in Fig. 113.3 by summarizing the mode's components discussed in Sect. 113.3.1 to Sect. 113.3.3.

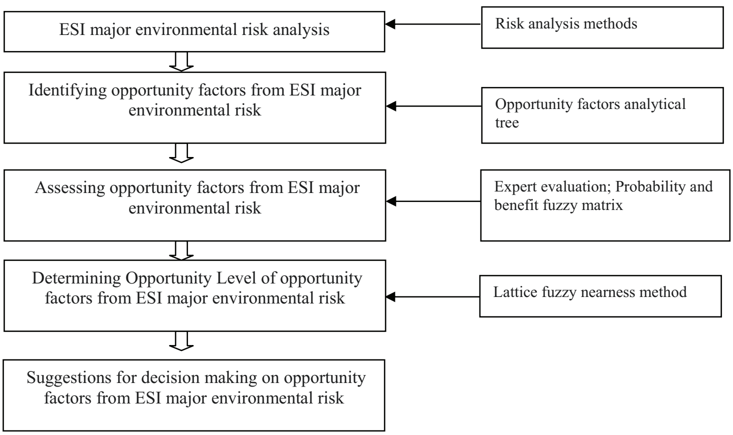

Fig. 113.3 Decision making analyzing mode for opportunity factors from ESI major environmental risks

113.4 Case Study on XX Bio-tech Company

113.4.1 Major Environmental Risks of XX Bio-tech Company in Its Current ESI Process

XX bio-tech Company is an excellent innovative enterprise aiming at natural plant extract business in China. Its plants extract products are mainly exported to Europe and other developed countries. After over 10 years of development, XX has grown into one of the largest natural plant extract producers and exporters in China. The company is now stepping from infancy stage into internationalized development stage of ESI process.

In 2010, the company's planting base area, whose natural condition is very suitable for the growth of the company's main raw material plant A, suffered its worst drought in the past 50 years. Dramatic drop in crop yield (45% off) seriously threat to the company's supply security on raw materials plant A (for the extraction of core product Y). In front of such a major environmental risk, the company responded positively, establishing 3 new planting bases, rapidly, in non-disaster areas in China. On the other hand, because the disaster region's production of panted A accounted for about 60% of domestic production, also for a large proportion of internal production, the decline in total supply promoted the export market price of product Y significantly. Effective responds of XX Bio-tech Company made it take a good advantage of its competitors' delayed responding, resulting in 53.5% (in 2010) and 397.1% (in 2011) increase in its net profits.

Overwhelming advantages and accompanying fat profit, however, did not last long. The European debt crisis in 2012 puts an adverse change in the oversea market demand. The fat industrial profit in 2011, on the other hand, absorbed plenty of new entrants. Aggravated oversupply of product Y resulted in vicious price competition. The plummeting price of product Y in oversea market (from 50 US cents/g at its best point in April 2012, and rapidly declined down to 10 US cents/g in March 2013), makes export market price risk of core product to be XX bio-tech Company's currently major environmental risk, which put great threat to the company's consistency in ESI.

By applying our decision making analyzing mode, we made an analysis on opportunity factors from XX Bio-tech Company's currently major environmental risk: core product Y's export market price decline, with the following process:

113.4.2 Identifying Opportunity Factors from Risk of Core Product Y's Export market Price Decline for XX Bio-tech Company

Based on the investigating XX Bio-tech Company's practical situation, five cardinal opportunity factors that may emerge in second half year in 2014 due to its current major environmental risk were recognized by employing opportunity analytical tree. The five opportunity factors' sources are presented in detail as follows:

- Opportunity factor 1 (O_1): XX Bio-tech Company's possible expand in export market share of core product Y. Vicious competition in 2012 had put the profit of the whole industry below average cost bottom line, and companies accounting for 1/3 of the total members (in 2012) in product Y markets will have to withdraw from the market due to bankruptcy, another 1/3 will sustain hardly until 2014, the rest 1/3, which get powerful strength, will pull their business through with certain profit. This is a rare golden opportunity for XX Bio-tech who is the leader of the last group to expand market share.
- Opportunity factor 2 (O_2): The possible upturn of product Y's oversea market price. By the second half year of 2014, European debt crisis may be eased; on the other hand, oversupply of raw material A in 2012, which made plenty of plant A planters fail to regain their original capital in 2012, will lead a possible reduce in plant A acreage in 2013, and an subsequent reduce in plant A supply in 2014, and the final possible result of decline in product Y supply in the second half year of 2014. Either or both of positive changes mentioned above may lead to the possible recovery of product Y's oversea market price.
- Opportunity factor 3 (O_3): The possible regulation opportunity from the government support. Plants extract industry enjoys the priority in the national industry development during The 12th Five-Year Plan Period in China. The possible support from the governments and regulations at all levels will help the recovery of the industry and may put support priority on XX Bio-tech Company who is one of the most important leaders of the plant extract industry.
- Opportunity factor 4 (O_4): Financial opportunity. Policy guidance in addition to XX Bio-tech Company's excellent credit reputation will enhance the possibility that XX Bio-tech may enjoy wholesale loan with prime interest.
- Opportunity factor 5 (O_5): Technology and management innovation opportunities. Difficult time will stimulate innovation in technology and management to minimize cost and improve the product quality. Improvements in cost control and product quality will make the XX Bio-tech Company's more competitive in the export market.

113.4.3 Evaluating and Judging Opportunity Factors

7 experts were invited to evaluate probabilities and benefits of five opportunity factors mentioned above. Lattice fuzzy nearness method was then applied to each opportunity factors fuzzy set (presenting the evaluation results) and the standard Opportunity Level sets (showed in Table 113.6). The approaching principle of lattice fuzzy nearness determined the Opportunity Level of each opportunity factors (showed in the "the most approaching" column in Table 113.6).

According to Table 113.6, opportunity factor 1 (O_1) representing XX Bio-tech Company's possible expand in market share; opportunity factor 2 (O_2): the possible

Table 113.6 Determining opportunity factors' levels of ESI export market price risk

Opportunity factors	Lattice fuzzy nearness degree					The most approaching level
	$(\tilde{O}_i,\tilde{A})$	$(\tilde{O}_i,\tilde{B})$	$(\tilde{O}_i,\tilde{C})$	$(\tilde{O}_i,\tilde{D})$	$(\tilde{O}_i,\tilde{E})$	
O_1	<u>0.969</u>	0.949	0.720	0.429	0.040	$\tilde{A}$
O_1	<u>0.983</u>	0.801	0.444	0.131	0.00001	$\tilde{A}$
O_1	<u>0.975</u>	0.953	0.751	0.487	0.074	$\tilde{A}$
O_1	0.953	<u>0.987</u>	0.825	0.560	0.106	$\tilde{B}$
O_1	0.911	<u>0.999</u>	0.825	0.490	0.015	$\tilde{B}$

upturn of product Y's export market price; and opportunity factor 3 (O_3): the possible regulation opportunity from the government support are $\tilde{A}$ Opportunity Level factors. While opportunity factor 4 (O_4): financial opportunity and opportunity factor 5 (O_5): technology and management innovation opportunities are $\tilde{B}$ Opportunity Level factors.

113.4.4 Suggestions

Suggestions are proposed to XX Bio-tech Company according to the opportunity factors' Opportunity Level as discussed below:

Firstly, XX Bio-tech Company should seize the opportunity factor 1 by making sufficient preparation for the market share expanding. Secondly, by using opportunity factor 3 and factor 4 to get sufficient and prime loan, XX Bio-tech Company could, by aligning with its financial risk tolerance, purchase certain amount of the underselling product Y from competitors, to prevent the price of product Y getting even worse as and to make good return by the potential recovery of market price from opportunity factor 2. Furthermore, opportunity factor 5should be seized, too, by focusing on the tech-innovation for cost reduction of traditional product and for quality improvement with aiming at high end market, to proved more competent product in the recovery market of product Y.

113.5 Summary of Research Results and Future Study

The analysis of opportunity factors from major environmental risks in an ESI process is a creative issue in the field of ESI risk management theoretical and practical research. Based on the opportunistic characteristic of major environmental risks in an ESI process, by employing systematic analysis method and fuzzy evaluation method, this paper established a decision making analyzing mode for opportunity factors from ESI major environmental risks and applied it to the case study.

The use of opportunity factors will reduce specific major environmental risks on one hand, while bring new risks on the other hand, which will change the extent and content of risks an entity have to face, and call for reevaluation of risks. How to analysis and "balance" opportunities and risks in a dynamic way, in perspective of promoting ESI, will be the next focus of our research.

Acknowledgements We are grateful for CEO, CFO and other top managers from XX Bio-tech Company providing plentiful materials for our case study. Acknowledgement is made to National Natural Science Foundation of China (grants No.70862002 and No. 71262016) for support of this research.

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Chapter 114
A Study on Determinants of Unemployment in Pakistan

Asif Kamran, Sobia Shujaat, Nadeem A. Syed and Syed Nayyer Ali

Abstract This study has been carried out to examine the determinants of unemployment in Pakistan for the period of 1981-2010 using Regression Model, descriptive stats and graphs. Population growth, Interest rate, foreign direct investment, gross domestic product and literacy rate in Pakistan are being used as explanatory variables. Also the state of democracy in the country has been taken into consideration. Findings include that population growth fuels unemployment positively and where as literacy rate and foreign direct investment has negative impact on unemployment. Often it is perceived that unemployment rate of rural areas is greater because in rural areas there are less chances of employment as compared to urban areas where there are more chances of employment due to more industries.Political regime is also taken into consideration as a dummy variable. In this research we also analyze factors underlying the employment, study the trends of variables involved in the study and suggest recommendations for reduction in unemployment in Pakistan. Numerical data collected from various sources which will be presented in forms of charts and tables and will be given statistical and mathematical treatment through use of E-views. The study is by and large descriptive in nature all the findings will be analyzed theoretically and objectively.

Keywords Foreign direct investment (FDI) · Real gross domestic product (RGDP) · International monitory fund (IMF) · Unemployment rate (UE) · Population growth rate (PGR) · Political regime (PR) · Literacy rate (LR)

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114.1 Introduction

Unemployment is a critical problem and reflects the underutilization of manpower by one nation. High unemployment not only results resource wastage but also results in economic agony. Unemployment is one main problem faced by every nation, be it a highly developed and industrialized or a deprived country. There are several definitions and explanations for unemployment. It can be defined as “the condition of having no job or being out of work” or “Proportion of people which are able to work and actively searching jobs but they are unable to find it”. IMF report (1998) defines ‘unemployment is measured annually as percentage of labor force that can’t find a job’. International Labor Organization (2001) defines unemployment as situation for ages 16 or above of being out of work or need a job and continuously searching for it in the last four week but available to join work in the next two weeks. The unemployed category do not include those who voluntarily do not work, it includes students who are studying full time, those who are retired, medically unfit and children. However, all people who are without work, accessible for work and in search of for work are included in unemployed people.

Unemployment is more evident in developing nations and it gives birth to many undesirable social consequences in the country e.g. crimes such as theft and burglary, suicide, assassination and a threat to the national security etc. It not only affects the individuals but also by and large the country’s economic standing. According to Pakistan Bureau of Statistics, it has a population over 177 million and as per Pakistan Economic Survey 2011-12, the literacy rate in Pakistan is 58 percent. Foreign Direct Investment in Pakistan is around 532 million dollars in 2012, where as the GDP growth rate of the country is around 3.7 percent, which has steadily declined over the past decade. It is a developing country and is facing numerous social problems including unemployment being one of the major one. The unemployment rate in Pakistan is around 5.55 percent. There are numerous factors that affect the unemployment rate in Pakistan. The explanatory variables under study are Population Growth Rate (PGR), Gross Domestic Product (GDP), Poverty Rate (PR), Interest Rate (IR) and Foreign Direct Investment (FDI). Studies have been conducted to understand the determinants of unemployment in different nations and Pakistan, however there still exist a need to find out the relationships of all these factors with one another. This can provide insights to the policy makers to devise strategies for national growth. This study examines the trends in unemployment rate since 1981 to 2010 in Pakistan.

114.1.1 Literature Review

Considerable amount of text is available for the determinants of unemployment, which helps us to inspect the different aspects of unemployment as observed throughout the world. Khan and Ali [10] investigated the problem of educated unemployed persons in Pakistan, majority of which are less than thirty years of age.

The study analyzes primary and secondary data sources. It shows that around fifty percent of unemployed people are not willing to move away from their homes for employment purpose. The paper suggests that for career counseling the information base needs be enhanced. Chaudhry and Hamid [5] inspected the reasons on unemployment in Pakistan. It is observed that one of the main reasons of unemployment in Pakistan is the low quality of human resource in Pakistan. Hunt [14] studied the employment rate for east German for 10-54 years old after monetary union with the west. It is observed that the employment rate for them fell from 89 to 73 percent in six years. Non-employment period is larger for women and for those who are over 50 years of age. However the presence of children and their care does not have significant affect on unemployment. Cartmel and Furlong [4] contrasted the experiences of 18 to 24 years old unemployed people in rural and urban areas. As compares to urban areas, youth unemployment is less common in rural areas but labor market in rural areas has low skills, also labor market in rural areas is characterized by low demand of qualified workers', insecure employment, less training opportunities and married females lacks access to childcare and other facilities.

Rocha and Divino [13] studied the link between taxes on household expenditures, interest rate, and exchange rate in Brazil and Mexico. The data was analyzed by using autoregressive distributed lag models. The results indicate that in both countries, interest rate is positively related whereas taxes on household consumption is negatively related to unemployment, however exchange rate is positively linked with Brazil and negatively linked in Mexico.

A study conducted by Qayyum [11] identified that unemployment is higher in urban area of Pakistan due to structural mismatch of required skills, poor wage system and the lack of improper future counseling and training skills. A reverse relationship exists between youth unemployment and training. Unemployment is higher among females in Pakistan.

Ozturk and Akhtar [2] studied the relationship among FDI, direct investment, GDP and unemployment in Turkey for the year 2000-2007. The result shows that FDI do not ease unemployment in Turkey where as GDP is positively influenced by deviations in exports, however is insignificant. The study suggests that Turkey should increase its export in order to attract more FDI. Eita and Ashipala [6] examined unemployment causes in Namibia for the period of 1971-2007. The study reveals that inflation, GDP and investment are negatively where as wage increase is positively linked to unemployment in Namibia. If GDP is below potential GDP, that will also cause unemployment. It suggests workers' need to lower their wage demand in order to reduce unemployment, GDP will reduce unemployment. Investment will also help in reduction of unemployment. Faridi et al [8] examined the influence of education on employment of Pakistan through use of primary data source in Bahawalpur. The study revealed that health, education and experience has a strong positive relationship with employment. Higher education provides higher results. It suggests government should play a strong role in development of health and education sector in both urban and rural areas.

Berentsen et al [3] inspected the linkage between money and unemployment and the impact of monetary factors on labor market behavior. Inflation and interest rate are taken as measures for money. The study reveals a weal positive relationship between the variables under study.

Emst [7] identified numerous factors contributing to unemployment in-and outflows. These factors include investment dynamics, interest rates, wage bargaining centralization, productivity growth, and legislations for employment protection. The study suggests income support and training measures. Public employment services can also help in outflow of unemployment. Rafiq et al [12] conducted a study in the period 1998-2008 to examine the factors of unemployment in Pakistan. The explanatory variables used in the study included PGR, inflation rate and FDI. The findings revealed that population growth rate has a positive influence on unemployment whereas FDI and inflation are negatively linked to unemployment in Pakistan. Another study by Andrews and Nickel [15] studied the phase after world war and suggested that increase in real wages results in prolong unemployment spell. The finding reveals that one percent rise in real wage results in two to five percent raise in duration of unemployment.

114.2 Research Methodology

114.2.1 Regression Model

$$\mathrm{UE} = \beta_0 + \beta_1 \mathrm{PGR} + \beta_2 + \beta_3 \mathrm{PR}_3 + \beta_4 \mathrm{FDI}, \tag{114.1}$$

where,
UE = Unemployment rate;
PGR = Population Growth rate;
RGDP = Real Gross Domestics Product;
PR = Political regime (DM);
FDI = Foreign Direct investment;
LR = Literacy rate.

114.2.2 Hypothesis

H_0 : There exists no relationship between unemployment and population growth, Interest rate, literacy rate, GDP, FDI in Pakistan.
H_1 : There exists relationship between unemployment and population growth, Interest rate, literacy rate, GDP, FDI in Pakistan.

114.2.3 Research Objectives

- To analyze the relationship between unemployment and its determinants in Pakistan.
- To analyze factors underlying unemployment.
- To study the trends of explanatory variables involved in the study.
- To suggest recommendations for reduction in unemployment in Pakistan.

114.2.4 Type of Research

It is a secondary research, based on longitudinal study, in which the researcher is trying to study the actors which have a direct effect on unemployment rate in Pakistan. It is a Quantitative research.

114.2.5 Nature of Study

The research is explanatory in nature as it describes the cause and effect relationship between two variables.

114.3 Data Sources

The study analyzes secondary data. Data related to unemployment, literacy rate, population growth, interest rate FDI and GDP is readily available on state bank of Pakistan website and from economic survey of Pakistan different editions.

114.3.1 Limitations of the Research

The overall scope of the study being too large requires more detailed research; as the secondary data understudy is for last 30 years only, further more primary research can give more insights and the views of unemployed people. Industry specific, area specific, gender/age specific research needs to be carried out. The study is carried out on limited determinants where as more determinants (e.g. inflation, poverty, etc) may be included to have wide and in-depth analysis in future.

114.3.2 Treatment of the Data

It is a descriptive study and all findings are analyzed theoretically and objectively. The numerical data collected from various sources is presented in forms of charts and tables and treated statistically through use of e-views.

114.4 Presentation of Data

Fig. 114.1 shows the trends of the variables selected for study.

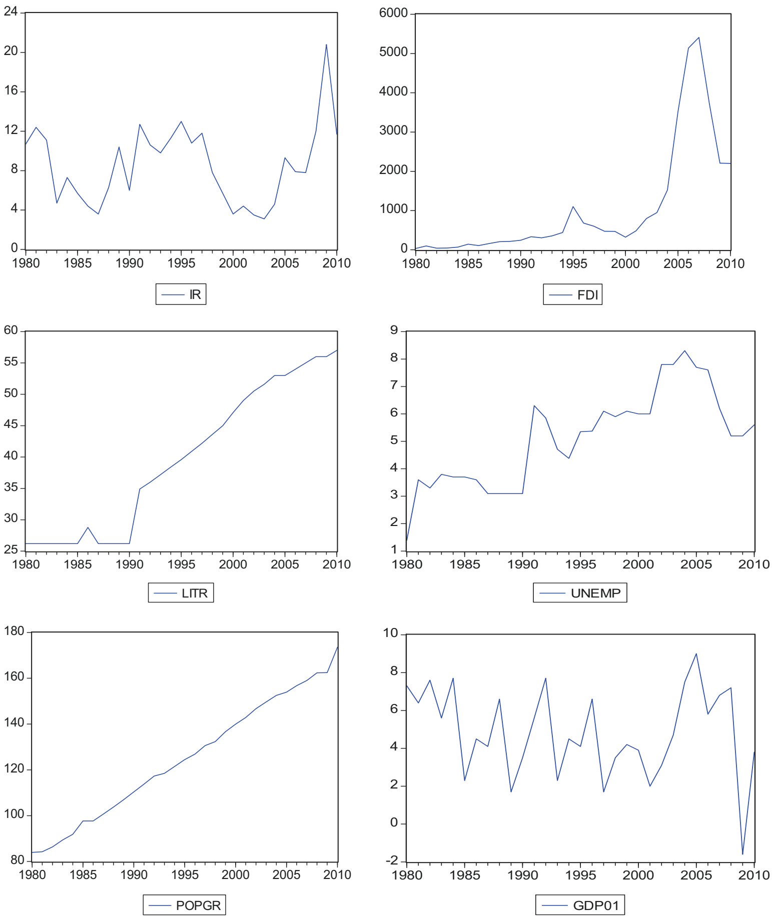

Fig. 114.1 The trends of the variables selected for study

Table 114.1 shows the data for the selected dependent and undependable variables for last 30 years.

Table 114.1 Data for the selective variables of the study for the year 1981-2010

Year	Y	X_1	X_2	X_3	X_4	X_5
	Unemp	PoPGR	RGDP	IR	LitR	FDI
1980	1.4	84	252463	10.7	26.2	35
1981	3.6	84.25	300888	12.4	26.2	98
1982	3.3	86.4	349508	11.1	26.2	42.1
1983	3.8	89.4	403782	4.7	26.2	48
1984	3.7	91.9	459397	7.3	26.2	70.3
1985	3.7	97.7	510468	5.7	26.2	145.2
1986	3.6	97.7	555891	4.4	28.8	108.2
1987	3.1	100.7	608857	3.6	26.2	162.2
1988	3.1	103.8	704484	6.3	26.2	209
1989	3.1	107	797750	10.4	26.2	216.2
1990	3.1	110.4	892843	6	26.2	246
1991	6.3	113.8	1044508	12.7	34.9	335.1
1992	5.85	117.32	1223922	10.6	36	306.4
1993	4.71	118.5	1351589	9.8	37.2	354.1
1994	4.38	121.48	1577085	11.3	38.4	442.4
1995	5.35	124.49	1879965	13	39.6	1101.7
1996	5.37	126.9	2113037	10.8	40.9	682.1
1997	6.1	130.58	2408962	11.8	42.2	601.3
1998	5.9	132.35	2653292	7.8	43.6	472.3
1999	6.1	136.69	2912832	5.7	45	469.9
2000	6	139.96	3778155	3.6	47.1	322.5
2001	6	142.86	4155391	4.4	49	484.7
2002	7.8	146.75	4476319	3.5	50.5	798
2003	7.8	149.65	5027460	3.1	51.6	949.4
2004	8.3	152.53	5765058	4.6	53	1524
2005	7.7	153.96	6634243	9.3	53	3521
2006	7.6	156.77	7773106	7.9	54	5139.6
2007	6.2	159.06	8830640	7.8	55	5410.2
2008	5.2	162.37	10451715	12	56	3719.9
2009	5.2	162.49	13070268	20.8	56	2205.7
2010	5.6	173.51	15402783	11.7	57	2201

114.4.1 Interpretation of Graphs

No trend is observed in Interest rate, but a jump in interest rate is seen in the year 2009, that reflects tight monetary policy stance of State Bank of Pakistan aiming to reduce inflation.

The increase in FDI can be observed in early 90s and another from 2002 to 2008 because of stable political and economic conditions. The decrease in FDI can be observed in 2009-10, indicating adverse law and order situation resulting in economic instability.

An increasing trend can be observed in 1990 in literacy rate. One major cause being the funding provided by the united nation and the increase in budget allocated by the government to education sector.

An increasing trend can be observed in population growth rate.

No trend can be observed in unemployment and GDP rate as unemployment varies according to the economic situation. However an increase in the unemployment trend can be seen in 2009-2010 because of the political instability, law and order threats, and elevating commodity prices, and other such factors.

114.4.2 E-views Output

As shown in Table 114.2, the first column of descriptive statistics shows that unemployment was at its peak level in 2004 and minimum in 1980, population growth rate, GDP and literacy rate was highest in 2010 and lowest in 1980, interest rate highest in 2009 and lowest in 2003 and FDI at its peak level in 2007 and lowest in 1980. The Values of skewness and kurtosis shows that all variables are relatively normally distributed, as the skewness values are closer to 0 and kurtosis values are closer to 3.

Table 114.2 Descriptive stats

	UNEMP	POPGR	RGDP	IR	LITR	FDI
Mean	5.127742	125.0087	3495699.	8.541935	39.70323	1045.855
Median	5.350000	124.4900	1879965.	7.900000	39.60000	442.4000
Maximum	8.300000	173.5100	15402783	20.80000	57.00000	5410.200
Minimum	1.400000	84.00000	252463.0	3.100000	26.20000	35.00000
Std. Dev.	1.726215	26.62806	3961289.	3.948820	11.63258	1473.810
Skewness	0.014196	0.036833	1.546607	0.757591	0.071320	1.885103
Kurtosis	2.272312	1.802889	4.630699	3.965735	1.471281	5.444088
Jarque-Bera	0.685017	1.858063	15.79341	4.170039	3.044882	26.07620
Probability	0.709987	0.394936	0.000372	0.124305	0.218179	0.000002
Sum	158.9600	3875.270	$1.08E+08$	264.8000	1230.800	32421.50
Sum Sq. Dev.	89.39454	21271.61	$4.71E+14$	467.7955	4059.510	65163463
Observations	31	31	31	31	31	31

114.4.3 Correlation Matrix

It can be seen from Table 114.3 that correlation matrix shows that literacy rate and Population growth are strongly correlated with Unemployment, where as GDP, FDI are moderately correlated with unemployment rate. The value of IR shows that IR is negatively weakly correlated with unemployment rate.

Table 114.3 Correlation matrix

	UNEMP	POPGR	RGDP	IR	LITR	FDI
UNEMP	1.000000	0.787930	0.501831	−0.129627	0.824591	0.505850
POPGR	0.787930	1.000000	0.872227	0.099757	0.976452	0.716139
RGDP	0.501831	0.872227	1.000000	0.308921	0.851646	0.742722
IR	−0.129627	0.099757	0.308921	1.000000	0.112032	0.181900
LITR	0.824591	0.976452	0.851646	0.112032	1.000000	0.716921
FDI	0.505850	0.716139	0.742722	0.181900	0.716921	1.000000

114.4.4 Regression Results

Regression results are shown in Table 114.4.

Table 114.4 The non-metallic mineral products variable value summary in 2008

Dependent variable: UNEMP				
Method: Least squares				
Date: 12/20/11 Time: 20:51				
Sample: 1980 2010				
Included observations: 31				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	−17.60352	4.219402	−4.172041	0.0003
POPGR	−0.02121	0.038225	−0.554884	0.5839
RGDP	$-1.86E-07$	$8.89E-08$	−2.092772	0.0467
LOG (IR)	−0.639825	0.364186	−1.756862	0.0912
LOG (LITR)	6.759596	2.029334	3.330944	0.0027
LOG (FDI)	0.451645	0.32494	1.389935	0.1768
R-squared	0.839655	Mean dependent var		5.127742
Adjusted R-squared	0.807586	S.D. dependent var		1.726215
S.E. of regression	0.757204	Akaike info criterion		2.453618
Sum squared residual	14.33396	Schwarz criterion		2.731164
Log likelihood	−32.03109	F-statistic		26.18277
Durbin-Watson stat	1.183809	Prob (F-statistic)		0

114.4.5 Regression Equation

Regression equation can be shown as follows:

$$UE = \beta_0 + \beta_1 PGR + \beta_2 GDP + \beta_3 PR_3 + \beta_4 FDI,$$
$$Y = \alpha + \beta X,\ Y = -17.60 - .02X1 - 1.86X_2 - 0.64X_3 + 6.76X_4 + 0.4516X_5.$$

It states that the expected unemployment rate is equal to $-17.60 - 0.02X_1 + -1.86X_2 + -0.64X_3 + 6.76X_4 + 0.4516X_5$. The c value shows that if all other variables are zero, the average level of unemployment will be 17 percent per year.

R squared measures the goodness of fit, its value of 0.839 means that about 84 percent variations in unemployment is explained by the understudy variables.

Coefficient of population growth shows if there is 1% increase in population, unemployment rate will decrease by 0.02%. This result is unexpected and cannot be justified through empirical study.

Coefficient of GDP shows if there is 1% increase in GDP, unemployment rate will decrease by 0.000000186% that is a negligible amount. As increase in GDP is an indicatotor of economic growth, resulting in job creation in the country, reducing unemployment rate.

Coefficient of interest rate shows if there is 1% increase in interest rate, unemployment rate will decrease by 0.63%. If there is increase in interest rate, it shows the increase in return on investment in that case people will invest more in business.

Coefficient of literacy rate shows if there is 1% increase in literacy rate, unemployment will increase by 6.759%. It shows that there will be frictional unemployment in the economy, which represents the mismatch between job specification and job description.

Coefficient of FDI shows if there is 1% increase in FDI, unemployment will increase by 0.45%. It was expected that there would be an inverse relationship between the two variables but the research show that there exist a positive relationship.

114.4.6 Hypothesis Testing

T statistics

T calculated values for GDP and Literacy rate are greater than T tabulated, so we can reject the null hypothesis that there exist no relationship between GDP, Literacy rate and unemployment.

T calculated values for population growth rate, interest rate and FDI are lesser than T tabulated, so we can not reject the null hypothesis. We can reject the null hypothesis at 58%, 9%, and 1% respectively.

F Statistics

F-calculated is greater than F-tabulated, so we can reject null hypothesis that that there exist no relationship between GDP, Literacy rate and unemployment.

114.5 Conclusions

Progress can be seen in the last few years in Pakistan's literacy rate, showing the efforts made by the government. Stringent measures are being taken and an improvement is seen in law & order situation in the country. Coming election are considered to bring political stability. Government is providing micro loan facility and many self employment/rozgar schemes have been initiated to decrease in unemployment. Efforts are also in hand by the government to provide relaxation in investment policies to encourage big guns to invest in major industries to afford employment at large scale. However, providing technical facilities and training at grass toot level low to skilled unemployed persons is yet another gray area and still a lot to be done in this domain. A healthy budget required to be allocated for education sector and research & development area. However, on the contrary Government is cutting down already set budget in this field which could be fatal for improving employment rate.

The statically study indicates that IR, GDP Growth rate and LR have a significant impact in determining the unemployment rate. So if we try to improve the three explanatory variables that will result in decrease of unemployment rate. The null hypothesis is being rejected as there exists a relationship between the variables under study. Whereas, a positive relationship between FDI and unemployment has been observed. FDI and population growth rate proved to be statistically insignificant. These results are contradictory to the existing literature. Unemployment trend does not show any significant change but the rising unemployment in the year 2009-10 is due to the worse law & order situation and political instability. Under such conditions, investors did not find Pakistan as an attractive market for business and many winded up their operations from the country. This led to an increase in unemployment. Literacy rate and unemployment rate are positively related to each other showing that if literacy rate increases than there will be a mismatch between a person's qualification and his job description, in this case the people will remain unemployed, in search of better job opportunity.

114.6 Recommendations

A good law and order environment is believed to be essential for inflow of foreign investment in a country. Hence it is suggested that more strong actions must be taken by the government for further improvement in law & order situation. This will result in conducive environment for not only domestic business but will also attract foreign investors in the country thus providing better opportunities for employment. Democracy, though still in a process of getting matured in Pakistan, should flourish by all means to bring political stability in the country. Government must promote such industries which can create better job opportunities. A number of steps have already taken by government in this regard however, for this purpose more relaxation in investment policies and confidence & security to the investors is advisable. Consideration should be paid towards the low skilled unemployed persons by providing technical facilities and training at grass toot level throughout the country in order to enhanced their chance to earn rationally. The increasing trend of population growth rate can be taken as an advantage to the country, they can be better trained, and more industries can be set up for ultimately country can act as export hub for various commodities. Enhanced and proper budget should be allocated for education sector and research and development domain, which will result in creation of more specialized fields and generation of better employment openings. Some results are unexpected, hence it is suggested that further studies can be carried out to find the reasons for unanticipated outcomes.

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Part VIII
Industrial Engineering

Chapter 115
The Travelling Wave Solutions of the Active-dissipative Dispersive Media Equation by $\left(\frac{G'}{G}\right)$-expansion Method

Refet Polat and Turgut Öziş

Abstract Over the past decades a number of approximate methods for finding travelling wave solutions to nonlinear evolution equations have been proposed. Among these methods, one of the current methods is so called $\left(\frac{G'}{G}\right)$-expansion method. In this paper, we will examine the $\left(\frac{G'}{G}\right)$-expansion method for determining the solutions of the active-dissipative dispersive media equation. The active-dissipative dispersive media equation is given by $\mu_t + \mu\mu_x + \alpha\mu_{xx} + \beta\mu_{xxx} + \gamma\mu_{xxxx} = 0$, where for positive constants α and γ in equation are small-amplitude. This equation describe long waves on a viscous fluid flowing down along an inclined plane, unstable drift waves in plasma and stress waves in fragmentated porous media. When $\beta = 0$, equation is reduced to the Kuramoto-Sivashinsky equation, which is the simplest equations that appears in modelling the nonlinear behaviour of disturbances for a sufficiently large class of active dissipative media. It represents the evolution of concentration in chemical reactions, hydrodynamic instabilities in laminar flame fronts and at the interface of two viscous fluids.

Keywords $\left(\frac{G'}{G}\right)$-Expansion method · The active-dissipative dispersive media equation · Wave solutions

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115.1 Introduction

Nonlinear equations are widely used to describe complex physical phenomena in various fields of sciences, especially in fluid mechanics, solid state physics, plasma physics, plasma waves and biology. The most important problem is to obtain travelling wave solutions of these equations. Recently, there are variety of powerful methods to obtain new exact solutions of nonlinear PDEs such as inverse scattering method [1, 2], bilinear transformation [3], the tanh-sech method [4–6], extended tanh method [7–9], sine-cosine method [10], homogeneous balance method [12], Exp-function method [13, 14] and improved tanh-function [15] method. The mentioned methods are analytic or semi-analytic method in which use we do not consider the stability and convergence of the solutions.

Now, we consider one of the recent methods $\left(\frac{G'}{G}\right)$-expansion method which is introduced by Wang et al [23], has become widely used to search for various exact solutions of nonlinear equations [23–30]. The method depends on the linearization of the nonlinear equation and also, by the method, nonlinear differential equation convert to a system of algebraic equations.

In this paper, we study the application of $\left(\frac{G'}{G}\right)$-expansion method to the active-dissipative dispersive media equation.

115.2 The $\left(\frac{G'}{G}\right)$-expansion Method

We assume that the given nonlinear partial differential equation for $u(x,t)$ to be in the form:

$$P(u, u_x, u_t, u_{xx}, u_{xt}, u_{tt}, \cdots) = 0, \tag{115.1}$$

where P is a polynomial in its arguments, which includes nonlinear terms and the highest order derivatives. Then; using the transformation $u(x,t) = u(\xi),\ \xi = k(x - ct)$ one can reduce Equation (115.1) to the ordinary differential equation:

$$Q(u, u_\xi, u_{\xi\xi}, u_{\xi\xi\xi}, \cdots) = 0. \tag{115.2}$$

Hence, for the solution of Equation (115.2), let us assume that the exact solution can be expressed as simple expansion in the form of:

$$u(\xi) = \sum_{i=0}^{N} g_i \left(\frac{G'(\xi)}{G(\xi)}\right)^i, \tag{115.3}$$

where $g_i, (i = 0, 1, \cdots, N)$ are constants which will be determined later and function $G(\xi)$ is an appropriate function that yields:

$$G''(\xi)+\lambda G'(\xi)+\mu G(\xi)=0, \tag{115.4}$$

where λ and μ are arbitrary constants.

Now, let us remember the process for finding the unknown coefficients $g_i,(i=0,1,\cdots,N)$ where

$$(\xi)=\sum_{i=0}^{N} g_i\left(\frac{G'(\xi)}{G(\xi)}\right)^i.$$

Substituting Equation (115.3) and Equation (115.4) into the given nonlinear equation and equating each coefficient of a power of $\left(\frac{G'(\xi)}{G(\xi)}\right)$ to zero yields an algebraic system. Hence, all coefficients g_i can be determined by solving the algebraic system and the parameter N is a positive integer and can be determined by balancing the highest order derivative terms and the highest power nonlinear terms in Equation (115.2) in general.

Hence, in ansatz (115.3), the parameter N is a positive integer and can determined by balancing the higher order derivative term and highest power nonlinear terms in Equation (115.2). The highest degree of $\frac{\partial^p \mu}{\partial \xi^p}$ can be calculated by:

$$\begin{cases} o\left[\frac{\partial^p \mu}{\partial \xi^p}\right]=N+p, & p=0,1,2,\cdots \\ o\left[\mu^q\frac{\partial^p \mu}{\partial \xi^p}\right]=qN+p, & q,p=0,1,2,\cdots \end{cases} \tag{115.5}$$

Consequently substituting Equation (115.3) and Equation (115.4) into Equation (115.2) and equating the coefficients of all powers of $\left(\frac{G'(\xi)}{G(\xi)}\right)$ to zero in the resulting equation, several algebraic equations will be obtained. Then solving these algebraic equations by the symbolic computation system Maple, and combining Equation (115.3), we can get the exact solutions for Equation (115.1).

115.3 The Active-dissipative Dispersive Media Equation

In this section, we are going to combine the $\left(\frac{G'(\xi)}{G(\xi)}\right)$-expansion method with the new solutions of the active-dissipative dispersive media equation which is a real life problem [11]. The active-dissipative dispersive media equation is given by:

$$\mu_t+\mu\mu_x+\alpha\mu_{xx}+\beta\mu_{xxx}+\gamma\mu_{xxxx}=0, \tag{115.6}$$

where for positive constants α and γ in Equation (115.6) are small-amplitude. Equation (115.6) describe long waves on a viscous fluid flowing down along an inclined plane [11], unstable drift waves in plasma [35] and stress waves in fragmentated porous media [36]. When $\beta=0$, Equation (115.6) is reduced to the Kuramoto-

Sivashinsky equation, which is the simplest equations that appears in modelling the nonlinear behaviour of disturbances for a sufficiently large class of active dissipative media. It represents the evolution of concentration in chemical reactions [37], hydrodynamic instabilities in laminar flame fronts and at the interface of two viscous fluids [38]. To find the traveling wave solutions for Equation (115.6), we use the wave variable $\xi = k(x-ct)$, where $c \neq 0$ and $k \neq 0$. The wave variable ξ carries Equation (115.6) into the ordinary differential equation:

$$c\mu' + k\mu\mu' + \alpha k^2\mu'' + \beta k^3\mu''' + \gamma k^4\mu^{(4)} = 0. \tag{115.7}$$

From Equation (115.3), and using Equation (115.5), we have $N = 1$. Therefore, the ansatz yields

$$u(\xi) = g_0 + g_1\left(\frac{G'(\xi)}{G(\xi)}\right), \tag{115.8}$$

function $G(\xi)$ is an appropriate function that yields Equation (115.4) where λ and μ are arbitrary constants.

Now, substituting Equations (115.8) and (115.4) into Equation (115.7), we obtain the following algebraic system;

$$\begin{aligned}
&60\gamma\lambda - 6\beta = 0,\\
&-12\beta\lambda + 50\gamma\lambda^2 - g_1 + 2\alpha + 40\gamma\mu = 0,\\
&-g_1\lambda + 60\gamma\lambda\mu + 3\alpha\lambda - g_0 - c - 8\beta\mu + 15\gamma\lambda^3 - 7\beta\lambda^2 = 0,\\
&16\gamma\mu^2 + 22\gamma\lambda^2\mu - g_1\mu - g_0\lambda - 8\beta\lambda\mu + \alpha\lambda^2 + 2\alpha\mu + \gamma\lambda^4 - c\lambda - \beta\lambda^3 = 0,\\
&-g_0 + 8\gamma\lambda\mu - c + \gamma\lambda^3 - 2\beta\mu + \alpha\lambda - \beta\lambda^2 = 0.
\end{aligned}$$

Solving the system by the aid of Maple 13, we can determine the coefficients:

Case 115.1.

$$c = -\frac{5}{2}g_1 - 5000\gamma - g_0,\ \mu = -25,\ \alpha = 625\gamma + \frac{1}{2}g_1,\ \beta = -50\gamma,\ \lambda = -5.$$

Case 115.2.

$$c = -\frac{5}{2}g_1 - 1875\gamma - g_0,\ \mu = \frac{25}{4},\ \alpha = 625\gamma + \frac{1}{2}g_1,\ \beta = -50\gamma, \lambda = -5.$$

Case 115.3.

$$\begin{aligned}
c = \ & \frac{1}{2}\Bigg(-15\alpha_1\lambda + 3\alpha_1\lambda^2 - 900\gamma\lambda^3 + 20(-\alpha_1 + \alpha_1\lambda^2 + 46\gamma\lambda^4 - 12\gamma\lambda^3\\
& -10\gamma\lambda^2 + 4\sqrt{125\gamma^2\lambda^4 - 50\gamma^2\lambda^5 - 35\gamma^2\lambda^6 - 4\gamma^2\lambda^7})\lambda/(\lambda^2-1)\\
& -2(-\alpha_1 + \alpha_1\lambda^2 + 46\gamma\lambda^4 - 12\gamma\lambda^3 - 10\gamma\lambda^2\\
& +4\sqrt{125\gamma^2\lambda^4 - 50\gamma^2\lambda^5 - 35\gamma^2\lambda^6 - 4\gamma^2\lambda^7})\lambda/(\lambda^2-1)\\
& +120\gamma\lambda^4 - 10\alpha_0 - 2\alpha_0\lambda\Bigg)\Bigg/(5+\lambda),
\end{aligned}$$

$$\mu = \frac{1}{8}\Big(-70\gamma\lambda^2 - \alpha_1 + (-\alpha_1 + \alpha_1\lambda^2 + 46\gamma\lambda^4 - 12\gamma\lambda^3 - 10\gamma\lambda^2$$
$$+4\sqrt{125\gamma^2\lambda^4 - 50\gamma^2\lambda^5 - 35\gamma^2\lambda^6 - 4\gamma^2\lambda^7})/(\lambda^2 - 1)$$
$$+\alpha_1 + \alpha_1\lambda^2 + 46\gamma\lambda^4 - 12\gamma\lambda^3 - 10\gamma\lambda^2$$
$$+4\sqrt{125\gamma^2\lambda^4 - 50\gamma^2\lambda^5 - 35\gamma^2\lambda^6 - 4\gamma^2\lambda^7})\lambda/(\lambda^2 - 1) + 46\gamma\lambda^3\Big)\Big/(\gamma(5+\lambda)),$$
$$\alpha = \frac{1}{2}(-\alpha_1 + \alpha_1\lambda^2 + 46\gamma\lambda^4 - 12\gamma\lambda^3 - 10\gamma\lambda^2$$
$$+4\sqrt{125\gamma^2\lambda^4 - 50\gamma^2\lambda^5 - 35\gamma^2\lambda^6 - 4\gamma^2\lambda^7})\lambda\Big/(\lambda^2 - 1).$$

Substituting the above coefficients into ansatz Equation (115.3) with the solution of Equation (115.4), we obtain one of new solution of the active-dissipative dispersive media equation for Case 115.1:

$$\mu(x,t) = 1250\gamma - 5\alpha - c$$
$$+(-1250\gamma + 2\alpha)\Big(\_C_1\left(\frac{5}{2} + \frac{\sqrt{25-4\mu}}{2}\right) e^{((\frac{5}{2}+\frac{\sqrt{25-4\mu}}{2})\mu(x-ct))}$$
$$+\_C_2\left(\frac{5}{2} - \frac{\sqrt{25-4\mu}}{2}\right) e^{((\frac{5}{2}-\frac{\sqrt{25-4\mu}}{2})\mu(x-ct))}\Big)\Big/\Big(\_C_1 e^{((\frac{5}{2}+\frac{\sqrt{25-4\mu}}{2})\mu(x-ct))}$$
$$+\_C_2 e^{((\frac{5}{2}-\frac{\sqrt{25-4\mu}}{2})\mu(x-ct))}\Big).$$

The graph of the solution is illustrated for the selected values by [33]. in Fig. 115.1.

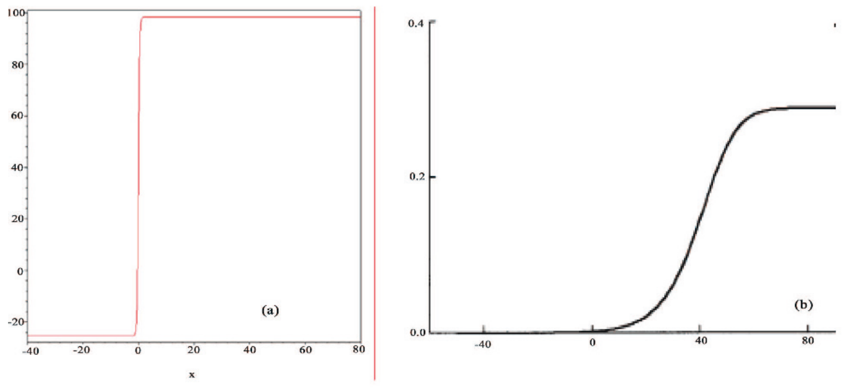

Fig. 115.1 Graph of solution (a) is the $\left(\frac{G'(\xi)}{G(\xi)}\right)$-expansion method solutions for the values $\delta = 3, c = 10, g_1 = 1, a_6 = 1$, (b) is for the same values obtained by [33]

As it is seen in Fig. 115.1, the solution is obtained by the $\left(\frac{G'(\xi)}{G(\xi)}\right)$-expansion method is more stable than the solution which is obtained by a high-order finite-difference scheme method in [33].

115.4 Conclusion

As is seen, the key idea of obtaining new travelling wave solutions for the nonlinear equations the $\left(\frac{G'(\xi)}{G(\xi)}\right)$-expansion method is successful. This method is reliable and easy to applicable, also give more solutions. In this letter, we have successfully obtained some new exact travelling solutions of the active-dissipative dispersive media equation. We compare our solutions with the solutions obtained by [33]. The presented method could lead to finding new exact travelling wave solutions for other nonlinear problems.

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Chapter 116
Industry Competitiveness Evaluation Based on RCA and Information Entropy

Mei Han, Dan Zhang and Yue He

Abstract With the global competitiveness becoming fiercer and fiercer, the industry competitiveness has been a vital factor to measure the development of a nation or a district. Therefore, it is important to discuss the evaluation method of the industry competitiveness. This paper proposes an evaluation index system to measure the industry competitiveness of a district by analyzing the existing literature and using information entropy to give every index a certain weight. The experiment chose the Sichuan province to study, and got the strength and shortness comparing with the same industry of China by applying the RCA index. The experiment study shows that the total competitiveness of seven industries in Sichuan province is higher than the average level of China, but these industries do have weakness in some of detail index. According to the result, this paper also comes up with some advice about the industry development.

Keywords Industry competitiveness · Index system · RCA · Information entropy

116.1 Introduction

With the rapid development of economic globalization and information technology, domestic and international competition is becoming increasingly fierce. Since China has become a member of the WTO, China is bound to be huge competition for world economic pressure. In this era of context, exploring the theories and methods of evaluation of industrial competitiveness will become important theoretical and practical problems facing a strong reality and urgency.

Competitiveness is the ability that competitors compete for resources or markets in the market competition. Basing on different criteria, competitiveness can be di-

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vided into different levels including national competitiveness, regional competitiveness, and industry competitiveness, the competitiveness of enterprises and product competitiveness. However, compared to the analysis of the competitiveness of the national or corporate level, analyzing of the industry competitive makes researchers to a better understanding of the competitive situation of the industry, and it also provides more details of the comparison [1].

Scholars elaborated the understanding of industrial competitiveness from different angles. From the perspective of productivity, Boltho [2] believes that the international competitiveness of industry is "compatible with the external balance of the maximum possible productivity growth". From the point of view of competitive advantage, Porter believes the trend of industrial development and the quality of a country (region) will largely determine the level of economic development of the region [3]. From the perspective of comparative advantage, Fetscherin [1] thinks that industrial competitiveness is the ability which refers to a country's industry relative to other countries with strong production and ability to innovate and then the country's industry takes advantage of the competitive position in the market and sustained profit. From the point of view of productivity and market forces, Chinese scholars Jin [4, 5] thinks industrial competitiveness that is under conditions of free trade is the overall quality that an industry of a country can be more effective than other countries of similar industries to market production or services. From the angle of the allocation of resources, Pei [6] believes that Market allocation of resources is an important factor to impact the industrial competitiveness of countries (regions).

With the development of the economy, scholars continue to explore the meaning of industrial competitiveness. Scholars based on the definition above and they synthesize the various factors. However, if they want to solve the problems of the industry competitiveness evaluation, they will find a suitable method to evaluation. We summed up three ways about industry competitiveness evaluation in foreign country [7]: (1) The evaluation method which is based on the sustainable competitive perspective, which include both a measure of current industry competition and a measure of the ability which industry continues to participate in the competition and obtain benefits. (2) The production perspective evaluation which is based on the industrial competitiveness. The method includes method of total factor productivity, relative labor productivity evaluation method and the cost element contribution evaluation method. (3) The evaluation method which is based on the international division of labor. Such methods based on the international trade indicators and it has 2-3 indicators used in combination to improve the scientific nature of the comparison such as RCA (Revealed Comparative Advantage) index, TSC (Trade Specialization Coefficient) Index [8]. In China, industrial competitiveness evaluation methods can be divided into four categories including Index comprehensive evaluation method, evaluation of the outcome of competition, the impact factor profiling method, and total factor productivity method. What is more, the most widely used index is comprehensive evaluation method [9]. To select the index, Xie [10] established evaluation index system from the industrial competitiveness and outside competitiveness. Huang [11] explored industrial competitiveness evaluation method from static competitiveness evaluation, the competitive potential change in trend estimates and the competitive impact of factors on the changes in the competitiveness. Indicators in the evaluation method of the composite indicator can fully consider the geographical and the industry characteristics of the selection of indicators. Therefore, if the method is applied to the problems of industrial competitiveness, it will reflect the competitive status of a geographical or industry accurately. By previous studies, we found that exhaustive index system generally exist in the theoretical study establishment of evaluation index system. In empirical research articles, the establishment of evaluation is usually based on the characteristics of the empirical country or region for the deletion and adjustment to make the evaluation index more practical. But there are also some studies either calculated too cumbersome or too much choice of indicators. There are autocorrelation or less related issues to solve. Besides, some indicators have a single study which is difficult to fully reflect the actual situation of the regional competitiveness. Expert advice and principal component analysis is a commonly method to determine the weight, but human's judgment always have subjective factors.

This paper built the basic theory framework of a new regional competitiveness and evaluation index system according to regional characteristics. What is more, paper determined the index weight by using information entropy method and got strengths and gaps of the regional industry and the national industry by RCA Index. Last but not the least, some rationalization proposals for development were proposed.

116.2 Study Design

116.2.1 Building the Industry Competitiveness Evaluation Index System

This paper agrees the idea that the industry competitiveness is compared from the view of industrial competitive advantage, and this advantage will embody the product, enter-prise and industry of ability to market in the final. The comparative productivity means an integrative ability that the firm or the industry can continuously produce the products which consumers would like to buy in an efficient way that better than other competitors, and firms or industries can benefit from it [12]. The World Economic Forum, WEF, has published "International Competitiveness Report" year by year since 1979, which evaluates the competitiveness of every nation through the perspective of productivity [13]. So the index we use include the key economic index which can reflect the production capacity, such as the overall labor productivity. In addition, we add the other two indexes, the proportion of total industrial output value and the proportion of industrial added value, to measure production capacity. Also the market competition is a critical factor. Wu [14] proposes the competitive advantage and the scale advantage method, which combined the market realities competitive and the scale of factor and product occupied in the market scale of the main competition (region) to measure the competitiveness of the main competition. So we put forward the market competitiveness indicators, and its second level indexes are the product sales rate and the product export rate. In the era of knowledge economy, scientific and technological innovation is essential for industrial development [15], and the technological competitiveness of industry can just show the degree of technological innovation.

The basic starting point of designing the industry competitiveness evaluation index system is to reflect regional industry competitiveness objective and accurately and use the data provided by the available statistics as much as possible. And too many indicators have the contrary situation, and the complementarities between the indexes will cover the difference between the evaluation object. Therefore, the scale of the index system should be appropriate [16]. Based on the principle of the combination of emphasis and accurate, scientific and feasibility, process indicators and status, and according to the data of Sichuan province, the paper designs the index system. As shown in Table 116.1.

Table 116.1 The industry competitiveness evaluation index system

Target	First level index	Second level indexes
Industry competitiveness	Production competitiveness	Proportion of total industrial output value Proportion of industrial added value Overall labor productivity
	Market competitiveness	Product sales rate Product export rate
	Technological competitiveness	Coefficient of equipment ageing index Output value of new products rate
	Assets competitiveness	Ratio of profits to cost Ratio of total assets contribution

(1) The second level indexes of production competitiveness

- Proportion of total industrial output value. This index can measure the industrial importance among the entire economic structure.

$$\begin{aligned}&\text{Proportion of total industrial output value}\\&=\left(\frac{\text{Total industrial output value}}{\text{GDP}}\right)\times 100\%.\end{aligned}$$

- Proportion of industrial added value. This index can show the position of the new added value of the industry in the regional economic structure.

$$\text{Proportion of industrial added value}=\left(\frac{\text{Industrial added value}}{\text{GDP}}\right)\times 100\%.$$

- Overall labor productivity. This index is a kind of comprehensive evaluation, which can display production level, the management level, staff technical proficiency and labor enthusiasm of a firm.

$$\text{Overall labor productivity} = \left(\frac{\text{Industrial added value}}{\text{Employees average of year}}\right) \times 100\%.$$

(2) The second level indexes of market competitiveness

- Product sales rate. This index can reflect the extent of industrial products have achieved sales, analyze the connection status of industrial production and sales.

$$\text{Product sales rate} = \left(\frac{\text{Sales value of industry}}{\text{Gross industrial output}}\right) \times 100\%.$$

- Product export rate. This index is a key factor to measure the external competitiveness of industry. And it can show the competitiveness of an industry in other regions.

$$\text{Product export rate} = \left(\frac{\text{Industrial export output}}{\text{Gross industrial output}}\right) \times 100\%.$$

(3) The second level indexes of technological competitiveness

- Coefficient of equipment ageing index. If the index is high, that means a single device generally newer or all the equipment in the proportion of new equipment, and new equipment in general means technical level. Therefore, the higher the index is, the better the development of the industry technology is.

$$\begin{aligned}&\text{Coefficient of equipment ageing index}\\&\quad = \frac{\text{Net fixed assets of the production equipment}}{\text{Fixed assets at cost of production equipment}}.\end{aligned}$$

- Output value of new products rate. It can reflect the degree of technical innovation and product structural optimization.

$$\begin{aligned}&\text{Output value of new products rate}\\&\quad = \left(\frac{\text{New products output of industry}}{\text{Gross output of industry}}\right) \times 100\%.\end{aligned}$$

(4) The second level indexes of assets competitiveness

- Ratio of profits to cost. The index can show the economic benefits that the industrial production costs and expenses for the period made.

$$\text{Ratio of profits cost} = \left(\frac{\text{Net profit}}{\begin{array}{c}\text{Revenue of main business} + \text{Operating costs}\\ + \text{Administration expense} + \text{Financial expense}\end{array}}\right) \times 100\%.$$

- Ratio of total assets contribution. The indicator reflects the profitability of all the assets of the industrial enter-prises, management level and a concentrated expression of the results of operations of the industrial enter-prise, and evaluates all of the assets of the enter-prise profitability.

$$\begin{aligned}&\text{Ratio of total assets contribution}\\&=\left(\frac{\text{Total profit}+\text{Total tax}+\text{Interest expense}}{\text{Average of total assets}}\right)\times 100\%.\end{aligned}$$

116.2.2 Weighting Indexes by Using Information Entropy

Entropy was first proposed by Clausius in thermodynamics to describe the state of a system. Then this tool was introduced in many realms, so the concepts of L.Boltzmann entropy, information entropy and probability measure entropy gradually appeared. According to the characteristic of entropy, entropy value can be used to determine not only the degree of randomness and disorder in an event, but also the discrete degree of an index. In general, the stronger the discrete degree of the indicator is, the greater the entropy value is; conversely, the smaller entropy value is. When we use multiple indicators to comprehensive evaluation, if each individual's value is not much different because of one index, the role of this index is not big in the comprehensive evaluation. On the contrary, if the value of each part is much different because of one index, that is to say the discrete degree of the indicator is large, so this index makes huge influence on comprehensive evaluation. Therefore, it can provide the basis for multiple indicators by using the tool of entropy to calculate the weight of every index [17].

Traditional fuzzy evaluation method, it determines the weight of indicators by using the method of subjective expert. So for more objectively results of evaluation and comparing the differences of various evaluation indicators more scientifically, we weight combined with the concept of information entropy [18].

The approach of weighing based on information entropy is shown below:

Step 1. Structure decision matrix $A=(a_{ij})_{n\times m}$ or a multiple attribute problem, and use appropriate methods to make it standardized as $R=(r_{ij})_{n\times m}$.

Step 2. Calculate the matrix $R=(r_{ij})_{n*m}$, and then get the standardized matrix $R=(r)_{n*m}$, and $r_{ij}=r_{ij}\big/\sum_{i=1}^{n} r_{ij},\ i\in N,\ j\in M$.

Step 3. Calculate the information entropy of property u_j, $E_j=-\frac{1}{\ln n}\sum_{i=1}^{n} r_{ij}\ln r_{ij},\ j\in M$. While if $r_{ij}=0$, stipulate $r_{ij}\ln r_{ij}=0$.

Step 4. Calculate vector of attribute weight $w=(w_1,w_2,\cdots,w_n)$, and

$$w_j=\frac{1-E_j}{\sum\limits_{k=1}^{m}(1-E_k)}. \tag{116.1}$$

116.2.3 Judging Industry Competitiveness by Using Revealed Comparative Advantage Index

The RCA index, Revealed Comparative Advantage Index, is proposed by the development economists Balassa in 1965, which has been the most widely used since the 1980s. RCA index can be used to longitudinal comparison of different industries in the same area, which can show the industry competitive position relative to other industries; it also can be used to horizontal comparison on the same industry in different regions, in order to fully explain the competitive strength of the industry [19].

Meaning of the index is the ratio between one rate that a country's exports of a certain commodity relative to its total exports and the other rate that the world's total exports of the commodity relative to its total exports.

The formula can be written as:

$$\mathrm{RCA} = \left(\frac{X_i}{X_t} \div \frac{W_i}{W_t} \right) \times 100, \tag{116.2}$$

where X_i represents a country's exports of a certain commodity, X_t is the country's total exports; W_i is the world's exports of this commodity, and W_t represents the world's total exports. If RCA > 100, then a comparative advantage of the country's commodity is revealed [20].

When this index is used to analyze the regional competitiveness of industry in Sichuan, it can be defined as the ratio between one rate that industrial industries in each economic indicator of the area relative to the total economic output in Sichuan and the other rate that the same economic index of each corresponding industry of the whole nation relative to national total economic output. The RCA index can be represented by the following model:

$$\mathrm{RCA}_{ij} = \left(\frac{X_{ij}}{\sum\limits_{j=1}^{n} X_{ij}} \div \frac{\sum\limits_{i=1}^{m} X_{ij}}{\sum\limits_{j=1}^{n} \sum\limits_{i=1}^{m} X_{ij}} \right) \times 100, \tag{116.3}$$

where i represents regions and j represents industries, RCA_{ij} is the revealed comparative advantage index of industry j in region i; X_{ij} represents the value of economic indicators of industry j in region i; $\sum_{j=1}^{n} X_{ij}$ is the total value of economic indicators of region i; is the value of economic indicators of industry j of country; $\sum_{j=1}^{n} \sum_{i=1}^{m} X_{ij}$ represents total economic indicators value of the country. Let i represents Sichuan province, $j \in$ (electronic information industry, equipment manufacturing, beverage and food industry, energy and electric power industry, oil and gas chemical industry,vanadium and titanium steel industry, modern medicines industry), and use the second level indicators of the industry evaluation index system proposed by this paper as economic indicators. And then doing the calculation by using the Equation (116.3), we can get the result to analyze.

When $RCA_{ij} > 100$, it represents comparative advantage of a certain economic indicator of an industry in Sichuan is higher than the national average. And the larger RCA_{ij} is, the stronger its comparative advantage is.

When $RCA_{ij} < 100$, it means comparative advantage of a certain economic indicator of an industry in Sichuan is lower than the national average. And the smaller RCA_{ij} is, the weaker its comparative advantage is.

When $RCA_{ij} = 100$, it means comparative advantage of a certain economic indicator of an industry in Sichuan is equivalent to the national average.

The biggest advantage of RCA index is to examine the relative position of regional industries in a larger space, and judge the strength of the comparative advantage of each index in Sichuan by using the frame of reference which is the relative position of national industrial industries in the whole national economy.

116.3 Empirical Analysis

The empirical data comes from the Sichuan Provincial Statistical Yearbook 2008 and the National Statistical Yearbook 2008.The seven industries of Sichuan province is the evaluation objects which are the electronic information industry, equipment manufacturing, energy and electric power industry, oil and gas chemical industry, vanadium and titanium steel industry, the beverage and food industry, and modern medicine industry.

Using the weights shown in Table 116.1 and the industrial competitiveness evaluation index system, and according to the Equation (116.1) is calculated for each evaluation, we got a composite score of seven industries and the country in the same industry by information entropy method. And then we used RCA index to analyze the competitiveness of this seven industries of Sichuan province comparing with the same industry of the country. The comparative result is shown in Table 116.2.

As we can see from Table 116.2, the competitiveness of seven industries in Sichuan province is slightly higher than similar industries of the country. Proportion of total industrial output value and proportion of industrial added value of Sichuan seven industries are higher than national average in production competitiveness, which represents the proportion scale of these seven industries, has a greater advantage. And the RCA index of labor productivity is lower than 100, so we can get the conclusion that the comprehensive level of production level, the management level, staff technical proficiency and labor enthusiasm of the seven industries is below the nation's, and the labor productivity should be improved.

Similar with the above analysis, in the market competitiveness, the RCA index of product sales rate is basically the same with the national level, and which means the seven industries of Sichuan have the ability to adapt to market demand on the overall; and the external trade competitiveness and the ability to adopt to the international market of the products of the seven industries of Sichuan is far lower than the national level. When it comes to the technological competitiveness, the result shows it is higher than the country. The RCA index of coefficient of equipment

Table 116.2 Comparison of seven industries in Sichuan province and the country with the competitiveness of the industry in 2007

	Index	Weights	Total value of seven industries in Sichuan	Total value of similar industries of the country	RCA index of Sichuan country
Production competitiveness	Proportion of total industrial output value	0.1237	77.63%	73.40%	105.76
	Proportion of industrial added value	0.0818	87.76%	73.73%	119.03
	Overall labor productivity (billion/ thousand)	0.1510	1.71	1.83	93.44
Market competitiveness	Product sales rate	0.1606	98.08%	98.29%	99.79
	Product export rate	20.0522	3.70%	20.88%	17.72
Technological	Coefficient of equipment	0.1114	63.98%	64.12%	99.78
Competitiveness	Ageing index				
	Output value of new products rate	0.0986	18.76%	12.73%	147.37
Assets competitiveness	Ratio of profits to cost	0.1111	6.40%	6.28%	147.37
	Ratio of total assets contribution	0.1096	11.90%	13.75%	86.55
Comprehensive competitiveness		1.0	0.5101	0.5039	101.2304

ageing index is close to 100, indicating that the high technical level of the seven industries in Sichuan Province, roughly equal to the national level; the RCA index of output value of new products rate, indicating that the seven industries of Sichuan in the degree of industrialization of technological innovation, product structure optimization is far ahead of the national average. And the assert competitiveness is slightly lower than the national average. The RCA index of ratio of profits to cost is slightly higher than the 100, showing that the economic benefits of investment by the industry's production costs and period expense of seven industries in Sichuan is higher than the national level, and these seven industries have a comparative advantage; the RCA index of Ratio of total assets contribution is less than 100, so there are some gaps of profitability between enter-prises of seven industries in Sichuan and the country.

Overall, comparing to the country on the production competitiveness, market competitiveness, technological competitiveness and assets competitiveness, the seven industries in Sichuan have their own advantages and disadvantages. The RCA index of Sichuan/Country is 101.2304 > 100, indicating the comprehensive competitiveness of seven industries in Sichuan is slightly higher than the national average.

The paper used the same method to compare the competitiveness of seven industries and the corresponding industries of the country. The result is shown as Table 116.3.

Table 116.3 Comparison of seven industries in Sichuan and the country's corresponding industries with the competitiveness

Industry competitiveness index	PC			MC		TC		AC		CC
	PTIOV	PIAV	OLP	PSR	PER	CEAI	OVNPR	RPC	RTAC	
Electronic information	−−	−−	√	−−	−−	√	√	√	−−	√
Equipment manufacturing	−−	−−	√	−−	−−	−−	√	√	−−	√
Energy and electric power	√	√	−−		−−	√	−−	−−	−−	−−
Oil and gas chemical	−−	√	−−	−−	−−	√	√	√	√	−−
Vanadium and titanium steel	√	√	−−	−−	−−	−−	√	−−	−−	−−
Beverage and food	√	√	√	√	−−	−−	√	−−	−−	√
Modern medicines	√	√	−−	√	−−	−−	√	−−	−−	−−

Note: a $\surd$ indicates that the index is higher than the national average, or below the national level. Abbreviations: PC – Production competitiveness, MC – Market competitiveness, TC – Technological competitiveness, AC – Assets competitiveness; PTIOV – Proportion of total industrial output value, PIAV – Proportion of industrial added value, OLP – Overall labor productivity, PSR – Product sales rate, PER – Product export rate, CEAI – Coefficient of equipment ageing index, OVNPR – Output value of new products rate, RPC – Ratio of profits to cost, RTAC – Ratio of total assets contribution.

We can learn from Table 116.3, four industries competitiveness is lower than the national level, which are energy and power industry, oil and gas chemical industry, vanadium and titanium steel industry and modern medicines industry, and In order to catch up with the national average, these industries should be invested hugely. Specially, we should point out that products export rate of each industry is lower than the level of the same industry in the country, and the urgent task is to improve the external trade competitiveness and the ability to adopt to the international market of the products of the seven industries of Sichuan.

116.4 Conclusions

Combining Sichuan industry characteristics, the paper established an industrial competitiveness evaluation system. And the index weights are determined by information entropy method. Then, there are empirical researches for the seven industries in Sichuan in the paper. The paper's innovation lies in the use of information entropy method to determine the industrial competitiveness indicators'weight and it is able to eliminate the subjectivity of expert method. The paper that used the RCA index placed the relative position of the regional industrial in a larger space to examine and it makes conclusions more synthesized and exhaustive.

The empirical analysis used the individual indicators evaluation method and reflected the competitiveness of such an industry. Then, in order to coordinate the complementary and overlapping between the sub-indicators and to cover the incomplete individual indicator, the paper used the comprehensive index evaluation method and determined the weight by Information entropy. We drew the following conclusions and advice by our study:

- The Index about seven industries in Sichuan divided by the index about similar industry of China is 101.2304, which are greater than 100. It indicates that the 7 competitiveness of industry in Sichuan Province are slightly higher than the national similar level. Therefore, to make the seven industries grow better and faster, Sichuan Province should actively develop competitive industries and increase investment of the slightly disadvantaged industry.
- The seven industries in Sichuan have a large advantage in the production scale and the technology competitiveness. But its production efficiency and product export rate are significantly backward. Therefore, the paper presents future development proposals about seven industries in Sichuan Province: Maintaining the scale, promoting innovation, improving efficiency, and exploring the international market.

With the continuous development of China's industry, researches about the industry competitiveness evaluation will encounter a new problem and papers will also be more diverse. Future research could study in improving the sophistication of the evaluation index, mixing a variety of evaluation methods and increasing empirical object. Due to the limitations of the data sources, the paper lacks some important indicators such as the market share and the technology funding strength. In addition to the index comprehensive evaluation method, the industrial competitiveness evaluation methods also involve the evaluation method of the result of the competition, the impact factor profiling law and the law of total factor productivity. Different methods have different strengths, and comprehensive utilization of the advantages of the various evaluation methods will increase the accuracy of the evaluation results.

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Chapter 117
Power Generation Capacity and Its Investment Requirements in Pakistan for Twenty Years (2011-2030)

Nadeem A. Syed, Akbar Saeed and Asif Kamran

Abstract Pakistan is facing an unprecedented power crunch. Despite sufficient generating capacity, there is extreme shortage of output, and load shedding for long hours has become the norm. This paper develops a forecasting model for estimating the least possible generating capacity of electric power, required in Pakistan during the 20 years (2011-2030). The estimation is based on demographic and macroeconomic factors. Data from 1950 to 2010 has been analyzed. After developing the model, forecast has been made over the 20 years for the least possible generating capacity in mega watts (MW) which needs to be in place. The investment requirements have been identified for each of the years in the forecasted period. It may be noted that forecasting electric power demand is not the objective of this study.

Keywords National Transmission and Dispatch Company Limited (NTDC) · Gross Domestic Product (GDP) · Mega watts (MW) · Independent Power Producers (IPP)

117.1 Introduction

The first energy (oil) crisis in the world occurred in early 1970s. After the crisis, demand forecasting for energy in general, and demand forecasting for electricity in particular has vastly gained researchers' interest. As per kumar Policy makers and planners need reliable demand forecast for electricity and energy to formulate

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strategies [8]. The task is especially challenging for developing countries because necessary data and institutional framework are lacking. Developing countries such as Pakistan, although having sufficient generating capacity, also experience supply shortages of electricity, which arise because of inappropriate policies as well as investment decisions in power generation. The concept of unfulfilled or suppressed demand inhibits analysis. Demand Side Management (DSM), which is considered an internationally accepted technique, is applied extensively to bridge the demand supply gap. The current per capita consumption is one of the lowest in the world at 640 KWH compared to 13,000 for USA. The objective of this study is to forecast the bare minimum power generating capacity that should be continuously enhanced to meet the least possible power requirements of the country, keeping in view the population growth and economic growth. The period covered is twenty years (2011-2030). The study also computes the forecast for investment requirements in power generation over the same 20 year period. It is emphasized that the objective of this study is not to forecast the demand for electricity.

117.1.1 Literature Review

The World Bank has come up with several publications in context of energy demand forecasting and management. "Energy Demand Models for Policy Formulation — A Comparative Study of Energy Demand Models" concludes its investigation that two types of approaches are used in the world. The first one is econometric in nature and the other one is accounting. "Forecasting Investment Needs in South Africa's Electricity and Telecom Sectors" is another World Bank publication of 2006. The study has estimated required investment in electricity and telephone lines for 2003-2010 for South Africa using panel data on 52 countries for the period 1980-2002. The study has predicted that the required average annual investment in electricity over the period 2003-2010 are of the order of $ 0.52 billion which is about 0.2% of GDP. Using the Granger Causality approach, Aqeel investigated the relationship between energy consumption and economic growth, and energy consumption and employment in Pakistan [3]. The study applied techniques of co-integration and Hsiao's version of Granger causality. The study reveals that economic growth causes total energy consumption. As per Bhattacharyya Economic growth also causes increase in usage of petroleum products, no particular relationship was found between economic growth and gas consumption. Electricity consumption was found to affect economic growth [1]. Chaudhry has been estimated the electricity demand on firm-level and economy-wide level in Pakistan. The research paper concludes that consumption of electricity per capita will increase at a rate of 0.65% for every 1% increase in per capita income. The research estimates that higher prices will significantly reduce the demand for electricity in the manufacturing sector [4]. National Transmission and Despatch Company Limited (NTDC) is an organization under the Ministry of Water and Power, Government of Pakistan. NTDC has prepared the Electricity Demand Forecast for the period 2011 to 2035. NTDC has computed the

2010 peak demand as 20,223 MW, 2020 peak demand as 45,398 MW and 2035 peak demand as 134,814 MW. NTDC has projected that the present transmission losses of 3% will reduce to 2.5% in 2015 and would remain at that level thereafter. The present distribution losses of 14.6% have been assumed to reduce to 8% by 2019 and then remain at the same level thereafter. NTDC study also found that industrial share in the electricity sales in the years 1980, 1990, 2000 and 2010 has been recorded as 42%, 40%, 36% and 35% respectively, which shows that industrial share is continuously decreasing. On the other hand domestic share for the same years was 21%, 30%, 43%, and 42% respectively. This is considered alarming by NTDC and warrants facilitation to the industrial sector by the Government [5] (The Electricity Demand Forecast for the period 2011 to 2035, Feb 2011). A detailed review of the NTDC study reveals lack of data pertaining to the role of private sector. The Independent Power Producers that is the IPPs such as the Hub Power Company with a capacity of 1300 MW and more than twenty other private sector producers with varying capacities have a definite role in this regard. But their contribution appears to have been missed out in this elaborate study. The investment requirements have also not been identified in the NTDC research. As can be seen, most of the studies have focused on estimation of demand.

117.2 Past Data - Capacity & Output in Pakistan

The electricity generation capacity in Pakistan has progressively increased from a total of 106 MW in 1950 to 20,728 MW in 2010. The decade wise breakup of the generation capacity into its constituents, that is, hydro, thermal and nuclear is presented in the following table along with the total output (in GWH). Population, GDP, and generating capacity installed 1950-2010 are shown in Table 117.1.

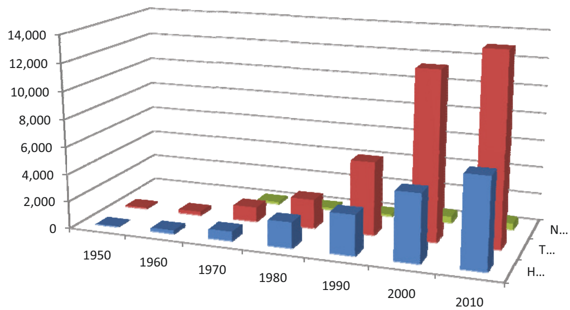


Fig. 117.1 Electricity generation capacity

As can be seen from the above Table 117.2 and Fig. 117.1, the reliance on thermal sources of power generation has proportionally increased since 1980s.

Table 117.1 Population, GDP, and generating capacity installed 1950-2010

Years	Population	GDP	MW	Prod. GWH
1950	35.31	12398	87	156
1951	36.18	12881	106	206
1952	37.07	12647	130	282
1953	37.98	12865	144	385
1954	38.91	14180	164	469
1955	39.87	14468	168	593
1956	40.86	14978	207	726
1957	41.87	15424	216	830
1958	42.90	15815	229	1066
1959	43.95	16680	241	1126
1960	45.03	16826	493	1047
1961	46.20	17649	521	1298
1962	47.53	18710	584	1692
1963	48.90	20056	726	2171
1964	50.31	21356	742	2712
1965	51.76	23360	899	3176
1966	53.26	25126	948	3698
1967	54.79	25901	1311	3925
1968	56.37	27659	1411	4677
1969	58.00	29454	1470	5518
1970	59.70	32337	1725	6380
1971	61.49	32336	1862	7202
1972	63.34	33495	1862	7572
1973	65.89	35773	1972	8377
1974	67.90	38439	2072	9064
1975	69.98	39930	2430	9941
1976	72.12	41229	2528	10319
1977	74.33	42401	3334	10877
1978	76.60	45679	3417	12375
1979	78.94	48204	3467	14174
1980	81.36	51736	3518	14974
1981	83.84	55048	4105	16062
1982	86.44	59012	4205	17688
1983	89.12	63018	4798	19697
1984	91.88	65522	5010	21873
1985	94.73	71227	5615	23003
1986	97.67	75760	6298	25589
1987	100.69	80162	6653	28703
1988	103.82	85321	6811	33091
1989	107.04	89424	7104	34562
1990	110.36	93527	7949	37259
1991	112.61	98734	8356	41042
1992	115.54	106351	9369	45440
1993	118.50	108767	10586	48751
1994	121.48	113706	11319	50640
1995	124.49	118405	12100	53545
1996	127.51	126218	12969	56946
1997	130.56	128367	14818	59125
1998	133.48	132852	15659	62104
1999	136.69	138411	15663	65402
2000	139.96	143817	17399	65751
2001	142.86	148293	17498	68117
2002	146.75	155301	17799	72406
2003	149.65	166921	17798	75682
2004	152.53	181875	19257	80826
2005	153.96	192457	19384	85628
2006	156.77	205572	19450	93629
2007	162.91	220368	19419	98213
2008	166.41	228373	19420	95661
2009	169.94	238325	19786	91616
2010	175.31	229344	20921	95358

Source: SBP Hand Book of Pakistan's Statistics 2010.

Table 117.2 Electricity generation capacity

Year	Hydro (MW)	Thermal (MW)	Nuclear (MW)	Total (MW)	Generation (GWH)
1950	21	85		106	156
1960	240	253		493	1047
1970	667	1058	137	1862	6380
1980	1847	2121	137	4105	14974
1990	2898	5321	137	8356	37259
2000	4867	12169	462	17498	65751
2010	6481	13785	462	20728	95358

Source: Hand Book of Pakistan's Statistics 2010, State Bank of Pakistan.

117.2.1 The Gap between Capacity and Output

The thermal sources include generation plants based on fuels derived from imported crude oil and the indigenous natural gas. The international prices of crude oil have nearly tripled since 1980s thereby putting a great deal of pressure on generating costs which cannot be matched with selling prices of electrical units of output because of policy constraints [2]. Hence there is no other alternative other than to produce less electricity because the Government simply cannot pay the bill of fuel. Another reason for the gap is the capacity factor, which is significantly different for each of the method of generation. Because of constraints of the water level in dams, 50% capacity factor for hydroelectric plants is quite common in the world. Power capacity factor for nuclear plants in USA is 90%, wind farms 20-40%, and solar 20%. Geothermal plants, based on Earth's heat have a higher capacity factor. The current world-wide geothermal installed capacity is 10,715 MW. The largest is in USA (3,000 MW) followed by Philippines and Indonesia.

117.3 Forecasting Electricity Generating Needs (2011-2030)

Forecast of the increasing electric generating requirements for the next 20 years can be undertaken on several criteria such as increasing population, increasing economic factors such as GDP. Table 117.1 contains the data from 1950 to 2010 regarding Pakistan's Population, GDP and the installed capacity of electricity generation measured in MW. In the following sections, forecasting model is first developed on the basis of population, then GDP, and then finally on the basis of both population and GDP taken together.

117.3.1 Regression Model-I: Installed Capacity (MW) and Population

The regression model for forecasting installed capacity of electricity as a function of population is presented in the following graph, which also shows the regression equation. In terms of this regression model, the required generating capacities for 2010, 2020, and 2030 are 20,667 MW, 28,147 MW and 34,977 MW respectively. The model is statistically acceptable. The forecast of population is described in the later sections.

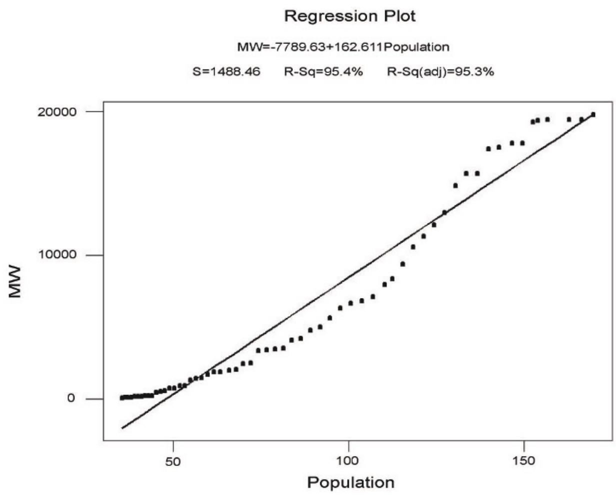


Fig. 117.2 The regression model for forecasting installed capacity of electricity as a function of population

Fig. 117.2 shows the regression equation. In terms of this regression model, the required generating capacities for 2010, 2020, and 2030 are 20,667 MW, 28,147 MW and 34,977 MW respectively.

117.3.2 Regression Model-II: Installed Capacity (MW) and GDP

Regression model for GDP and Electricity generating capacity is presented in the following figure. The graph also shows the regression equation. It may be noted that the GDP has been measured in terms of constant factor cost of 1959-60. If this model is applied, then the required generation capacities in 2010, 2020, and 2030 are 22,967 MW, 32,637 MW and 44,018 MW respectively. This regression equation is also statistically acceptable. Forecasting of GDP is undertaken in the later sections.

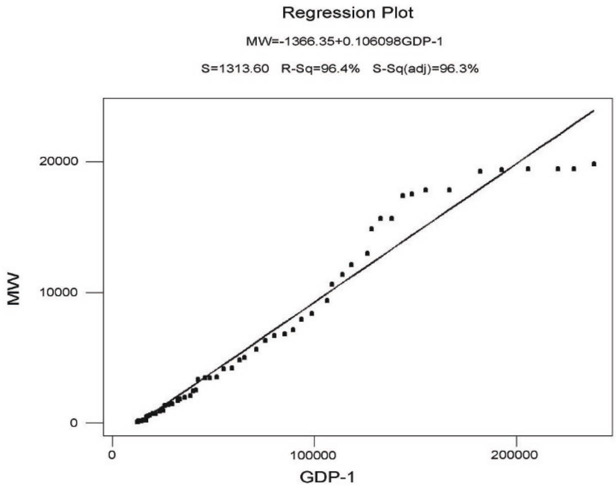


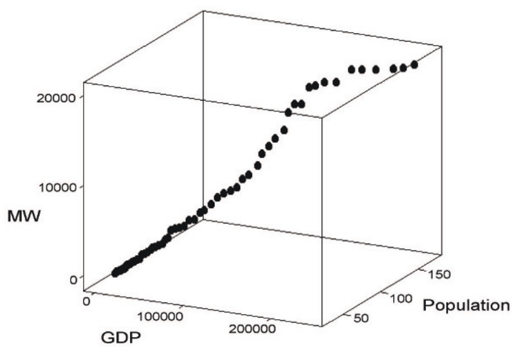
Fig. 117.3 Regression model for GDP and Electricity generating capacity

Fig. 117.3 shows the regression equation. It may be noted that the GDP has been measured in terms of constant factor cost of 1959-60. If this model is applied, then the required generation capacities in 2010, 2020, and 2030 are 22,967 MW, 32,637 MW and 44,018 MW respectively.

117.3.3 Regression Model-III: Installed Capacity (MW), Population and GDP

Finally, the dependent variable (installed capacity in MW) is estimated together with two independent variables that is population and the GDP. The 3-D graph of the three variables is depicted in Fig. 117.4.

Fig. 117.4 Egression Model: Installed Capacity(MW), Population & GDP



Analysis of Multiple Regression (see Table 117.3): Installed Capacity (MW), Population, and GDP.

Table 117.3 Analysis of multiple regression

Predictor	Coef	SE Coef	T	P
Constant	−3978.2	757.1	−5.25	0.000
Population	63.86	17.56	3.64	0.001
GDP	0.06562	0.01139	5.76	0.000

S= 1194, R-Sq= 97.1%, R-Sq(adj)= 97.0%.

The regression equation is:

$$\text{Installed Capacity(MW)} = -3978 + 63.9\text{Population} + 0.0656\text{GDP}.$$

Analysis of Variance (see Table 117.4)

Table 117.4 Analysis of variance

Source	DF	SS	MS	F	P	Seq SS
Regression	2	2691818566	1345909283	944.47	0.000	
Residual Error	57	81227443	1425043			
Total	59	2773046009				
Population	1					2644546494
GDP	1					47272072

The above regression model (Fig. 117.4), estimates of population and estimates of GDP are required to be made for the years 2011 to 2030.

117.4 Forecasting of Population and GDP Till 2030

In order to estimate the electric power generating capacity requirements with the help of the above regression model, estimates of population and estimates of GDP are required to be made for the years 2011 to 2030.

117.4.1 Population

The trend of population increase can be statistically forecasted with help of following three techniques:

- Linear
- Quadratic
- Exponential

Figs. 117.5 ∼ 117.7 depict the above three trends for the increase in the population.

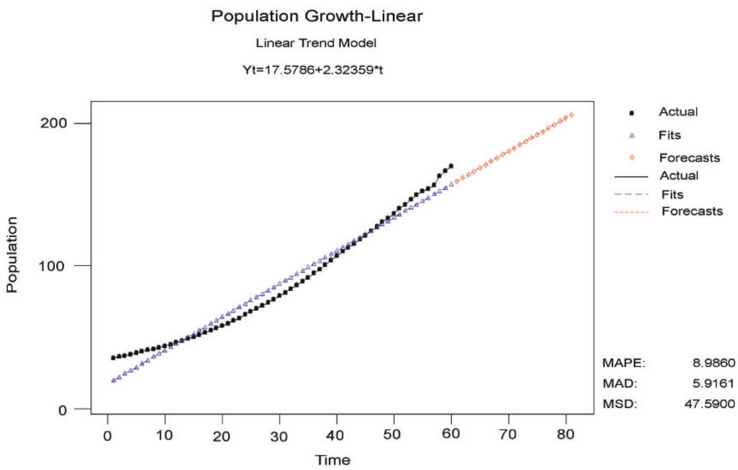


Fig. 117.5 Linear trends for the increase in the population

Based on the above three models, the population growth has been forecasted for the period 2010 to 2030 in Table 117.5.

Considering all aspects, the quadratic growth forecast for population increase appears to be suitable. Hence the quadratic forecast for population increase has been adopted for determining the future requirements of electricity generation in Pakistan.

117.4.2 Gross Domestic Product (GDP)

As stated earlier, the forecast of GDP for the next 20 years is also required for determining the electricity generation requirements for the next 20 years. The GDP growth can also be forecasted on the following three basis:

- Linear
- Quadratic
- Exponential

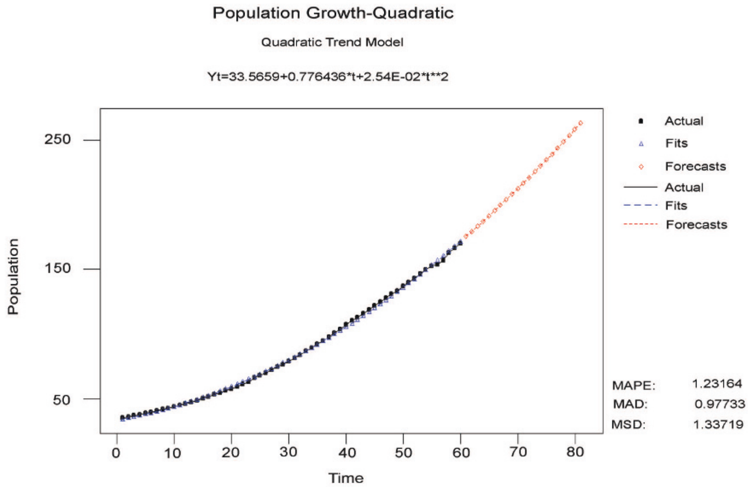


Fig. 117.6 Quadratic trends for the increase in the population

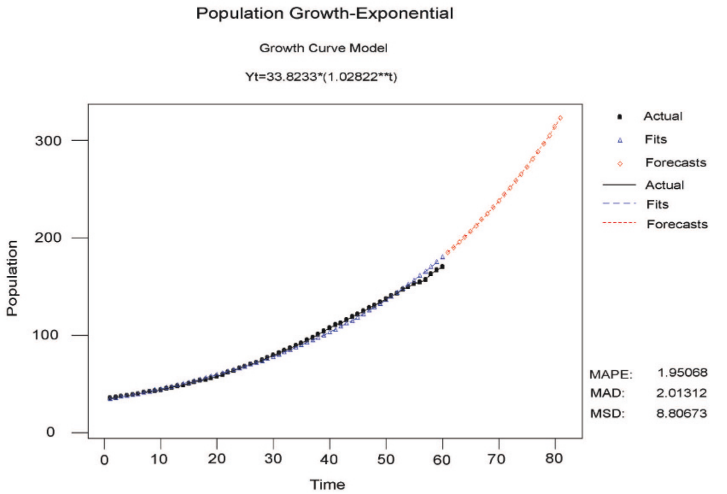


Fig. 117.7 Exponential trends for the increase in the population

Figs. 117.8 $\sim$ 117.10 depict the above three techniques for determining the increase in the size of Gross Domestic Product for the next 20 years. Based on the above three models, the GDP has been forecasted for the period 2010 to 2030 in Table 117.6.

Considering all aspects, the exponential forecast appears to be more ambitious and improbable. Therefore, for the regression analysis, the quadratic forecast for

Table 117.5 Population forecast (millions)

Years	Linear	Quadratic	Exponential
2010	159.318	175.305	184.702
2011	161.641	179.201	189.914
2012	163.965	183.148	195.274
2013	166.289	187.146	200.784
2014	168.612	191.194	206.450
2015	170.936	195.293	212.276
2016	173.259	199.443	218.267
2017	175.583	203.643	224.426
2018	177.906	207.894	230.760
2019	180.230	212.196	237.272
2020	182.554	216.549	243.968
2021	184.877	220.952	250.853
2022	187.201	225.406	257.932
2023	189.524	229.911	265.211
2024	191.848	234.467	272.695
2025	194.172	239.073	280.390
2026	196.495	243.730	288.303
2027	198.819	248.438	296.439
2028	201.142	253.196	304.805
2029	203.466	258.005	313.406
2030	205.790	262.865	322.251

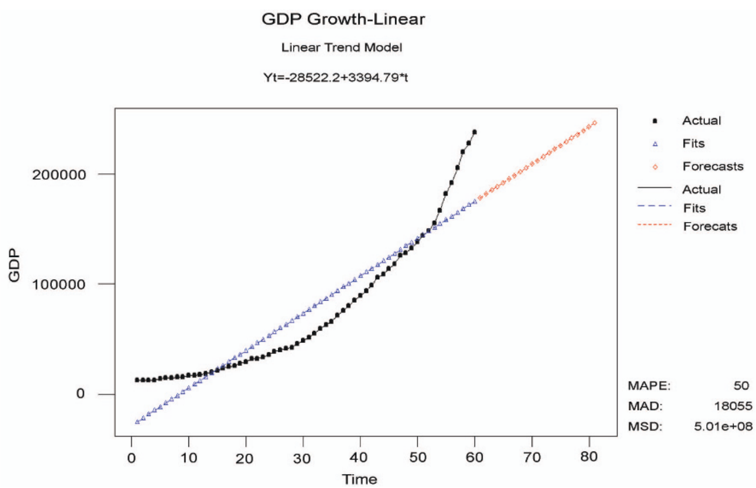


Fig. 117.8 Linear techniques for determining the increase in the size of Gross Domestic Product

GDP increase has been adopted for determining the future requirements of electricity generation in Pakistan.

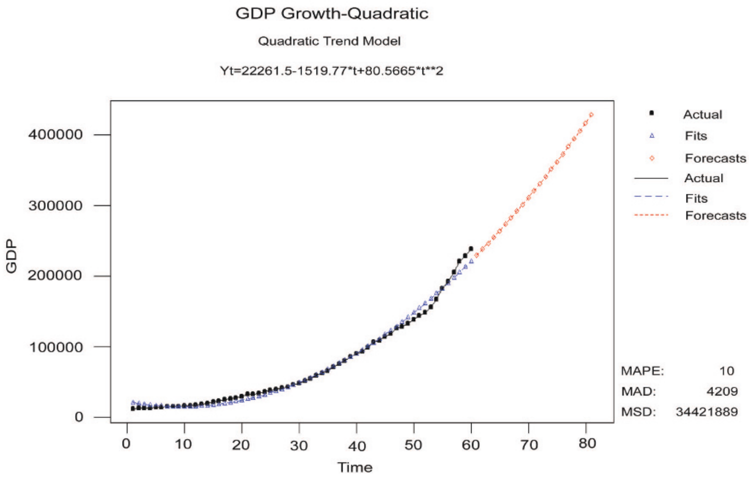


Fig. 117.9 Quadratic techniques for determining the increase in the size of Gross Domestic Product

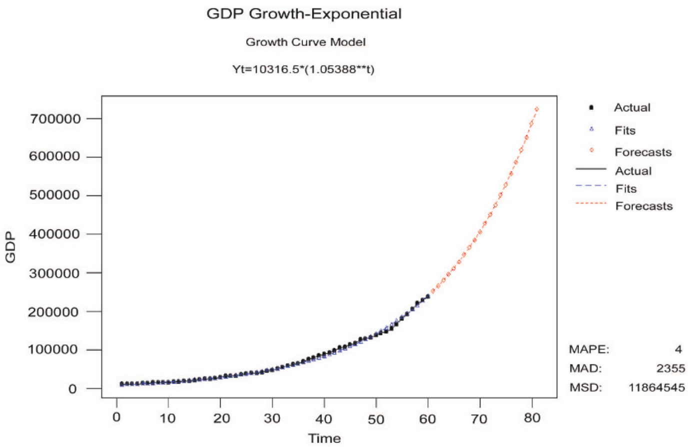


Fig. 117.10 Exponential techniques for determining the increase in the size of Gross Domestic Product

117.4.3 Estimation of Power Generation Requirements

The regression model to forecast the power generation requirements which was developed in the earlier section is reproduced below:

$$\text{Installed Capacity (MW)} = -3978 + 63.9 * \text{Population} + 0.0656 * \text{GDP}. \quad (117.1)$$

Table 117.6 GDP growth (millions of rupees)

Years	Linear	Quadratic	Exponential
2010	178560	229344	253414
2011	181955	237733	267069
2012	185349	246284	281459
2013	188744	254997	296624
2014	192139	263870	312606
2015	195534	272904	329450
2016	198928	282100	347201
2017	202323	291457	365909
2018	205718	300975	385625
2019	209113	310653	406403
2020	212508	320494	428300
2021	215902	330495	451378
2022	219297	340657	475699
2023	222692	350981	501330
2024	226087	361465	528342
2025	229482	372111	556810
2026	232876	382918	586812
2027	236271	393886	618430
2028	239666	405015	651752
2029	243061	416306	686870
2030	246455	427757	723879

Based on the above equation, and also based on the forecasted values of population and GDP, the requirements for capacity of power generation in Pakistan for the next 20 years have been computed. The same is shown in Table 117.7.

117.4.4 Forecasting Investment Requirement in Power Generation for the Next 20 Years

The present power generating assets would gradually get depreciated and would need to be replaced at some point in time in the future. For example the KANNUP with 137 MW capacity has outlived its life. Sooner or later it would be shut down and retired and 137 MW from the existing capacity would be eliminated. Therefore, for estimating the investment requirements, it is assumed that physical wear and tear (annual depreciation) would result in elimination of 2% generating capacity every year and would thus need yearly replenishment. Investment requirements in US Dollars per one MW varies from \$1.00 million to \$1.50 million, depending on the type of the power generation envisaged. The lower limit is for hydel and the upper limit is for off shore wind mill. The conventional thermal power units planned in and around 2010 and which are likely to become operational by 2015 are expected to cost around \$1.25 million per 1.0 MW. Based on the foregoing capital cost, the

Table 117.7 Forcasted population, GDP, and power generation capacity requirements 2010-2030

Years	Population (millions)	GDP (million Rs.)	Power generation capacity (MW)
2010	175.305	229,344	22,269
2011	179.201	237,733	23,068
2012	183.148	246,284	23,881
2013	187.146	254,997	24,708
2014	191.194	263,870	25,549
2015	195.293	272,904	26,404
2016	199.443	282,100	27,272
2017	203.643	291,457	28,154
2018	207.894	300,975	29,050
2019	212.196	310,653	29,960
2020	216.549	320,494	30,884
2021	220.952	330,495	31,821
2022	225.406	340,657	32,773
2023	229.911	350,981	33,738
2024	234.467	361,465	34,717
2025	239.073	372,111	35,709
2026	243.730	382,918	36,716
2027	248.438	393,886	37,736
2028	253.196	405,015	38,770
2029	258.005	416,306	39,818
2030	262.865	427,757	40,880

investment requirement in US Dollars is estimated for the next 20 years in Table 117.8.

117.5 Conclusion

Pakistan's population is projected to increase to 263 million and the GDP is projected to increase to Rs. 430 billion by the year 2030. The minimum electricity generating capacity required to support the present living standards is projected at 40,000 MW for the year 2030. The 2010 installed capacity is around 20,000 MW. Assuming a 2% wear and tear of the installed capacity every year, continuous replenishment of the existing installed capacity together with additional required to support the increasing population and consequent increasing economic activity (GDP) would increase from 1,350 MW in 2010 to 26,750 MW in 2030. As per Cichanowicz the capital cost of new investment in power plants ranges from US Dollars 1.0 million to 1.5 million per one MW [6]. The lower limit is for hydel and the upper limit is for off shore wind mill. The conventional thermal power units planned in and around 2010 and which are likely to become operational by 2015 are expected to cost around $1.25 million per 1.0 MW. Based on the foregoing cost, the investment requirement in US Dollars is estimated as $4.6 billion for 2012. The

Table 117.8 The investment requirement in US Dollars

Years	Power capacity required (MW)	Actual capacity installed (MW)	Additional capacity required (MW)	Required investment ($ in millions)
2010	22,269	20,921	1,348	1,685
2011	23,068	20,728	2,340	2,925
2012	23,881	20,313	3,568	4,460
2013	24,708	19,907	4,801	6,002
2014	25,549	19,509	6,040	7,550
2015	26,404	19,119	7,285	9,106
2016	27,272	18,736	8,536	10,670
2017	28,154	18,362	9,793	12,241
2018	29,050	17,995	11,056	13,820
2019	29,960	17,635	12,326	15,407
2020	30,884	17,282	13,602	17,002
2021	31,821	16,936	14,885	18,606
2022	32,773	16,598	16,175	20,219
2023	33,738	16,266	17,472	21,840
2024	34,717	15,940	18,776	23,470
2025	35,709	15,621	20,088	25,110
2026	36,716	15,309	21,407	26,758
2027	37,736	15,003	22,733	28,417
2028	38,770	14,703	24,067	30,084
2029	39,818	14,409	25,409	31,762
2030	40,880	14,121	26,759	33,449

investment requirement in each year after 2012 will gradually increase. In the year 2015 it would be $9 billion, in 2020 it would be $17 billion. In 2025 the investment requirement is estimated at $25 billion and for 2030 it is estimated at $33 billion. The investment requirements may be lowered if the investment is made in plants based on hydroelectric sources. It is re-emphasized that the foregoing estimates of investment cost are not based on estimates of future demand of electric power. The estimates are based on the minimum possible power requirements of the growing population and the consequent growing economic activity. The other studies referred have estimated the demand rather ambitiously, which is unlikely to be met. This study has attempted to determine the bare minimum capacity of power generation needed in the years 2011 to 2030. The optimum mix of hydoelectric, thermal, nuclear, wind, and solar needs to be determined. Capacity building is needed to undertake research and development in area of renewable sources. The need to build consensus on the major issues and concerns amongst the stakeholders is paramount. Delays are going to cause greater efforts to recover from the slide.

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Chapter 118
The Effect of CNH Market on Relationship of RMB Spot Exchange Rate and NDF

Chuyang Kou and Liuliu Kong

Abstract Using vector autoregressive model (VAR), Granger causality test, MA(1)-GARCH(1,1) model, this paper made a Granger causality test between RMB spot exchange rate (SPOT) and NDF, and impulse response and spillover effects analysis between the two markets comparatively before and after the establishment of Hong Kong's offshore RMB market (CNH). The result shows that after the establishment of CNH, the guidance effect from NDF market on SPOT exchange rate has been weakened. Granger causality, yield spillovers and volatility spillovers between the NDF and SPOT have undergone significant changes. Therefore, the development CNH market has important implications for pricing mechanism of the RMB spot exchange rate pricing.

Keywords CNH · RMB spot exchange rate (SPOT) · NDF

118.1 Introduction

Since the reforming of formation mechanism of RMB exchange rate in 2005, the internationalization of RMB has been processed step by step. The inter-bank RMB forward market was established on August 15, 2005. Market maker system was introduced into inter-bank foreign exchange market and the system of foreign exchange settlement with cash position management was replaced by the accrual basis system on January 4, 2006. Since July 2009, cross-border trade RMB settlement pilot started, and till August 2011, the settlement has been expanded to the whole country. At the same time, Chinese government signed currency settlement and currency swap agreements. Among these measures, the key step is to establish the RMB

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Hong Kong's offshore market (CNH) that provides effective place to trade and hedging mechanisms for the gradual opening up of the capital account and the offshore RMB.

RMB NDF (none delivery forward) has been the most important RMB offshore market trading tool. Appeared in Singapore and Hong Kong in 1996, NDF experienced a slow development process. Along with China's rapid economic development and alleviation of Southeast Asian financial crisis, NDF market has been developed rapidly, reaching about 20 to 30 billion dollars of daily turnover in Singapore.

Generally, it is believed that Hong Kong's offshore market (CNH) began trading on August 23, 2010. In July 2010, the People's Bank of China and Hong Kong Bank of China, the clearing bank of RMB business in Hong Kong, signed the new revised "Agreement of Settlement of RMB business in Hong Kong banks", abolishing Yuan ceiling which enterprises of the Hong Kong exchange by dollars, allowing RMB deposits in Hong Kong banks transfer among the banks. Since then the Hong Kong inter-bank RMB exchange market began to develop rapidly. In late 2011, the amount of RMB deposits in Hong Kong reached 588.5 billion Yuan. Since June 2011, a number of financial institutions in Hong Kong began providing RMB deliverable forwards. In this background, using the latest data and econometric method, we made empirical research on the different relationships of RMB spot exchange rate (onshore SPOT) and NDF before and after the establishment of CNH market.

118.2 Literature Review

The researches on the interaction between offshore market forward exchange rates and onshore market spot exchange rate have been conducted by domestic and foreign scholars. Park [1] found that after the exchange rate reform in 1997 in South Korea, the fact that SPOT market singly passed yield spillover effect to NDF market and mutual transmission of volatility spillovers before changed into NDF market passed yield and volatility spillover to spot market in one direction. Huang and Wu [2] used the data before (April 7, 2003 to July 20, 2005) and after (July 22, 2005 to April 26, 2006) RMB exchange reform, 1-year and 1-month NDF and the SPOT rate data, made Granger causality test and found that interaction between the two markets strengthened after the reform. Dai and Yang [3] used Granger causality test to study RMB SPOT, DF and NDF market. The results show that SPOT market and DF market is able to guide the NDF market, and the domestic market is more information superiority. Xu et al [4] used data of RMB NDF and the SPOT exchange rate from July 25, 2005 to June 13, 2006 and the MA(1)-GARCH(1,1) model to study the mean and volatility spillovers between 1-year RMB NDF and spot market, the conclusion is that the SPOT market has no spillovers effect on RMB NDF market, the RMB NDF market has spillovers effect on SPOT market. Wang and Liu [5] used MA(1)-GARCH(1,1) model with data of 1-year NDF and the spot exchange rate from July 22, 2005 to June 16, 2008 to do the same study, and the result showed that RMB NDF market has mean spillover effect on RMB SPOT market, there were bidirectional volatility spillovers between SPOT and NDF markets.

In the above papers, with matured models, the interactions among RMB NDF market and SPOT market and DF market were studied with different ranges of data and different results were obtained. However, all the data used in the researches are before the establishment of offshore RMB market in Hong Kong (CNH). Along with the establishment and development of CNH, whether the interaction between the NDF market and onshore SPOT market is changed? So this paper will use the data before and after the establishment CNH and make empirical analysis.

118.3 Empirical Testing and Analysis

118.3.1 Data Sources

The NDF data from Singapore market of this article were from WIND database, and RMB SPOT exchange rate data were from the website of People's Bank, with time interval: January 4, 2010 to May 7, 2012. The CNH was established in August 23, 2010, with this day as node, the time interval is divided into two terms, respectively, defined as T1 and T2. Meanwhile, in order to smooth data, we make yield treatment on daily trading data. The data are taken logarithm and then are differential. At the same time, we take NDF with two different forward period, 1-month and 6-month NDF, in the comparative analysis.

118.3.2 Empirical Testing and Analysis

(1) Descriptive statistical analysis and stationary test

Table 118.1 shows the statistics of rates of return of NDF and SPOT exchange rate in T1 and T2. Both are in direct quotation. The statistics obtained by the statistical software EVIEWS. Ndf1m means one month forward period NDF, Ndf6m means 6 months forward period NDF, Spot means SPOT exchange rate data.

It can be seen in Table 118.1 that in both T1 and T2 means of rates of return of NDF and SPOT are negative, indicating appreciation of RMB in all terms. In T1, the standard deviation of SPOT is the smallest which means that the volatility of the SPOT is less than that of NDF. With increasing forward duration, volatility of NDF increases. That indicates that the longer the time of forward, the more uncertainty on the future, and the larger is the volatility of NDF. In T2, all standard deviations of three variables are larger than that of them in T1 respectively, revealing that the volatilities of three are becoming larger. View from the values of skewness and kurtosis, both NDF and SPOT do not follow a normal distribution.

Table 118.1 The simple math results obtained by the statistical software EVIEWS

Period	Variable	Mean	Median	Maximum	Minimum
T1	Spot	$-2.76E-05$	$-1.46E-05$	0.003638	−0.00433
	Ndf1m	$-2.91E-05$	0	0.002506	−0.0039
	Ndf6m	$-2.63E-05$	$5.92E-05$	0.008332	−0.006681
T2	Spot	−0.000197	−0.000190	0.003308	−0.003135
	Ndf1m	−0.000185	−0.000139	0.005482	−0.009469
	Ndf6m	−0.000154	$-6.28E-05$	0.009187	−0.010365
Period	**Variable**	**Standard deviation**	**Skewness**	**Kurtosis**	**Jarque-Bera**
T1	Spot	0.000651	−1.263934	23.58914	2779.039
	Ndf1m	0.000846	−0.689224	6.92966	112.0027
	Ndf6m	0.001823	−0.140871	7.137053	111.0483
T2	Spot	0.001004	0.002209	3.423882	2.979953
	Ndf1m	0.001465	−0.473517	8.427577	503.3947
	Ndf6m	0.002166	−0.153344	7.130257	284.4552

Table 118.2 Time series ADF test (including a trend term and intercept)

Period	Variable	1% reference value	T-statistic	P
T1	Spot	−4.018748	−13.33236	0
	Ndf1m	−4.019151	−10.20167	0
	Ndf6m	−4.018748	−12.29061	0
T2	Spot	−3.981343	−18.08790	0
	Ndf1m	−3.981402	−17.18011	0
	Ndf6m	−3.981402	−16.57683	0

Table 118.3 SC and AIC values based on SOPT and 1-month NDF time series

Period	Lags	1	2	3	4	5
T1	AIC	−23.30615	−23.284	−23.24239	−23.20917	−23.18429
	SC	−23.18783	−23.08593	−22.96388	−22.84950	−22.74273

From Table 118.2, it can be seen that through previous data processing (taking rate of return), the three time series are stationary for the original hypothesis that the time series have unit root are all rejected at a significant level of 1%. That means the resulting time series are stationary time series and VAR model can be adopted.

(2) VAR model analysis

First, a VAR model is built based on the SOPT and 1-month NDF time series in T1. The SC and AIC values with different number of lags are shown in Table 118.3.

According to SC and AIC criterion, we choose lag order 1 to establish VAR model for SOPT and 1-month NDF time series in T1. Using the same method, lag order 1 is chosen for VAR model of SOPT and 6-month NDF time series in T1. As to VAR model for SOPT and 1-month NDF time series in T2, lag order 2 is chosen based on SC and AIC criterion. As to VAR model for SOPT and 6-month NDF time

series in T2, lag order 1 is chosen based on SC and AIC criterion.
(3) Granger causality test
Granger causality test results are shown in Table 118.4.

Table 118.4 Granger causality test results

Period	Null hypothesis	F-Statistic	P	Conclusion
T1	Ndf1m can't Granger cause spot	25.1495	1.5E-05	Rejected
	Spot can't Granger cause ndf1m	1.52526	0.21874	Accepted
	Ndf6m can't Granger cause spot	14.1699	0.00024	Rejected
	Spot can't Granger cause ndf6m	0.40931	0.52329	Accepted
T2	Ndf1m can't Granger cause spot	1.51152	0.22186	Accepted
	Spot can't Granger cause ndf1m	3.29130	0.03824	Rejected
	Ndf6m can't Granger cause spot	0.23294	0.62962	Accepted
	Spot can't Granger cause ndf6m	0.00314	0.95535	Accepted

The test results of T1 show that at significant level of 1%, for 1-month and 6-months NDF, both null hypothesis "NDF can't Granger cause Spot" are rejected. However, at 1%, 5%, 10% significant level, whether for 1-month NDF or 6-months NDF, both null hypothesis "Spot can't not Granger cause NDF" can't be rejected. That means, from the point of view of the price guiding, NDF market was in a major position in T1.

The test results of T2 show that at the 5% level, null hypothesis "1-month NDF can't Granger cause SPOT" is accepted, and on the other hand, null hypothesis "SPOT can't Granger cause 1-month NDF" is rejected. Obviously in T2, 1-month NDF's price guidance status is no longer significant. Conversely, the SPOT exchange rate starts to play guiding role to the price of the 1-month NDF. In addition, the test results also show that null hypothesis "6-month NDF can't Granger cause SPOT" is accepted at levels of 1%, 5%, 15%. 6-month NDF's price guidance status is no longer significant in T2 too.
(4) Impulse response and variance decomposition
The responses of SPOT to one standard deviation shock from 1-month NDF and 6-month NDF in T1 are shown in Fig. 118.1 and variance decomposition results are also in Fig. 118.1.

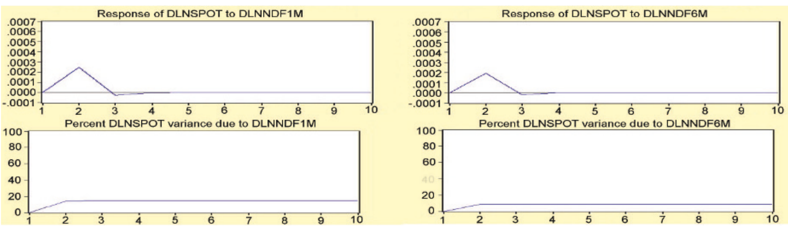

Fig. 118.1 Impulse responses and variance decompositions in T1

From Fig. 118.1, it is can seen that the responses of SPOT to both 1 and 6 months NDFs reach maximum at period 2, then follow a convergence trend to disappear after four. Comparatively, the response of SPOT to 1-month NDF is more significant than that to 6-month NDF and the first has longer duration. This shows that the short-term NDF has more significant impact and market conduction on SPOT market compared to longer-term NDF. The results of the variance decomposition is stable, and figures show that the impact from 1-month NDF accounts for about 14.26% of the value of the SPOT prediction error, and the impact from 6-month NDF accounts for only about 8.57%, further illustrating the guiding effects of short-term NDF to spot market is more obvious.

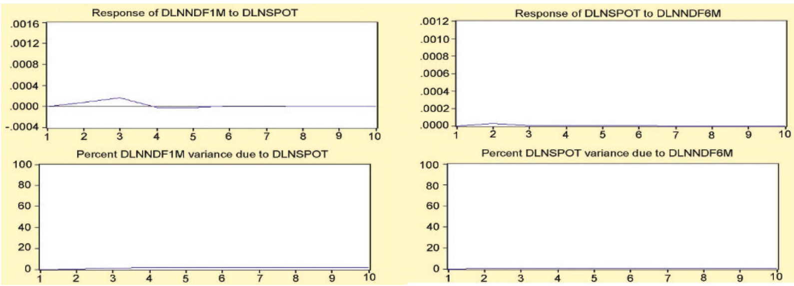

Fig. 118.2 Impulse responses and variance decompositions in T2

From Fig. 118.2, it can be seen that an impact of one standard deviation from the SPOT, the response of 1-month NDF peaks in the first 3td period and converges after 4th period. For the impact from the 6-month NDF, the response of SPOT is not obvious, and after peaking in second period converges. The variance decomposition results show that impact from SPOT accounts for about 1.5% of the value of the 1-month NDF prediction error, and the impact from 6-month NDF accounts for only about 0.06% of the value of the SPOT prediction error.

(5) Spillover effect

MA(1)-GARCH(1,1) model was used in 1990 [6] and will be applied to study the spillover effects between the NDF and the SPOT market in this paper. First, a standardized GARCH(1,1) model includes a mean equation and a conditional variance equation, specifically in the form of as following: $y_t = x_t' + u_t, \quad \sigma_t^2 = w + \alpha u_{t-1}^2 + \beta \sigma_{t-1}^2$.

In order to test the spillover effects between the NDF and the SPOT market, the MA(1)-GARCH(1,1) model is adopted as:

$$R_{it} = \alpha_i + \varphi_i \varepsilon_{i,t-1} + \varepsilon_{it} + \delta_i R_{j,t-1}, \tag{118.1}$$

$$\sigma_{it}^2 = \alpha_{0i} + \alpha_{1i} \varepsilon_{i,t-1}^2 + \beta_{1i} \sigma_{i,t-1}^2 + \gamma_i \varepsilon_{j,t-1}^2. \tag{118.2}$$

In Equation (118.1), R_{it} represents rate of return of i market in t period. After the introduction of exogenous variables, δ_i and γ_i can be used to examine the spillover effects of j market to i market. If δ_i is significant, then the j market has yield spillover effects for i market, if γ_i is significant, j market has volatility spillovers effects to i market.

The estimation results by EVIEWS are shown in Table 118.5.

Table 118.5 The estimation results by EVIEWS

Period	NDF period	i-SPOT, j-NDF	i-NDF, j-SPOT
T1	1 month	$\delta_i = 0.0363$ ($p = 0.0062$)	$\delta_i = -0.005993$ ($p = 0.9563$)
		$\gamma_i = 0.016938$ ($p = 0$)	$\gamma_i = -0.086391$ ($p = 0.1543$)
	6 month	$\delta_i = 0.005298$ ($p = 0.09036$)	$\delta_i = -0.029316$ ($p = 0.9203$)
		$\gamma_i = 0.010376$ ($p = 0$)	$\gamma_i = -0.122937$ ($p = 0$)
T2	1 month	$\delta_i = -0.016109$ ($p = 0.7321$)	$\delta_i = 0.112473$ ($p = 0.1926$)
		$\gamma_i = 0.010631$ ($p = 0.3421$)	$\gamma_i = 0.089273$ ($p = 0.1810$)
	6 month	$\delta_i = -0.004798$ ($p = 0.8666$)	$\delta_i = -0.109372$ ($p = 0.3908$)
		$\gamma_i = 0.004828$ ($p = 0.3152$)	$\gamma_i = 0.544516$ ($p = 0.0003$)

In T1 term, firstly, the results show that 1-month NDF market has yield spillover effects on SPOT market, conversely SPOT market has no yield spillover effects on 1-month NDF market, consistent with the conclusions of the Granger causality test, indicating that the 1-month NDF market's price discovery function is more significant. Secondly, NDF market has significant volatility spillovers effects to SPOT market, and the volatility spillovers effects of SPOT market to NDF market is also significant especially for longer-term NDF.

In T2 term, yield spillover effects of SPOT market to NDF market are much more significant than that of opposition direction. The volatility spillover effects of SPOT market to NDF market are also much more significant than that of opposition direction. Especially in long period, SPOT market has very significant volatility spillovers effects to 6-month NDF.

118.4 Conclusions

It can be seen from the descriptive statistical tests that after the establishment of the Hong Kong offshore RMB market (CNH), RMB has experienced a process of appreciation. Meanwhile, fluctuations of RMB spot exchange rate and the NDF forward exchange rate are more and more obvious.

The results of the Granger causality test show that prior to the establishment CNH, NDF market price was in the guidance position, both1-month and 6-month NDFs constitute the Granger reason for SPOT. After the establishment CNH, 1-month and 6-month NDF are no longer SPOT's Granger cause. SPOT become 1-month NDF's Granger cause and SPOT market is increasingly in guidance position in the market especially in guiding short-term NDF. Impulse response and variance decomposition analysis show that the response of SPOT to the impulse from

NDF has an obvious difference before and after the establishment CNH. Further analysis of variance decomposition demonstrates that the impact of the NDF to SPOT exchange rate prediction error percentage is also significantly reduced after CNH. Spillovers test reveals obvious changes of spillover effects between NDF and SPOT exchange rate mechanism before and after the establishment CNH. Original spillovers effects from NDF to SPOT are no longer evident, while SPOT market still exists volatility spillovers to NDF market.

The empirical research test results can be explained in following aspects.

First, prior to the establishment CNH, the offshore transactions of RMB mainly trade in Singapore NDF market. After the establishment of CNH, the opening policy of RMB trade settlement and the development of CNH opened the door for capital flows, even more for short-term capital flows. In this situation, investors would like to choose CNH for trading, that weakened Singapore NDF market.

On the other hand, from the perspective of investors' arbitrage, CNH would be more attractive that other offshore market. In expectation of appreciation of RMB, the normal mode of arbitrage on offshore market is that: borrowing dollars, buying RMB currency and then selling RMB and buying dollars in the forward market. In this arbitrage mechanism, arbitrage space will become smaller and smaller. However in CNH, the arbitrage space could exist for a longer time, because RMB trade settlement from Mainland could be poured into CNH constantly. In fact, according to Reuters, Hong Kong, till February 2012, the turnover of CNH market has increased to 30-50 billion dollars in daily trading volume, closing and catching up with NDF. So, financial institutions in CNH buying RMB could not significantly lead RMB's appreciation. In this case, investors prefer CNH to other offshore market. As a result, Singapore NDF market's influence on RMB onshore market weakens.

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Chapter 119
From “Control” to “Serve”: Brand-construction of Public Service of CII

Ying Zheng

Abstract Brand-construction of public service is an innovation and provides a new way for building a service-oriented government as present. Based on this appeal, China Immigration Inspection (CII) also attempt to transfer their function from “control” to “serve”. Referring to the theory of new public administration, this paper will bring the idea of strategic enterprise brand-development into the field of public administration in China Immigration Inspection. This paper designs a China Immigration Inspection brand-construction plan after a deep discussion of definition of the brand-construction of public service and provides referable thoughts and methods for China Immigration Inspection’s exploration of new administration mode.)

Keywords New public administration · Public service · Brand-construction of China immigration inspection · New administration mode

119.1 Introduction

With the transformation of government function, it becomes the goal for currant government reform to realize the “ultimate value” of government public service. On the one hand, the transformation of government function is the background and premise for brand-construction of public service. The essential ideal and quality of service lie the foundation for brand-construction of public service. On the other hand, brand-construction of public service develops new approach to the construction of public-service-oriented government (and organs) as well and is an innovation in this aspect. So China Immigration Inspection organs have also transferred their function from “control” to “serve” and set their future work goal as to improve service standards and to construct a public service band for China Immigration Inspection with advanced world standard. Unfortunately, this construction

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for China Immigration Inspection organs is still in the process of exploration. If the successful experience of commercial brand-construction can be borrowed, the brand-construction of public service for China Immigration Inspection organs will improve its service level, gain wider and continuous social fairness and efficiency, and play an important role in setting up a new image for modern China Immigration Inspection organs–transparent, efficient, just, responsible and normative. Zeithaml [1] has pointed out that Compared with tangible product brand, brand-construction of public service emphasizes the process of offering service and the perception of quality of service and acknowledgments from the public in the process. Therefore, this paper will focus on designing a feasible plan for brand-construction of China Immigration Inspection service and carry out the new administration mode thoroughly.

119.2 Connotations of Public Service Band for CII

(1) Public service brand

Public service brand is the sum of the significance of the public's association in mind, their impression and expression aroused in the process when the pubic server (the state, government, public service organs or other organizations) provide public products and service [2]. In essence, it is the server's commitment to the public. It shows the brand constructor's ideal of public service (service culture), conveys the fundamental property of public service–social justice, publicity and equal benefit, and embodies the core value of public service–that is, to serve all the members of the society equally without discrimination according to social demands and the "equalization" principle [3]. The value public service brand delivers surpasses the public product and service. It not only tells the quality of service but also represents the server's image in the public's mind. Hence, only when the public are satisfied with public products and service, can they trust the public service brand; and only when they develop a sense of identification and belonging, can they have positive opinion on specific public service and appraise the state, government and pubic service organs more approvingly.

(2) Connotations and characteristics of public service band for CII

(a) Connotations of public service band for China Immigration Inspection

Uniting the meaning of public service brand with characteristics of our country's entry-exit China Immigration Inspection offices, this paper defines public service band for China Immigration Inspection as the service objects' association in mind, their impression and expression given by the entry-exit China Immigration Inspection offices when they provide services for entry-exit personnel and transportation entry-exit activities. It shows the EEBIO's ideal of public service, tells features of public service of China Immigration Inspection–social justice, publicity and equal benefit, and embodies the core value of public service of China Immigration Inspection–to serve all the personnel and entry-exit activities equally without discrimination according to their demands. It not only tells the quality of public service of CII but also represents the image in the public’s mind. Public service band for China Immigration Inspection is in fact CII’s commitment to all the entry-exit personnel and activities, and also service objects’ evaluation for the service they receive. It is a mark or symbol for the public to distinguish and identify different countries’ and governments’ services. The promises and principles set up by China Immigration Inspection organs, firstly, reflect comprehensively the organs’ aim of organization, service concept and management philosophy. They also embody the overall elements of the organs’ in terms of institution, function orientation, government functionary, administrative culture, public service and administrative efficiencies. Lastly, for the brand owner, they are intangible capital, bringing a certain popularity, reputation and credibility. Connotations of public service band for CII mainly include the brand name and logo of service, service items, service modes and service supporters, etc. The main function of public service band for CII is to show the individuality and features of the organs’ service and distinguish their own public service with competitors.

(b) Characteristics of public service band for China

Immigration Inspection Public service brand means more than merely a symbol for an organization. It integrates the organization’s quality and performance of service and degree of reliability, demonstrates the organization’s cultural connotations, and determines as well as affects its development and orientation of service [4]. It contains aspects like the brand recognition, brand reputation, brand quality image, brand loyalty, brand association and special assets attached to the brand. A successful public service brand will affect the public and society tremendously and an influential brand may even become symbol of a country’s national power, of the country and its people. Concerning about the foreign affairs, CII is a nation’s first gate for foreigners and its own citizens as well. In terms of law, China Immigration Inspection officials are the first group people met by foreigners as soon as they step into china’s territory and CII is the first gate of china. Therefore, the image of China Immigration Inspection’s public service is closely related with china’s overall national image. In a sense, it reflects our nation’s civilization in service.

Public Service Band for CII has the following characteristics: firstly, different from concrete tangible products, the server of service brand is the CII as a whole. The services CII provides are mainly intangible public activities and the brand is maintained through the servers’ popularity, reputation and degree of satisfaction [5]. In consequence, partial success will not necessarily glorifies the brand while subtle failure in service may bring shame on the whole team. That is the difficult point in keep the PSBBI. Secondly, service brand focuses on the process of serving and does not complete in one time. The service itself is made up by numerous links and the quality of service must be showed through process of serving, which can be realized only by tacit cooperation of China Immigration Inspection officials and requires more collective strength and team spirit than other brands. Thirdly, the service brand for CII should base upon first-rate services. Quality of service decides service level. First-rate service comes not only from promoting the serving methods but also from officials’ compassion, and it is demonstrated through the serving process. In this sense, first-rate service is the basic feature of the service brand for CII and the starting point of public service brand competition. Lastly, the service brand for CII outstands for its prominent/premium services. Service is made up by the core service, embodying the most basic function of service, and the prominent/premium service, showing the creating function.

119.3 The Construction Scheme of Public Service Brand of CII

Model of service brand construction of CII is shown below (Fig. 119.1):

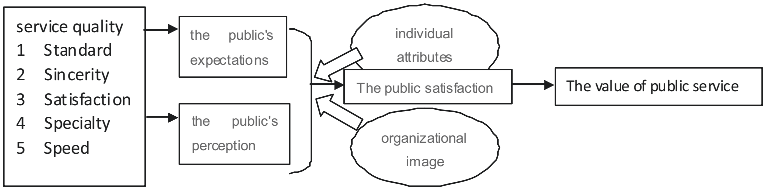

Fig. 119.1 Model of service brand construction of CII

119.3.1 Construction of Sincere Service Based on Service Quality Reliability

Construction of sincere service is systematic, and it takes some time and practice to create "sincerity" image among the public [6].

- Concept of sincere service should be implemented, and the inspection staff should cultivate awareness of sincere service and enhance sense of responsibility. The immigration inspection authorities should take it as the foundation for occupation morality construction to "abide by credit" and "base on sincerity", and they shall regard "keeping in good credit" as the bottom line of public service ethics credit of immigration inspection.
- The environment construction of sincerity in credit system should be paid special attention to. Firstly, perfect internal & external supervision and restriction of immigration inspection service credit mechanism should be established. Secondly, the social effect of brand shall be fully played, to constantly improve reliability of brand service. Through the construction of border brand integrity environment, border integrity services brand can be constructed to improve the trust degree of the public to the immigration inspection service.
- Sincere behavior should be well implemented. First of all, the immigration inspection authorities should adhere to lawful administration, legal services and improved service quality. Lawful Administration is the basic demand and the

most fundamental guarantee of creditable administration. As administrative law enforcement organization of the state, the immigration inspection authorities must exercise the power of port immigration inspection entrusted by the state according to law. Typically, the degree of integrity and credibility is greatly determined by the ability of the organizations to enforce the law strictly and administrate lawfully, to display fairness and justice of the social benefits in the public service. Secondly, the immigration inspection organizations shall establish and implement the internal supervision and restriction mechanism of creditable behavior; slightly non-standard service credit of individual inspection staff should be corrected according to the shortcomings of the trust degree of service; the institutions shall strengthen credit construction of immigration inspection, adhere to administration according to law and legal services, and build the trustable border service brand.

119.3.2 Construction of Standard Service Based on Tangibility of Service Quality

- Existing China Immigration Inspection system ought to be improved; standards and practices universal for international entry and exit inspection system shall be researched and developed through the reports to related department and bureau for audit, so as to be applied into the actual immigration inspection work, and continuously improved and innovated in practice.
- Service process of China Immigration Inspection posts should be standardized, and brand service shall be established. Aiming at the problems in tangibles service quality, the current measures and methods ought to be continuously researched and improved, and high standardized brand service process and service model shall be realized.
- Construction of border customs service environment needs strengthening; according to the brand standard requirements, the facilities and inspection equipment for public service of border ports needs further improving, the facilities for border public service shall be renovated to improve hardware environment of public services. In the passenger port, the main measures are to regulate the site sign construction, and according to the brand requirements, to set up five types of logo signs on site including occupation logo, service mark, on-duty signal, channel symbol, warning signals of China Customs to improve the tangible service quality of passenger terminal port. In harbor port, public services basic environment shall be improved.
- Service etiquette of inspection staff should be strengthened. In accordance with the requirements of tangibles brand standard, the appearance, verbal politeness speech manner and foreign etiquette inspection staff will be improved, and viable service details will be formulated, to raise the overall tangible brand services.

119.3.3 Construction of Specialty Service Based on Profession Degree of Service Quality

- The selection of customs staff should be well controlled in quality, so that specialization degree and the overall quality level of new staffs will achieve the quality requirements to be brand inspector. That is to say, based on different service quality requirements of different positions, corresponding professional and high-quality civil servants should be employed.
- Existing border officials shall be integrated. The serving officials should be regularly trained on inspection professional knowledge and skills, occupation spirit and brand service awareness. Through training, they will be familiar with the frontier management and service, able to effectively use the internal and external resources and skilled in border exit-entry administration and service, to enhance communication ability with the public and service capabilities, which will help to provide quality assurance for enhancing border public service standards, improving service quality and building professional inspection service brand.
- The evaluation mechanism must be established. The inspectors should follow the system to be rated and given remuneration accordingly, so as to be excited in professional degree and consciousness improvement, followed by the result that the "brand" inspectors with excellent service skills will emerge in group. By creating "brand inspector" which is expanded gradually, the overall service quality and professional degree of the staff will be enhanced.

119.3.4 Construction of Satisfaction Service Based on Equality and Fairness of Service Quality

- Awareness of service brand should be established, culture of inspection service brand should be formed. On one hand, the administrative culture has great influence on administrative services, therefore, it is necessary for immigration inspection authorities to establish culture corresponding to service brand, in order to promote brand awareness whose improvement is the foundation for immigration inspection personnel to improve equality and fairness of service quality; on the other hand, it should be strengthened to cultivate inspection staff in service brand awareness, adjust service attitude and implement the system of rewards and penalties. Through various means, the inspection staff shall set up the concept of service brand. According to the requirements of Ministry of Public Security 6th Bureau, "all the immigration inspection personnel should be the same as each other strictly, personal reasons shall not influence working effect, and every object of service can enjoy the same high quality and efficient service at any time and any position", which is the training objective; the inspection staff should further develop and strengthen awareness of equality and fairness and service type, so that they will not influence equality and fairness of service quality due to personal reasons in the services process.

- According to the shortcomings in equality and fairness of inspection service quality, humanistic quality and service skills of inspection staff shall be strengthened, and international exchanges and learning ought to be expanded. When necessary, the first-line inspectors and the counterparts of other countries can have business and service exchanges for entry-exit inspection, to promote the human geography quality of inspection staff, so as finally to improve the equality and fairness of service quality for foreign passenger. At the same time, the immigration inspection authorities shall establish training mechanism for regular training and regular examination and urge inspection staff to improve their service quality and skills, to improve the equality and fairness of service quality, in order to improve the public satisfaction and credibility on immigration inspection service quality.
- Features service of immigration inspection based on the equality and fairness of service quality should be offered in accordance with the geographical environment advantages (port, airport, train station). Requirements of entry-exit activity shall be studied, to formulate the corresponding service brand measures and service mode and build inspection featured services, such as "smile" and "elegant" service with airport characteristics, "one-stop service" with harbor characteristics, "three zero" service and "24-hour" service, as well as "green clearance" service and "care" services with station characteristics, to establish easy access for those in need, especially the old, weak, sick and disabled.

119.3.5 Construction of Speed Service Based on Response Speed to Service Quality

- Concept of service efficiency of the immigration inspection personnel should be strengthened and the professional level should be enhanced, in order to adapt to the development of modern ports and improve the speed service level.
- In view of the fact that the environment of existing border ports does not meet the demand of service brand construction, the customs clearance environment of existing port should be improved, which is the difficulty of service brand building, since on one hand, strong support of the Guangzhou municipal government is necessary and construction funding preparation needs strengthening; on the other hand, coordination and overall planning with the joint inspection units of the ports are needed to ensure the practicability and universality of customs clearance environment improvement and consistency of services.
- Entry-exit inspection service mode of the immigration inspection authorities shall be continuously improved, service mode should be innovated, process of service is supposed to be optimized and simplified, service resources will be integrated, the service channels ought to be expanded, and the efficiency of customs clearance must be improved.

- The police force should be further strengthened, investment in science and technology shall be increased, outdated inspection equipment and facilities of ports should be updated, the ports should be equipped with advanced equipment for customs clearance, in order to improve the inspection service efficiency an outstand the “speed” service in service brand building process.

Through the above measures and methods, the efficiency of clearance and service of immigration inspection authorities can be greatly improved and “speed” service image in public service brand building will be established, to better meet the new challenges of entry-exit needs in new times.

119.4 Conclusions

The innovation of this paper lies in, referring to the theory of new public administration, bring the idea of strategic enterprise brand-development into the field of public administration in China Immigration Inspection. This paper designs a China Immigration Inspection brand-construction plan after a deep discussion of definition of the brand-construction of public service and provides referable thoughts and methods for China Immigration Inspection’s exploration of new administration mode.

Because of the limitations of my knowledge, there existed problems during the course of writing the article. These will be improved in the following study.

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Chapter 120
The Fuzzy Time-Cost-Quality-Environment Trade-off Analysis of Multi-mode Construction Systems for Large-scale Hydroelectric Projects

Huan Zheng

Abstract This paper studies the time-cost-quality-environment trade-off problem of construction project and establishes a multi-objective decision making model under a fuzzy environment. The objective functions are to minimize the total project time, total executed cost, quality defect of all activities, and the environment impact. Furthermore, a fuzzy based adaptive-hybrid genetic algorithm is developed for finding feasible solutions. Finally, Jinping-II hydroelectric project was used as a practical example to demonstrate the practicality and efficiency of the method.

Keywords Time-cost-quality-environment trade-off · Multi-mode · Construction project · Fuzzy · Genetic algorithm

120.1 Introduction

Time, cost, quality and environment of project delivery are among the crucial aspects of construction projects. Nowadays, construction project has been developed so rapidly in quantity and scale in many countries. Construction planners often face the challenges to compromise among different conflicting aspects of projects. The objective of the project management decision is to find a start time and an executive time for each activity such that the makespan is minimized which may with some other management objectives and the schedule is feasible with respect to the precedence, budget and cost intensity constraints. Four objectives are considered: (1) minimization of the project duration; (2) minimization of the total executive costs; (3) minimization the quality defect of the all activities; (4) minimization of the environment impact. In real-life situations, the duration and environment impact property of each activity are uncertain, the project manager must handle multiple

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conflicting goals in uncertain environment owing to information is incomplete and unavailable. Therefore, it is necessary to consider uncertainty and multi-objectives in project management practice.

This paper will effectively solve time-cost-quality-environment trade-off problem with fuzzy uncertainty. In Sect. 120.2, a multi-objective time-cost-quality-environ-ment trade-off problem under fuzzy environment is described, and makes assumptions and notation for this problem. A multi-objective fuzzy optimization model is then proposed for this problem. Sect. 120.3 involves a case study regarding the works of construction systems for large-scale hydroelectric projects, sensitivity analysis and the results comparison of (f)a-hGA with other heuristic algorithms are also provided. Finally, concluding remarks are outlined in Sect. 120.4

120.2 Problem Description and Mathematical Formulation Model

120.2.1 Problem Description

Some research have assumed activity duration is characterized by a fuzzy number due to environmental variation [7]. Fuzzy uncertainty is the uncertainty of the states that the event itself are not clear. It leads to different people will have different feeling when they observe the same event, so they could educe different conclusion, so fuzzy uncertainty is subjective uncertainty. Different from the traditional problem, we consider the uncertainty of the environment, so we think the duration of each activity is uncertain when we consider its scheduling under certain capital limit. This study focuses on developing (f)a-hGA technique to optimize activity sequence and executed mode for each activity in the project with the constraints of maximum resource limit. The original fuzzy programme model designed in this study aims to simultaneously minimize total project costs, total completion time, quality defect and environment impact which is shown in Fig. 120.1.

120.2.2 Dealing with the Fuzzy Variable

The basic knowledge about fuzzy variable, which includes the definition, the measure and the expected value are introduced in below literatures.

Fuzzy set theory has been well developed and applied in a wide variety of real problems. Here we adopted the definition proposed by Zadeh [9]. The term fuzzy variable was first introduced by Kaufmann [5], then it appeared in Nahmias [6]. Possibility theory was proposed by Zadeh [10], and developed by many researchers such as Dubois and Prade [1]. Membership function of fuzzy variable are introduced in Dubois and Prade [2]. However, the traditional fuzzy measures of fuzzy events

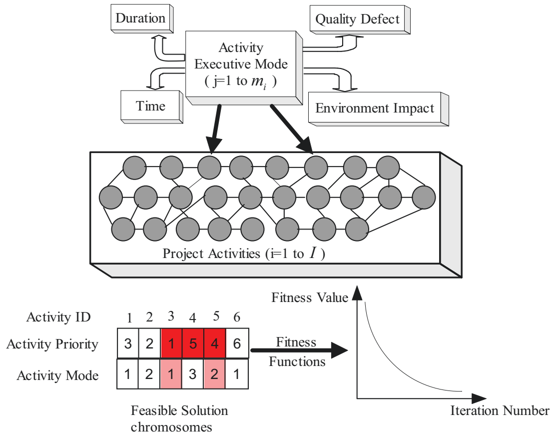

Fig. 120.1 The time-cost-quality-environment trade-off problem

can not express the preference of decision makers. Thus, this paper introduces the fuzzy measure Me [8] which embeds the optimistic-pessimistic parameter to determine the combined attitude of a decision maker.

120.2.3 Model Formulation

The problem is represented on an activity-on-node (AON) network with a single starting and a single ending node both corresponding to dummy activities. The following notation is used.

Index

i : the index of activity in a project, $i = 1, 2, \cdots, I$;
j : the mode, $j = 1, 2, \cdots, m_i$,(m_i is the number of possible modes for activity i);
$\lceil \, \rceil$: ceiling operator rounding upward to integer;
t : the period in a project, $t = 1, 2, \cdots, \lceil E[\tilde{T}_{I+1}] \rceil$;
p : the index for weight of quality indicator compared to other indicators in activity i, $p = 1, 2, \cdots, P_i$. (P_i is the number of possible indicators for activity i);
r : the index for positive environment impacts of the environment factor, $r = 1, 2, \cdots, R$;
k : the index for negative environment impacts of the environment factor, $k = 1, 2, \cdots, K$;
n : the index for positive environment impact properties, $n = 1, 2, \cdots, N$;
f : the index for negative environment impact properties, $f = 1, 2, \cdots, F$.

Variables

z_1 : total project costs;
z_2 : total project completion time;

z_3 : total project environment performance;
z_4 : total project environment impact;
$\tilde{D}_{ij}$: the duration of activity i operating in mode j, here the duration is fuzzy variable;
$E[\tilde{D}_{ij}]$: the expected duration of activity i operating in mode j;
$\tilde{T}$: specified project completion time;
t_i^{EF} : the earliest finish time of activity i;
t_i^{LF} : the latest finish time of activity i;
$E[\tilde{T}_i]$: the expected start time of activity i;
B : maximum-limited budget available with the whole project duration availability;
C_{ij} : cost of activity i operating in mode j per unit time, that is cost intensity;
l_t^M : maximum-limited budget only available in tth period availability;
$Pre(i)$: set of the immediate predecessors of activity i;
$Q_{i,p}^j$: performance of quality indicator p in activity i of selected mode j;
w_i : weight of activity i compared to other activities in the project about quality assessment;
$w_{i,p}$: weight of quality indicator p in activity i;
y_i : weight of activity i compared to other activities in the project about environment assessment;
$\overline{TV}$: the total environment impact of the project.
$\overline{TV}^+$: the total positive environment impact of the project;
$\overline{TV}^-$: the total negative environment impact of the project;
$\overline{V}_{ir}^+$: the positive environment impact r of activity i;
$\overline{V}_{ik}^-$: the negative environment impact k of activity i;
h_{ir} : the pondering coefficient for positive environment impact r of activity i;
h_{ik} : the pondering coefficient for negative environment impact k of activity i;
c_{inr} : the pondering coefficient which is assigned to each positive impact property n for positive environment impact r of activity i;
c_{ifk} : the pondering coefficient which is assigned to each negative impact property f for negative environment impact k of activity i;
$\tilde{p}_{ijnr}$: the positive environment impact property n for positive environment impact r in activity i of selected mode j;
$\tilde{p}_{ijfk}$: the negative environment impact property f for negative environment impact k in activity i of selected mode j.

Decision variables

$$x_{ijt} = \begin{cases} 1, & \text{if activity } i \text{ executed in mode } j \text{ scheduled to be finished in time } t, \\ 0, & \text{otherwise.} \end{cases}$$

The decision variable x_{ijt} decides whether the finishing time of current activity with the certain executed mode is scheduled in this certain time or not.

120.2.4 Fuzzy Multi-objective Model

(1) Objective functions

The present optimization model is formulated in order to provide the capability of minimizing construction time, cost, quality defect and environment impact. To this end, the model incorporates four major objective functions as shown in the following four equations to enable the evaluation of project performance in construction time, cost, quality and environment, respectively.

Construction managers aim at achieving option of executing mode for minimum cost to complete the project. So the first objective is to minimize the executed cost.

$$\min z_1 = \sum_{i=1}^{I}\sum_{j=1}^{m_i}\sum_{t=t_i^{EF}}^{t_i^{LF}} C_{ij}x_{ijt}E[\tilde{D}_{ij}]. \tag{120.1}$$

The second objective seeks to minimize the total project time. That is minimization the sum of the completion time for all activities.

$$\min z_2 = \sum_{j=1}^{m_I}\sum_{t=t_I^{EF}}^{t_I^{LF}} tx_{ijt}. \tag{120.2}$$

The third objective aims at minimizing project quality defect that is measured and quantified. It enables the aggregation of the estimated quality for all the considered activities to provide an overall quality performance at the project level using a simple weighted approach.

$$\min z_3 = \sum_{i=1}^{I} w_i \sum_{p=1}^{P_i} w_{i,p} \times Q_{i,p}^{j}. \tag{120.3}$$

The fourth objective is designed to minimize project environment impact that is measured and quantified.

$$\begin{aligned}\min z_4 &= \overline{TV} = \overline{TV}^{+} - \overline{TV}^{-} = \sum_{i=1}^{I} y_i\left(\sum_{r=1}^{R} h_{ir}\overline{V}_{ir}^{+} - \sum_{k=1}^{K} h_{ik}\overline{V}_{ik}^{-}\right)\\ &= \sum_{i=1}^{I} y_i\left[\sum_{r=1}^{R} h_{ir}\sum_{n=1}^{N} c_{inr}\frac{\tilde{p}_{ijnr}^{2}}{100} - \sum_{k=1}^{K} h_{ik}\sum_{f=1}^{F} c_{ifk}\left(100 - \frac{\tilde{p}_{ijfk}^{2}}{100}\right)\right].\end{aligned} \tag{120.4}$$

(2) Constraints

In project, precedence is the important basic term ensuring the rationality of the arrangement. That is to ensure that none of the precedence constraints.

$$\sum_{j=1}^{m_e}\sum_{t=t_e^{EF}}^{t_e^{LF}} tx_{ejt} + \sum_{j=1}^{m_i}\sum_{t=t_i^{EF}}^{t_i^{LF}} E[\tilde{D}_{ej}]x_{ijt} \le \sum_{j=1}^{m_i}\sum_{t=t_i^{EF}}^{t_i^{LF}} tx_{ijt}, \tag{120.5}$$

$$i = 1,2,\cdots,I,\ e \in Pre(i). \tag{120.6}$$

Each activity must be scheduled and its finish time must be in the range of its early finish time and last finish time to ensure the maturity constraint. Every activity must have a finish time with a certain mode within its earliest finish time and last finish time.

$$\sum_{j=1}^{m_i} \sum_{t=t_i^{EF}}^{t_i^{LF}} x_{ijt} = 1,\ i = 1,2,\cdots,I. \tag{120.7}$$

To aggregate the estimated quality for all the considered activities, we provide an overall quality at the project level using a simple weighted approach. w_i represents the importance and contribution of the quality of this activity to the overall quality of the project. These coefficients have to fulfil the following condition:

$$\sum_{i=1}^{I} w_i = 1. \tag{120.8}$$

The weight of quality indicators in activity i to indicate the relative importance of this indicator to others is used to measure the quality of the activity, it has to fulfil the following condition:

$$\sum_{p=1}^{P_i} w_{i,p} = 1,\ i = 1,2,\cdots,I. \tag{120.9}$$

To aggregate the estimated environment for all the considered activities, we provide an overall environment at the project level using a simple weighted approach. y_i represents the importance and contribution of the environment of this activity to the overall environment of the project. These coefficients have to fulfil the following condition:

$$\sum_{i=1}^{I} y_i = 1. \tag{120.10}$$

Pondering coefficients have to be assigned to each environmental factor $\overline{V}^+$ or $\overline{V}^-$ to quantify the environmental significance of the factor, which can be estimated by convergence methods. These coefficients have to fulfil the following condition:

$$\sum_{r=1}^{R} h_{ir} + \sum_{k=1}^{K} h_{ik} = 1,\ i = 1,2,\cdots,I. \tag{120.11}$$

Pondering coefficients have to be assigned to each impact property to quantify the influence of each $\tilde{v}$ on the value of the environmental impact V. They have to fulfil the following conditions:

$$\sum_{n=1}^{N} c_{inr} = 1,\ r = 1,2,\cdots,R,\ i = 1,2,\cdots,I, \tag{120.12}$$

$$\sum_{f=1}^{F} c_{ifk} = 1,\ k = 1,2,\cdots,K,\ i = 1,2,\cdots,I. \tag{120.13}$$

Firstly, cost planning is constrained according to activity breaking down. Constraint limits the total capital consumption to the available amount, so we consider the total budget for the project. It is basic and important in project to limit the total capital consumption used by all activities. It has a maximum limit B during the whole project duration.

$$z_1 \leq B. \tag{120.14}$$

Secondly, cost planning is constrained according to time. The total cost of all activities scheduled in time t cannot exceed the capital limit per period.

$$\sum_{i=1}^{I}\sum_{j=1}^{m_i} C_{ij} \sum_{s=t}^{t+E[\tilde{D}_{ij}]-1} x_{ijt} \leq l_t^M,\ t = 1,2\cdots,\lceil E[\tilde{T}_{I+1}]\rceil. \tag{120.15}$$

In order to describe some non-negative variables and 0-1 variables in the model for practical situation are presented. Non-negativity constraints on decision variable and its revelent variable

$$E[\tilde{D}_{ij}], E[\tilde{T}], t_i^{EF}, t_i^{LF} \geq 0,\ i = 1,2,\cdots,I,\ j = 1,2,\cdots,m_i, \tag{120.16}$$

$$x_{ijt} = 0 \text{ or } 1,\ i=1,2,\cdots,I,\ j=1,2,\cdots,m_i, t=1,2,\cdots,\lceil E[\tilde{T}_{I+1}]\rceil. \tag{120.17}$$

Constraints on project completion time.

$$E[\tilde{T}_{I+1}] \leq E[\tilde{T}]. \tag{120.18}$$

120.3 Case Study: The Time-cost-environment Trade-off for Jinping-II Hydroelectric Project

120.3.1 Presentation of the Case Problem

The project has 13 activities from preliminary work to clearing up and finishing work. Each of these has certain predecessors, successors, and fixed finishing time. Here, the company traditionally uses the month as a time unit (i.e. 1 month per unit). Two dummy activities were set up to help for the convenience of the model. The detailed corresponding data for each activity is as follows in Table 120.1, Table 120.2 and Table 120.3.

Based on the representation of the case problem, the proposed methods can be used to obtain the project scheduling model for our project.

Table 120.1 The number, mode, duration, budget, predecessor and two kinds of weight of each activity

I	II	III	IV	V	VI	VII
1	Dummy Activity					
2	1 2	(1,3,5) (5,9,13)	4 3	1	0.07	0.1
3	1 2 3	(0.5,1,1.5) (0.5,1,1.5) (2,5,8)	4 3 4	1	0.06	0.11
4	1 2	(3,5,7) (6,8,10)	4 3	1	0.03	0.08
5	1	(3,6,9)	5	2	0.06	0.1
6	1 2	(1,2,3) (3,6,9)	2 3	3	0.12	0.056
7	1 2	(1,3,5) (6,8,10)	5 4	2,3	0.15	0.07
8	1 2	(2,4,6) (8,10,12)	4 2	6	0.1	0.014
9	1 2 3	(1,2,3) (5,7,9) (7,10,13)	4 3 2	5	0.09	0.07
10	1 2 3	(0.5,1,1.5) (0.5,1,1.5) (7,9,11)	4 2 6	5,7	0.09	0.11
11	1 2 3	(3,6,9) (7,9,11) (7,10,13)	2 1 1	4,6,7	0.06	0.14
12	1 2	(9,11,13) (6,8,10)	2 4	8,10	0.04	0.028
13	1 2 3	(3,5,7) (4,6,8) (5,7,9)	3 3 2	8,9,11	0.07	0.056
14	1 2	(1,4,7) (1,3,5)	4 5	9	0.04	0.056
15			Dummy Activity			

Note: I: Activity i; II: Mode j; III: Duration $(\tilde{D_{ij}})$ (month); IV: Cost intensity (C_{ij} (billion)); V: Predecessor $(Pre(i))$; VI: Weight of activity for quality (w_i); VII: Weight of activity for environment (y_i).

Other relevant data are as follows: total budget is 180, maximum limited of cost intensity is 15 unite for each period, project completion duration under normal con-

Table 120.2 Activity mode option, their corresponding quality indicators and quality performance

I	II	IX	X	I	II	IX	X
2	1	72,71.14	0.3,0.7	9	1	66.7,66,7	0.5,0.5
	2	42,43.14	0.3,0.7		2	44.4,44.4	0.5,0.5
					3	33.3,33.3	0.5,0.5
3	1	87,82.35	0.2,0.8	10	1	42,58	0.85,0.15
	2	68,66.357	0.2,0.8		2	72,36.7	0.85,0.15
	3	56,48.5	0.2,0.8		3	38,6.7	0.85,0.15
4	1	70,61.75	0.6,0.4	11	1	60,67.44	0.1,0.9
	2	155,184.25	0.6,0.4		2	40,51.11	0.1,0.9
					3	103,99.7	0.1,0.9
5	1	66.7	0.5,0.5	12	1	82,73.76	0.15,0.85
					2	131,123.94	0.15,0.85
6	1	70,65.6	0.25,0.75	13	1	73,65.72	0.78,0.22
	2	58,58.4	0.25,0.75		2	58,53.9	0.78,0.22
					3	44,38.54	0.78,0.22
7	1	72,64.64	0.28,0.72	14	1	78,74.67	0.1,0.9
	2	55,43.47	0.28,0.72		2	52,49.78	0.1,0.9
8	1	63,101.89	0.82,0.18				
	2	98,109.11	0.82,0.18				

Note: I: Activity i; II: Mode j; IX: Quality Performance $Q^j_{i,p}$; X: Weight of quality indicator $w_{i,p}$.

dition 28 months and decision maker expected project completion duration below 30 months.

Table 120.3: Environmental impacts, impact properties and their pondering coefficients for each activity-mode

Activity i	Mode j	h_{ir}	c_{inr}	$\tilde{p}_{ijnr}$	h_{ik}	c_{ifk}	$\tilde{p}_{ijfk}$
2	1	0.3	0.4,0.6	99.5,97.81	0.07	0.8,0.2	63.25,77.46
		0.5	0.42,0.58	97.98,87.37			
		0.05	0.37,0.63	92.74,97.34	0.08	0.82,0.18	83.67,96.02
	2	0.3	0.4,0.6	99.5,98.64	0.07	0.8,0.2	51.96,95.92
		0.5	0.42,0.58	97.98,75.06			
		0.5	0.37,0.63	52.92,42.99	0.08	0.82,0.18	83.67,64.96
3	1	0.3	0.4,0.6	99.5,98.66	0.07	0.8,0.2	72.11,90.55
		0.5	0.42,0.58	97.468,98.35			
		0.05	0.37,0.63	46.90,24.76	0.08	0.82,0.18	88.32,61.42
	2	0.3	0.4,0.6	99.5,98.66	0.07	0.8,0.2	72.11,90.55
		0.5	0.42,0.58	97.468,98.35			
		0.05	0.37,0.63	46.90,24.76	0.08	0.82,0.18	88.32,61.42
	3	0.3	0.4,0.6	89.44,85.63	0.07	0.8,0.2	36.06,69.28
		0.5	0.42,0.58	90.55,66.385			
		0.05	0.37,0.63	77.46,58.82	0.08	0.82,0.18	69.28,79.09

Table 120.3: Continued

4	1	0.3	0.4,0.6	99.5,96.95	0.07	0.8,0.2	76.16,85.44
		0.5	0.42,0.58	98.99,96.35			
		0.05	0.37,0.63	61.64,56.26	0.08	0.82,0.18	97.88,99.73
	2	0.3	0.4,0.6	97.98,99.65	0.07	0.8,0.2	86.02,96.95
		0.5	0.42,0.58	99.75,99.32			
		0.05	0.37,0.63	81.85,76.85	0.08	0.82,0.18	97.98,92.89
5	1	0.3	0.4,0.6	98.49,97.64	0.07	0.8,0.2	69.28,65.57
		0.5	0.42,0.58	94.34,95.25			
		0.05	0.37,0.63	73.48,61.75	0.08	0.82,0.18	82.46,93.14
6	1	0.3	0.4,0.6	97.98,99.65	0.07	0.8,0.2	65.57,61.64
		0.5	0.42,0.58	95.92,94.10			
		0.05	0.37,0.63	88.32,82.75	0.08	0.82,0.18	78.74,99.40
	2	0.3	0.4,0.6	74.83,57.16	0.07	0.8,0.2	65.57,82.46
		0.5	0.42,0.58	36.06,46.50			
		0.05	0.37,0.63	57.45,50.06	0.08	0.82,0.18	88.32,98.01
7	1	0.3	0.4,0.6	97.98,99.65	0.07	0.8,0.2	65.57,61.64
		0.5	0.42,0.58	95.92,94.10			
		0.05	0.37,0.63	88.32,82.75	0.08	0.82,0.18	78.74,99.40
	2	0.3	0.4,0.6	97.88,99.65	0.07	0.8,0.2	86.02,96.95
		0.5	0.42,0.58	99.75,99.32			
		0.05	0.37,0.63	81.85,76.85	0.08	0.82,0.18	97.88,92.89
8	1	0.3	0.4,0.6	97.98,99.65	0.07	0.8,0.2	65.57,61.64
		0.5	0.42,0.58	95.92,94.10			
		0.05	0.37,0.63	88.32,82.75	0.08	0.82,0.18	78.74,99.40
	2	0.3	0.4,0.6	97.88,99.65	0.07	0.8,0.2	86.02,96.95
		0.5	0.42,0.58	99.75,99.32			
		0.05	0.37,0.63	81.85,76.85	0.08	0.82,0.18	97.88,92.89
9	1	0.3	0.4,0.6	97.98,99.65	0.07	0.8,0.2	65.57,61.64
		0.5	0.42,0.58	95.92,94.10			
		0.05	0.37,0.63	88.32,82.75	0.08	0.82,0.18	78.74,99.40
	2	0.3	0.4,0.6	97.88,99.65	0.07	0.8,0.2	86.02,96.95
		0.5	0.42,0.58	99.75,99.32			
		0.05	0.37,0.63	81.85,76.85	0.08	0.82,0.18	97.88,92.89
	3	0.3	0.4,0.6	97.88,99.65	0.07	0.8,0.2	86.02,96.95
		0.5	0.42,0.58	99.75,99.32			
		0.05	0.37,0.63	81.85,76.85	0.08	0.82,0.18	97.88,92.89
10	1	0.3	0.4,0.6	98.49,94.16	0.07	0.8,0.2	64.81,46.90
		0.5	0.42,0.58	92.20,82.32			
		0.05	0.37,0.63	47.96,38.81	0.08	0.82,0.18	26.46,54.06
	2	0.3	0.4,0.6	95.92,90.55	0.07	0.8,0.2	64.81,81.85
		0.5	0.42,0.58	99.00,97.24			
		0.05	0.37,0.63	85.44,76.62	0.08	0.82,0.18	95.52.98.77
	3	0.3	0.4,0.6	89.44,85.63	0.07	0.8,0.2	36.06,69.28
		0.5	0.42,0.58	90.55,66.385			
		0.05	0.37,0.63	77.46,58.82	0.08	0.82,0.18	69.28,79.09

Table 120.3: Continued

11	1	0.3	0.4,0.6	97.98,99.65	0.07	0.8,0.2	65.57,61.64
		0.5	0.42,0.58	95.92,94.10			
		0.05	0.37,0.63	88.32,82.75	0.08	0.82,0.18	78.74,99.40
	2	0.3	0.4,0.6	95.92,90.55	0.07	0.8,0.2	65.57,79.37
		0.5	0.42,0.58	88.32,92.14			
		0.05	0.37,0.63	78.74,57.82	0.08	0.82,0.18	92.20,98.61
	3	0.3	0.4,0.6	98.49,94.16	0.07	0.8,0.2	64.81,87.75
		0.5	0.42,0.58	90.55,66.39			
		0.05	0.37,0.63	44.72,9.75	0.08	0.82,0.18	61.64,86.49
12	1	0.3	0.4,0.6	97.98,99.65	0.07	0.8,0.2	65.57,61.64
		0.5	0.42,0.58	95.92,94.10			
		0.05	0.37,0.63	88.32,82.75	0.08	0.82,0.18	78.74,99.40
	2	0.3	0.4,0.6	97.98,99.65	0.07	0.8,0.2	86.02,96.95
		0.5	0.42,0.58	99.75,99.32			
		0.05	0.37,0.63	81.85,76.85	0.08	0.82,0.18	97.98,92.89
13	1	0.3	0.4,0.6	97.98,99.65	0.07	0.8,0.2	65.57,61.64
		0.5	0.42,0.58	95.92,94.10			
		0.05	0.37,0.63	88.32,82.75	0.08	0.82,0.18	78.74,99.40
	2	0.3	0.4,0.6	98.49,94.16	0.07	0.8,0.2	68.56,84.85
		0.5	0.42,0.58	90.55,66.39			
		0.05	0.37,0.63	44.72,9.75	0.08	0.82,0.18	93.81,89.64
	3	0.3	0.4,0.6	97.98,99.65	0.07	0.8,0.2	65.57,61.64
		0.5	0.42,0.58	95.92,94.10			
		0.05	0.37,0.63	88.32,82.75	0.08	0.82,0.18	78.74,99.40
14	1	0.3	0.4,0.6	97.98,99.65	0.07	0.8,0.2	65.57,61.64
		0.5	0.42,0.58	95.92,94.10			
		0.05	0.37,0.63	88.32,82.75	0.08	0.82,0.18	78.74,99.40
	2	0.3	0.4,0.6	98.49,94.16	0.07	0.8,0.2	68.56.37,84.85
		0.5	0.42,0.58	90.55,66.39			
		0.05	0.37,0.63	44.72,9.75	0.08	0.82,0.18	93.81,89.64

120.3.2 Result of the Case Problem

The parameters of the environment for the problem was set as follows:

Based on the above model, we uses the proposed (f)a-hGA using Visual C++ language and run on Pentium 4, 2.40 GHz clock pulse with 1024 MB memory, and tested the performance of this method with the actual data obtained from the above project.

The evolutionary environment for the problem was set as follows: pop_size was 20, the rate of crossover and mutation is 0.6 and 0.1 respectively, max_ generation was 200, the optimistic-pessimistic parameter is $\lambda = 0.5$.

After a run of a genetic algorithm computer program, the following satisfactory solution was obtained: the optimal value of the objective function is:

$$z_1 = 175,\ z_2 = 27,\ z_3 = 67,\ z_4 = 71,$$

using the objective weights 0.1, 0.5, 0.1, and 0.3 respectively, The optimal fitness is 0.57.

Using the chromosome illustrated above, we obtain the following schedule:

$$\begin{aligned} S =\ & 1,2,3,6,5,4,8,9,14,7,10,11,12,13,15 \\ =\ & a_1(0):0-0, a_2(1):0-3, a_3(2):3-4, a_6(1):4-6, a_5(1):4-10, \\ & a_4(1):6-11, a_8(1):6-10, a_9(1):10-12, a_{14}(1):12-16, \\ & a_7(1):12-15, a_{10}(2):15-16, a_{11}(1):16-22, a_{12}(1):16-27, \\ & a_{13}(1):22-27, a_{15}(1):27-27. \end{aligned}$$

The Gantt chart for the construction is shown in Fig. 120.2.

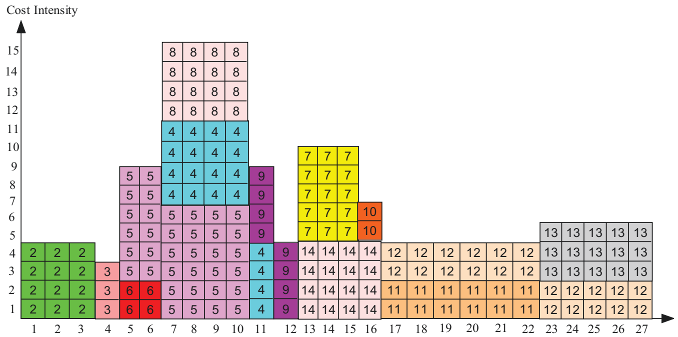

Fig. 120.2 Gantt chart for the construction project schedule

120.4 Conclusion

In this paper, the proposed fuzzy time-cost-quality-environment trade-off model attempts to minimize total project costs, total completion time, quality and the environment impact with reference to cost intensity, duration of activities, the constraint of precedence, total budget, weight and pondering coefficients. The main advantage of the proposed method is that it provides a systematic workable method for the problem that facilitates the decision-making process, enabling decision maker to control the schedule according to his optimistic-pessimistic parameter, and the fuzzy logic is a suitable tool for environment impact assessment for project. We have applied the model to construction systems for large-scale hydroelectric projects (Jinping-II) in the southwest region of China. The application of fuzzy variables makes the proposed multiple objective model more suitable for describing the vague situation in the real world. This work is original, and we develop fuzzy-based adaptive hybrid genetic algorithm to enhance the optimization quality and stability. Practical results indicate that both the proposed model and the (f)a-hGA are viable and efficient in handling such complex problems.

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Chapter 121
Firm Heterogeneity and Learning by Technology In-Licensing: Empirical Evidence from China

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Abstract In explaining variation in innovative performance of firms the resource-based view of the firm draws on the concept of firm heterogeneity. We contribute to this stream of research by introducing technology in-licensing as a learning mechanism and by highlighting the joint effect of five aspects of firm heterogeneity. Moreover, we provide empirical evidence that licensing experience together with other sources of firm heterogeneity lead to substantial differences in innovative performance of firms. We argue that the age and size, technological strength, experience of licensing agreements (integrative capability), and orientation towards foreign knowledge sourcing are factors that determine which firms are better positioned for learning through technology in-licensing - and so achieve superior innovative performances. This is illustrated by an empirical study based on a unique dataset that is owned by the Chinese government.

Keywords Firm heterogeneity · Technological learning · Innovative performance · Technology in-licensing · China

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121.1 Introduction

This empirical study explores how different sources of firm heterogeneity and their interaction with licensing experience can be used to jointly explain a licensee's technological learning through technology in-licensing and subsequent innovative performance. Firm heterogeneity is at the core of the resource-based view of the firm (from here on referred to as RBV) that explains how companies can achieve competitive advantage and how they can sustain this advantage over time [1, 2]. The RBV view of the firm concentrates on the internal organization of firms; and as such complements the conventional strategic positioning literature in explaining how firms obtain competitive advantages. The RBV framework assumes that firms can be conceptualized as bundles of resources, that those resources are heterogeneously distributed across companies, and that resource differences persist over time [3]. When a firm's resources are valuable, rare, non-imitable, and non-substitutable, the firm is well-positioned for achieving and sustaining competitive advantage.

Although the RBV of the firm has been highly influential in innovation research there are some aspects that have remained relatively unexamined. Firstly, researchers have largely ignored the question of whether different aspects of firm heterogeneity can be used to simultaneously explain differences in the innovative success of firms. Secondly, there has been a lack of attention in the RBV literature about the various learning mechanisms by which firm-specific characteristics and capabilities contribute to innovation performance. Prior studies have largely ignored the learning process by which heterogeneous capabilities can be converted into innovative output while taking into account differences in learning processes.

In this study, we contribute to the RBV view of the firm in three ways. Firstly, we conduct an empirical analysis of how different firm-specific characteristics and capabilities can be jointly studied as determinants of learning experiences and innovative outputs. Secondly, the study explores how innovating firms convert firm-specific capabilities into innovative output through learning-by-licensing as a learning mechanism. Thirdly, to the best of our knowledge this study is the first quantitative study to analyze the impact of firm heterogeneity on the learning experiences of firms and their subsequent innovative performance. In this study, we formulate several hypotheses about this relationship and we test them using a sample of Chinese licensing companies. This set of firms provides us with an interesting sample given that research shows that nearly 70% of current R&D expenditure in Chinese firms consists of licensing payments. The dataset underlying our analyses is a unique dataset that is owned by the Chinese government.

121.2 Theoretical Background and Hypotheses

Heterogeneity across-firms leads to differences in innovative performances. Heterogeneous capabilities are built through the different learning experiences that firms went through when creating new knowledge and capabilities [4, 5]. Companies typically develop new technological capabilities by drawing from internal knowledge sources (through in-house R&D as the main learning mechanism) and external knowledge sources (through learning mechanisms such as R&D alliances, joint-ventures, M&As, corporate venturing, and technology licensing) [6, 7]. Firms explore different knowledge sources to enhance their knowledge base, integrate different specialized knowledge areas, and apply new knowledge to spur new product development or product improvement. Different learning mechanisms require heterogeneous inputs and result in different performance outcomes [8].

The first aspect of firm heterogeneity under consideration is a firm's integrative capability, or its ability to learn from licensing agreements because of prior experience with licensing deals. Recent contributions on absorptive capacity have suggested that a recipient's ability to learn is not only related to its existing stock of knowledge but also to the optimal match between the knowledge of the external source and that of the recipient firm. This line of research highlights the role of integrating internal and external knowledge. A strong positive relation between newly acquired knowledge and the existing knowledge base of a recipient is indicative of a high relative absorptive capacity and contributes to a firm's learning from external sources and subsequent innovative performance [9]. Absorptive capacity is a two-dimensional construct consisting of: (1) the existing technological strength of a recipient that is related to its prior stock of knowledge; and (2) the integrative capacity of a firm that takes into account the relationship between the recipient's technological strength and the source's characteristics. This two-dimensional concept is congruent with Zahra and George's dynamic view of absorptive capacity [10]. These authors re-conceptualize absorptive capacity to include both the realized and potential dimensions of absorptive capacity. The former is related to the traditional interpretation of absorptive capacity that refers to the prior knowledge base. The latter focuses on the transformation process that denotes a firm's ability to develop and refine routines that facilitate the combination of existing knowledge and newly acquired knowledge.

Zahra and George [10] signal that this set of capabilities fuels a firm's learning potential and subsequent innovative performance and their arguments are supported by several other studies. Based on these arguments we hypothesize:

Hypothesis 1. The stronger a firm's integrative capacity, the greater the positive effect on its subsequent innovative performance.

The following hypotheses focus how integrative capability or prior experience in licensing -changes the impact other sources of firm-level heterogeneity on the innovative performance of companies. The second source of heterogeneity we take into consideration is *firm age*. Licensees with strong research capabilities and a rich tradition in developing innovations are better positioned for learning from their licensor and thus perform better with respect to their subsequent innovative efforts. Older companies typically have developed the necessary innovative routines, set up the required internal structures, and established the external relations that can support their innovative endeavors [11]. Nelson and Winter [11] argue that routines, which are built into the organization, make up a set of actions that the organization can handle confidently. However, we are mainly interested in the impact of routines developed during prior technology in-licensing agreements on the relationship between age and technological performance. These routines can help the licensee scan and search for technologies that are suitable for its internal organizational needs and capabilities, and then quickly assimilate these technologies within the internal technology base of the organization [3]. Routines that are essential for learning from technology in-licensing are usually well-established within older innovating firms. In line with these innovative routines there are organizational structural elements in these older innovative companies, such as experienced, skilled personnel, well-developed management capabilities, and a supporting culture, that accelerate the firm-specific learning experience that follows technology in-licensing [12, 13]. Innovative skills, capabilities, and experience are crucial in understanding, integrating, adapting, and exploiting the newly acquired knowledge [14]. An innovative firm's culture, which enhances learning experiences, is about delegating responsibility, tolerating creative mistakes, and providing slack time to work on new ideas. It takes time to create such a culture as well as to develop the necessary capabilities and experience - and this gives older companies an advantage. As a consequence, technology in-licensing can be considered as a dynamic learning process where organizations continually interact with customers and suppliers to learn, share knowledge, and innovate.Older licensees have long-term relationships with licensors and benefit from the inflows of knowledge from licensors that are not covered in licensing agreements - but are important for licensees to understand, assimilate, and build on licensed-in technologies [15, 16]. Hence, older firms are in an advantageous position to learn from licensing new knowledge. Consequently, we formulate the first hypothesis as follows:

Hypothesis 2. The older a firm, the greater the positive effect of its integrative capability on its subsequent innovative performance.

The identification of a new idea from an outside source is just the start of a firm's learning process. A successful learning process entails grasping the external technology, acquiring it, and integrating it into the existing internal knowledge base. This process is captured by the concept of absorptive capacity [4], which is defined as the stock of prior knowledge that a company needs to recognize the value of an external idea, assimilate it, and apply it to commercial ends. Several authors observed that firms are heterogeneous in terms of their absorptive capacity. Stocks of technological knowledge are heterogeneously distributed across companies. Consequently, firms differ in their ability to identify and absorb new technologies [17]. Several empirical studies have found that firm heterogeneity with respect to technological strength results in considerable differences in learning experiences and the subsequent innovative performance of companies [18]. When analyzing several types of technology transfer agreements, various authors have argued that companies with a strong absorptive capability and high technological strength are highly successful at analyzing, understanding, and processing technological knowledge received from their innovation partners [17]. However, this paper focuses on how absorptive capacity affects the relationship between the integrative capacity of licensees and their technological performance. The main issue is whether absorptive capacity is a substitute or a complement for a firm's integrative capability. Licensees with a strong knowledge stock can rely on a better developed absorptive capacity and will, therefore, learn more from their licensing agreements. As a result, firms with a strong technology base are more successful at extending their knowledge base because they have a better absorptive capacity than their weaker technological counterparts [2]. The effective integration of the licensee's knowledge base with the know-how received from the licensor is bound to lead to novel combinations of knowledge or innovations [18]. In sum, a large existing technological knowledge base facilitates a licensee's learning from prior licensing experience, which finally results in an improved innovation performance. This leads us to propose the following hypothesis:

Hypothesis 3. The greaterthe existing technological strength of a firm, the greater the positive effect of its integrative capability on its subsequent innovative performance.

The effect of firm heterogeneity on learning and *firm size* has been widely discussed in the literature as an important firm-specific characteristic that influences performance. In his seminal work, Schumpeter [19] asserts that there is a strong positive relation between size and innovative performance. Specifically, large companies are able to employ a vast number and highly specialized R&D staff. In large companies, large groups of scientists and engineers can interact to stimulate learning and innovation. For licensees, major and long-term investments in R&D, continuous enrollment of new engineers, and intensive training of R&D personnel are crucial for successfully absorbing and improving licensed-in technologies [20]. The larger the firm and the stronger its R&D capabilities, the greater its potential for benefiting from technology in-licensing. Furthermore, larger firms are likely to have access to a larger number of potential sources of knowledge such as customers, suppliers, complementors, R&D-labs, universities, etc. leading to a superior and speedier learning process [21]. In addition, larger firms have sufficient resources to tolerate occasional failures in knowledge integration and for executing R&D projects aimed at integrating internal knowledge and externally acquired technology and promoting new knowledge creation [22]. In sum, the literature shows that larger companies have several advantages as innovators. However, in this study we are interested in how firm size might affect the impact of licensing experience on firm performance. One might argue that larger companies have more resources (both financial and human) to facilitate the internal learning process following technology in-licensing, which in turn should lead to superior innovative performance [23]. However, while small firms have to license in technology because they lack the necessary resources to develop technology in-house, larger firms usually have the possibility to develop technological innovations in-house. Therefore, larger firms that rely on licensed technology signal one of the two following options. Firstly, licensing technology may be a deliberate strategy of the company to insource external technology rather than developing internal technological strengths. This is a viable strategy when companies rely on competitive drivers such as cost advantages, locational advantages, and lock-in positions. Secondly, relying on licensed technology also may signal that the licensee has not been able to develop internal technological capabilities. In both cases, we expect that licensing technology is a barrier to innovate rather than a driver to develop a firm's own technological capabilities. In other words, the larger a firm the greater the chance that licensed-in technology becomes a substitute rather than a complement for the development of internal technological capabilities. We therefore formulate the following hypothesis:

Hypothesis 4. The largera firm, the weaker the positive effect of its integrative capability on the subsequent innovative performance.

The Chinese knowledge landscape has developed strongly in recent years and so the firms in our sample have various options (including domestic partners such as indigenous companies and local universities on the one hand or foreign firms on the other hand). As we focus on Chinese licensees this distinction between domestic and foreign technology sources is important. Katrak suggests that importing more advanced technologies from developed countries may be a 'building block' that firms in emerging economies can use to develop strong technological capabilities [24]. Licensing-in technologies from foreign sources offers Chinese licensees a unique opportunity to catch up by stimulating their learning potential and subsequent innovative performance. In this study, we focus, however, on the impact of the choice to license from foreign or domestic sources on the integrative capacity of licensees. Although licensing from foreign sources has a direct positive effect on innovative performance, we argue that it also negatively affects the impact of a licensee's integrative capacity on innovation performance. Firstly, prior experience with licensees is useful when licensing domestic technology: a shared cultural and economic background makes it easier to use prior experience in new licensing agreements. Secondly, licensing from foreign licensors is in many cases targeting more advanced technology that is harder to assimilate and integrate for licensees in developing economies. Therefore, we assume that licensing from foreign licensors has a negative impact on the integrative capacity of licensees. Hence we hypothesize:

Hypothesis 5. The more foreign technology sourcing by a firm located in a developing economy, the weaker the positive effect of its integrative capability on its subsequent innovative performance.

121.3 Methodology

121.3.1 Data and Sample

We test the hypotheses on a database of 186 Chinese firms that were engaged in either foreign or domestic technology in-licensing agreements during the period 2000-2003. For this study, we consider a five-year learning period following the technology in-licensing agreements that took effect in one of the years between 2000 and 2003. For example, we measure the innovative performance effects in 2005 of technology in-licensing agreements that were agreed in the year 2000; in 2006 we examine performance effects of agreements negotiated in 2001, etc. This choice is consistent with previous studies that have examined how much time companies need to absorb technological knowledge, combine this knowledge with their existing know-how, and convert it into new, profitable applications. For instance, Johnson [25] shows that the time lag between foreign in-licensing experiences by Brazilian firms and measurable effects on their innovative performances is at least five years. Similarly, studies by Ahuja and Katila [6] and Hall et al [26] on the effects of mergers and acquisitions (M&As) on patent outcomes show a five-year time lag. We excluded all technology licensing agreements in which individuals play a role as licensors (and individuals are also excluded as licensees since we focus on Chinese companies). According to these selection criteria we obtained a sample of 202 local Chinese firms. We had to exclude 16 licensees from the sample sincethey ceased to exist during the five years following their technology in-licensing agreements due to bankruptcy or acquisition. We conductedour analysis based on a panel dataset of 186 firms that were active in technology in-licensing during the period 2000-2003.

According to the Chinese legislation (*Administration of Record Filing of Technology In-Licensing*) the State Intellectual Property Office (SIPO) is authorized to register technology licensing agreements within three months after the contracts have been negotiated between the licensor and licensee. The information in a record contains: the licensor's name, the licensed patent number, the patent name, the licensee's name, the contract number and date, and the agreement type (exclusive or non-exclusive). This information is complete for almost all technology licensing agreements negotiated during the period 2000-2009. Data is currently only partially available to the public for the years 1998 and 1999.

Complementary data was collected through newspaper articles, annual reports, telephone calls and emails directed to the management of the sample firms. The companies operating in multiple industries are based in 21 Chinese provinces and municipalities in the eastern developed regions and the economically most important provinces in middle and western China. We also collected patent data from SIPO for each firm.

121.3.2 Dependent Variables

The dependent variable, *innovative performance*, measures the technological learning of the focal firms using Chinese patent counts, namely, the total number of patent applications within the five-year period following the licensing date.

121.3.3 Independent Variables

Firm age measures the number of years that the firm has existed from the year of inception to the year of the technology in-licensing agreement. Following existing studies (e.g. Ahuja and Katila [6]) the variable *existing technological strength* is calculated as the total number of patents applied for in SIPO by the focal firm in the five-year period preceding the licensing year. The explanatory variable *integrative capacity* is constructed to take into account the effect of the licensee's licensing experience relative to its existing technological strength. We calculate this variable as the ratio of a licensee's licensed patents to its patent applications in the five-year period prior to the observation year. The variable *firm size* was used by a dummy variable, which takes on the value of 1 if a firm employs 500 or more people and 0 otherwise. This variable is lagged by one year. The *sourcing orientation* of a Chinese licensee is calculated as the ratio of the number of foreign technology in-licensing agreements (including those negotiated with subsidiaries of multinationals) to the total number of technology in-licensing agreements (including domestic and international agreements) in each year.

121.3.4 Control Variables

We first control for a licensee's technological context by calculating the total number of patents applied for in its province (*province patent stock*) during the five-year period preceding the licensing year. *Market competition* is another control variable. This variable is calculated as the number of firms that license-in the same technology from the same licensor during the year in which a Chinese company is licensing the technology. We furthermore control for differences between industries by including the variable *firm sector*, which is a dummy variable that takes on the value of 1 if the firm is operating in a manufacturing industry (*FS1*) and 0 if the firm is active in other sectors of industry (*FS0*).

121.3.5 Statistical Method

The dependent variable in our analysis is a count variable that only takes on non-negative integer values. Most Chinese licensees do not apply for a patent in each year during the observation period. A Poisson regression approach provides a natural baseline model for such data. However, Poisson regressions assume that the mean and variance of the event count are equal. This assumption is likely to be violated since overdispersion usually occurs in patent count data. Therefore, we use a negative binomial model which is the standard choice for basic count data. Similar to prior work, the negative binomial regression model we employ as the variance of the dependent variables is nearly eight times larger than the respective means (See Table 121.1). A Hausman test is used to test whether we should choose a random-effect or a fixed-effect model in the regressions for our panel data. The Hausman tests were not statistically significant, indicating that random-effect estimators are consistent for estimating the regressions. The negative binomial panel data models with random-effect estimators were estimated in STATA.

Table 121.1 Descriptive statistics and correlations among variables

Variable	Mean	Std. Dev.	Min	Max	Innovative performance	Existing technological strength
Innovative performance	145.28	1117.20	0	18420	—	
Existing technological strength	23.47	168.07	0	2158	0.66	—
Market competition	4.40	12.25	0	47	−0.02	−0.01
Province patent stock	4.30	0.40	2.63	4.85	0.11	0.06
Firm size	0.72	0.44	0	1	0.07	0.08
Sourcing orientation	0.15	0.36	0	1	0.01	0.01
Firm age	10.54	11.10	1	83	0.06	0.08
Integrative capacity	2.34	19.87	0	105	0.13	0.16
Variable	**Market competition**	**Province patent stock**	**Firm size**	**Sourcing orientation**	**Firm age**	
Innovative performance						
Existing technological strength						
Market competition	—					
Province patent stock	0.30	—				
Firm size	0.01	0.02				
Sourcing orientation	0.72	0.26	0.11	—		
Firm age	−0.04	−0.08	0.21	0.02	—	
Integrative capacity	0.05	−0.03	0.24	0.10	0.19	

a. Number of observations = 698; Number of firms = 186;
b. Dummy variables are excluded.

121.4 Results

Table 121.1 represents the descriptive statistics and correlations among all variables except for the dummies. The companies in our sample are 10.5 years old on average. Furthermore, we notice that the independent variables are in general not highly correlated with each other nor with the control variables. The only high correlation is between *sourcing orientation* and *market competition* (i.e. 0.72). However, robustness tests indicate that the modeled effects are not influenced by this high correlation. Table 121.2 and Table 121.3 presents the results using a negative binominal regression approach with random effects.

To lower the impact of the dimensionality of variables we standardized all the key independent variables ($z = (x\text{minus mean})/S.D$). The control variables and the variables reflecting the hypothesized effects are entered into the regression sequentially where Model (1) presents the estimated effects of the controls on innovative performance. In Models (2) to (6) we enter the explanatory variables one by one. Model

Table 121.2 Negative binomial random-effects models-I

Variables	(1)	(2)	(3)	(4)	(5)	(6)
Market competition	0.0107*** (0.00282)	0.00882*** (0.00281)	0.0109*** (0.00281)	0.00986*** (0.00283)	0.0104*** (0.00276)	0.00459 (0.00422)
Province patent stock	0.0340 (0.196)	0.246 (0.200)	−0.00774 (0.195)	−0.00688 (0.193)	−0.0719 (0.195)	0.0416 (0.195)
Firm sector	0.278 (0.279)	0.338 (0.277)	0.273 (0.278)	0.235 (0.275)	0.245 (0.274)	0.237 (0.282)
Firm age		0.0537*** (0.00954)				
Existing technology strength			0.000817*** (0.000169)			
Integrative capacity				0.184*** (0.0387)		
Firm size					0.720*** (0.192)	
Sourcing orientation						0.266** (0.135)
Firm age*IC						
Existing technology strength *IC						
Firm size*IC						
Sourcing orientation*IC						
Constant	0.138 (0.834)	−1.297 (0.866)	0.310 (0.827)	0.109 (0.818)	0.0461 (0.822)	0.123 (0.825)
Log-likelihood	−2136.54	−2118.47	−2130.81	−2125.41	−2129.89	−2134.82
LR-test		36.14***	11.46***	22.26***	13.30***	3.44
Reference model for LR-test		1	1	1	1	1

Notes:
- Standard errors in brackets;
- * significant at 10%; ** significant at 5%; *** significant at 1%;
- Number of observations = 698; Number of firms = 186;
- To check the robustness of the above results, several sensitivity analyses were carried out. These analyses indicate that the results are unaffected by correlations among the explanatory variables.

(7) is the full model including all the main effects of the independent variables - not including the interaction terms with integrative capacity.

In Hypothesis 1 we propose that Chinese firms with stronger integrative capacity are better positioned to learn from technology in-licensing and are therefore more likely to exhibit greater innovative performance. Model (4) indicates that prior experience with technology licensing agreements increases the innovative performance of Chinese licensees. The empirical results thus support Hypothesis 1. We introduce Models (2), (3), (5) and (6) to measure the direct effects of the other variables that we discussed in Hypotheses 2-4. The coefficient for age is positive and statistically

Table 121.3 Negative binomial random-effects models-II

Variables	(7)	(8)	(9)	(10)	(11)	(12)
Market competition	0.00591 (0.00400)	0.00876*** (0.00281)	0.00993*** (0.00284)	0.00949*** (0.00276)	0.00279 (0.00425)	0.00482 (0.00401)
Province patent stock	0.0474 (0.196)	0.175 (0.198)	−0.0420 (0.192)	−0.0404 (0.193)	0.00232 (0.193)	0.102 (0.199)
Firm sector	0.198 (0.275)	0.254 (0.277)	0.233 (0.275)	0.608* (0.343)	0.155 (0.286)	0.547 (0.339)
Firm age	0.0405*** (0.00978)	0.0472*** (0.0102)				0.0432*** (0.0114)
Existing technology strength	0.000614*** (0.000156)		0.00126* (0.000679)			0.00100 (0.000679)
Integrative capacity	0.142*** (0.0371)	0.114** (0.0539)	0.182*** (0.0389)	0.435*** (0.126)	0.180*** (0.0393)	0.371*** (0.125)
Firm size	0.523***			0.661*** (0.189)		0.547*** (0.194)
Sourcing orientation	0.095** (0.123)				0.865*** (0.325)	0.769** (0.303)
Firm age*IC		0.00179 (0.00245)				0.00176 (0.00259)
Existing technology strength *IC			−0.000170 (0.000216)			−0.000133 (0.000216)
Firm size*IC				−0.290** (0.132)		−0.298** (0.119)
Sourcing orientation*IC					−0.348** (0.177)	−0.377** (0.168)
Constant	−0.800 (0.834)	−1.024 (0.856)	0.255 (0.812)	−0.584 (0.857)	0.149 (0.813)	−1.335 (0.881)
Log-likelihood	−2102.41	−2112.48	−2117.81	−2117.38	−2121.60	−2096.06
LR-test	68.26***	11.98***	26.00***	25.02***	26.44***	12.70**
Reference model for LR-test	1	2	3	5	6	7

Notes:
- Standard errors in brackets;
- * significant at 10%; ** significant at 5%; *** significant at 1%;
- Number of observations = 698; Number of firms = 186;
- To check the robustness of the above results, several sensitivity analyses were carried out. These analyses indicate that the results are unaffected by correlations among the explanatory variables.

significant in Model (2), supporting Hypothesis 1. In line with Hypothesis 2, we expect that the impact of integrative capabilities on innovative performance is stronger for older firms. We also proposed in Hypothesis 3 that the impact of integrative capacity on a licensee's innovative performance is enlarged when the licensee has a well-developed absorptive capacity. The interaction term in Model (9) indicates that existing technological strength does not influence the impact of integrative capacity on the licensee's innovation performance, supporting Hypothesis 4. Finally, Model (11) empirically supports Hypothesis 5.

121.5 Conclusions

This study focused on learning-by licensing as a relatively unexplored area in the RBV literature. We consider learning-by-licensing as a specific learning mechanism that is one of the mechanisms by which firms build their technological capabilities and is therefore also an important source of heterogeneity among technology lagging companies in developing countries. The empirical analysis in this study shows that different dimensions of firm heterogeneity can be jointly used to explain innovation performance by firms. More specifically, we examine how different sources of firm heterogeneity determine the innovation performance of Chinese firms that build their own technological base by relying on in-licensed technology. We took firm age, existing technological strengths, integrative capacity, size, and sourcing orientation as the main antecedents for their innovative performance. The integrative capacity of the licensees in our sample is a learning mechanism that has not been studied before as a major determinant of innovation performance by technologically lagging companies in rapidly developing economies. Therefore, we narrowed the focus in this study to the integrative capacity of licensees and how other sources of firm-level heterogeneity affect the impact of integrative capacity on innovation performances.

What are the managerial implications of our findings? Firstly, there is no uniform method for improving a firm's technological performance. In particular, learning from in-licensing technology is affected by multiple features of firm heterogeneity. Each firm has to develop its own growth trajectory depending on its size, age, technological capabilities, integrative capability, etc. Secondly, more attention should be paid to the learning processes related to technology imported through licensing agreements. Last but not the least, companies in developing countries can use external technology sources from domestic or foreign suppliers. Foreign sourcing orientation leads to higher innovation performances for the recipient firms - but the effect diminishes integrative capacity and can be negative for companies that rely for long periods on foreign knowledge.

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Chapter 122
The Correlation Evaluation and Composite Industry Chain Research Between Jiangsu Marine and Land Industry

Qian Hui, Guojun Zhu and Hua Fan

Abstract Based on the data of marine economy in Jiangsu province from 2001 to 2010, analysis the correlation and grey relational between marine industry and land industry in Jiangsu province, construct the sea-land compound industry chain On the basis of the marine industry. This paper clarifies the status of Jiangsu sea-land compound industry chain, clear the Jiangsu dominant in sea-land compound industry chain: Marine fishery, marine salt, marine ship, marine transportation and marine biological medicine industry. The study will provide theoretical basis and empirical support for the Jiangsu coastal economic development and marine industry planning.

Keywords Gray correlation degree · The linkage between marine and land industrial · Composite system

122.1 Question

Relying on the difference of economic development region of space, economic system can be differentiated in "Marine economic system" and "Land economic system". Jiangsu is a large marine province, of which linking development between marine and land industry is the sticking point for leapfrog development of coastal areas. It become a topic that has theory and practical significance to improve quality of marine and land economic system and realize the linking development between marine and land industry.

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Xu [1] has analyzed the development potential of coastal resource, from this study he pointed out the basic correspondence of coastal and land industry in general, giving question about linkage development between both them. Zhang and Xu [2] put forward the principle for economic development integrating of coast and land, pointing out that the linkage between marine and land industry is one of those for strategy that build powerful coastal economy country. Luan [3] found that development of marine industry is beneficial for total optimization and adjustment of industrial structure of our country. Dai [4] pointed out that there is complement for each other between marine and land economy. Wang [5] classified systemically the coastal industry from different degrees, relying on the basic correspondence between marine and land industry. Zhou [6] made in-depth study on the interactive development of marine and land industry, using system theory, growth pole theory and Core and Periphery Theory in integrated manner. Xu [15] gave the explanation to the existence of the intrinsic relationship between marine and land industry, and measured the relationship between three marine industry and three land industry in Zhejiang province with gray relation analysis. Dong et al [7] analyzed the linkage development mechanism between coastal economic belt in the Northeast China and marine and land industry in the hinterland from natural resources, economic development, social needs and ecological environment and so on, using gray relation analysis to measure the gray correlation relationship between land economy and coastal economy, and between land economy and main marine industry. Yu [16] studied the correlation degree level of economic development and marine industry with making an empirical analysis on the data from various industries of marine industry through the introduction of correlation analysis.

Cheng [8] pointed out that building economic development model which accelerates the integration of land and coast, establishing association mechanism for marine industry and land industry are needed for balanced development of coastal area in Jiangsu province. Wu et al [9] utilized quantitative methods analyzed empirically influence coast economy had on regional economy in Jiangsu from static and dynamic aspects using the data historical of both them ranging from 1996 to 2005, based on the basis of Jiangsu marine economic development system itself. Wu et al [10] made quantitative analysis on correlation of main marine industry and coastal regional economy in Jaingsu province by the method of gray correlation analysis, based on research on present situation of marine industry structure and its evolution, reckoned that marine one, tertiary industry of Jiangsu province are highly relevant to coastal economic development, with which marine second industry has weak relevance, in additional, ocean transportation industry is still in primary stage.

For linkage development of marine and land industry, scholars have reached a consensus on its existence. Study on linkage development of marine and land industry has also turned gradually from qualitative analysis to quantitative research. But the existing research isn’t deep enough on specific process and internal structure of connection between marine and land industry.

This paper holds that Jiangsu Marine industry and land industry form a composite system in essence. Fan [11] explained the concept and connotation of coordination and coordinating degree of composite system. Using method of prey correlation further, this paper applies the conception of composite system to research area of linkage development of marine and land industry, with which to deepen the research of linkage development of marine and land industry in Jiangsu province. The correlation coefficient and industrial linkage of marine and land industry are studied relying mainly on the Jiangsu coastal economic data from 2001 to 2010, of which on the basis to construct sea - land composite industry chain whose core is marine industry, thus to provide the theoretical basis and empirical support to Jiangsu coastal economic development planning and industries planning related to marine industry.

122.2 Present Situation of Jiangsu Marine and Land Industry Development and Correlation Analysis

This paper mainly adopts the national classification standard that divides industries into three types. Industry related to marine economy is divided into the primary industry, the second industry and the third industry. Marine primary industry includes marine fisheries. Marine second industry mainly includes marine chemical, marine biological pharmaceutical, marine salt industry, and marine shipbuilding industry. Marine third industry mainly includes marine transportation and the coastal tourism. Due to lack of pure data of increased value of land industry, according to the classification of secondary industry, this programmer considers national second industry is corresponding to marine second industry, meaning that national primary industry includes marine industry, thus the rest can be done in the same manner that marine second industry and marine third industry are included in national second and third industries. In this study increased value of land three industries is the difference between increased value of all industries in Jiangsu and the same one of marine three industries in the value of GDP in local year. The gross output value of Jiangsu marine and land industry from 2000 to 2009 is shown in Table 122.1, and the gross output value of main Jiangsu marine industry from 2000 to 2009 is shown in Table 122.2. Marine industrial structure upgrading in Jiangsu province has is speeding up its pace. The ratio between marine primary industry, second industry and third industry has modulated from 78.3:10.3:11.3 in 2000 to 6.2:51.6:42.1 in 2009. Emerging marine industry highly technological such as marine biological medicine science have taken off, which accelerates strongly industrial structure upgrading.

Correlation analysis is a statistical analysis method to discuss correlation degree between variables. Use statistics software SPSS 18.0 to compute the correlation coefficient of Marine industry and land industry in Jiangsu province. They have been shown in the Table 122.3.

The correlation between marine primary industry and land three industries is not significant, and marine second industry is correlated significantly to land three industries at the level of 0.01, so is marine third industry, but speak relatively, that marine second industry is correlated more significantly to land industry.

Specific to the subdivided industry, the correlation between marine fishery industry and land industry isn't significant, thus marine chemistry industry is correlated

Table 122.1 Jiangsu output value of marine and land industry 2000 2009 (unite:billion yuan)

Year	Output value of marine industry	Marine primary industry	Marine second industry	Marine third industry	Land primary industry	Land second industry	Land third industry
2000	146.04	114.35	15.04	16.5	933.99	4420.85	3052.96
2001	171.98	125.2	38.18	8.6	969.28	4869.28	3446.3
2002	221.54	147.77	55.39	18.39	962.67	5549.1	3873.53
2003	453.61	231.79	191.51	30.39	930.66	6595.6	4462.92
2004	565.22	227.78	237.96	98.91	1139.8	8200.03	5099.12
2005	739.58	253.68	338.73	147.18	1207.83	10186.23	6465.04
2006	1287	65.64	546.98	674.39	1479.41	11735.91	7239.72
2007	1853.5	84.8	860.02	910.07	1731.51	13611.24	8820.84
2008	2114.5	85.8	968.7	1060	2014.31	16024.64	10828.53
2009	2717.4	168.48	1402.18	1144.03	2093.38	17164.19	12485.04

Remark:the data comes from ≪ China Marine Statistical Yearbook ≫ and information of Bureau of Jiangsu Marine Fishery.

Table 122.2 Jiangsu output value of main marine industry 2000 2009 (unite:billion yuan)

Year	Marine fishery	Marine chemistry	Marine biological medicine	Marine salt industry	Shipbuilding	Traffic transposition	Marine tourism
2000	114.37	14.69	4.1	5.39	9.71	11.28	5.29
2001	125.15	15.06	4.3	5.7	13.11	2.95	5.71
2002	147.7	15.31	10.77	6.2	23.14	11.33	7.09
2003	193.45	12.93	12.85	8.04	74.82	16.63	8.75
2004	194.6	21.41	14.67	6.65	98.24	12.04	72.48
2005	216.89	20.17	15.4	5.58	157.18	19.92	105.56
2006	208.23	24.42	16.56	5.41	276.36	26.94	126.21
2007	211.2	29.19	17.71	5.12	451.13	33.1	138.17
2008	202.17	30.29	16.27	4.14	296.12	36.38	138.25
2009	170.06	31.88	15.58	1.94	236.13	38.31	138.97

Remark: the data comes from ≪ China Marine Statistical Yearbook ≫ and information of Bureau of Jiangsu Marine Fishery.

Table 122.3 correlation coefficient of Marine industry and land industry in Jiangsu province

	I	II	III	IV	V	VI	VII	VIII	IX	X
Land primary industry	.409	.949**	.939**	.163	.819**	.432	.765*	.543	.792**	.652*
Land second industry	.340	.976**	.807**	.453	.944**	.675*	.811*	.762*	.944**	.858**
Land third industry	.361	.965**	.787**	.501	.946**	.712*	.489	.763*	.944**	.878**

I: Marine primary industry; II: Marine second industry; III: Marine third industry; IV: Marine fishery; V: Marine chemistry; VI: Marine biological medicine; VII: Marine salt industry; VIII: Shipbuilding; IX: Marine transposition; X: Marine tourism; ***. At the 0.1 level significantly correlated (double side). *. At the 0.05 level significantly correlated (double side).

significantly to land industry at the level of 0.01, and the correlation coefficient is big. Marine biological medicine isn't correlated significantly to land primary industry, but is correlated significantly to land second and third industry at the level of 0.05. Marine shipbuilding industry isn't correlated significantly to land primary industry, but is correlated significantly to land second and third industry at the level of 0.05. Marine transposition industry is correlated significantly to land industry at the level of 0.01, and the correlation coefficient is big. Marine tourism industry is correlated significantly to land primary industry at the level of 0.05, while is correlated significantly to land second and third industry at the level of 0.01.

All is told, there is already a significant correlation between Jiangsu marine and land industry, especially between marine second industry, marine third industry, marine chemistry industry, marine transposition and land industry.

122.3 The Evaluation of Correlation Degree between Marine and Land Industry and Composite Industry Chain Analysis

122.3.1 Research Methods

The article uses the method of gray correlation degree to analyze the correlation between marine industry and three land industries, with marine industry as center, to build marine and land composite industry chain relying on correlation degree. The method of gray correlation degree chosen is feasible. This method is a dynamic process that calculate, compare, research and forecast economic system by the relative changes of the time series between factors [12–14]. With the conception of gray correlation degree, we can describe the strength, size and sequence of the relationship between marine and land industry.

Set the primitive data column $X_0 = \{X_0(k),\ k = 1,2,\cdots,n\}$ as main behavioral factor.

Set comparative data column $X_i = \{X_i(k),\ k = 1,2,\cdots,n;\ i = 1,2,\cdots,n\}$ related behavioral factor. Give no dimensional normalization process to primitive data column and solve its absolute difference. This is: $\triangle i_k = X_0(k) - X_i(k)$ $(k = 1,2,\cdots,n;\ i = 1,2,\cdots,n)$. Choose $\rho = 0.5$ as distinguishing index, and correlation index is

$$\tau_i(k) = \frac{\left\{ \min_i \min_k |X_0(k) - X_i(k)| + \rho \max_i \max_k |X_0(k) - X_i(k)| \right\}}{|X_0(k) - X_i(k) + \rho \max_i \max_k |X_0(k) - X_i(k)|}, \quad (122.1)$$

$\tau_i(k)$ is the relative difference between comparative data column in this formula X_i, and primitive data column X_0at the moment "k". This form of relative difference is called X_i's relative index to X_0, at the moment "k". The formula to calculate it is below:

$$\eta_i = \frac{1}{n}\sum_{i=1}^{n} \tau_i(k), \tag{122.2}$$

generally considered, the bigger η_i, the larger influence factors have on the reference factors.

122.3.2 The Evaluation of Correlation between Marine and Land Industry in Jiangsu Province

During process of linkage development of Jiangsu marine and land industry, they keeps independent for each other, but as well as interact each other, and correlation degree itself is actually a measure for this kind of interaction. According to Equations (122.1) and (122.2), we can calculate correlation between three marine industries, each of their inner specific industries and three land industries (Table 122.4).

Table 122.4 Correlation degree between Jiangsu marine and land industry 2000-2009

	Land primary industry	Land second industry	Land third industry
Marine primary industry	0.7596	0.8408	0.7609
Marine second industry	0.4647	0.4402	0.4601
Marine third industry	0.4092	0.5012	0.4886
Marine fishery	0.6747	0.5868	0.5524
Marine chemistry	0.5655	0.5295	0.5345
Marine biological medicine	0.5928	0.6493	0.5734
Marine salt industry	0.7793	0.6308	0.6532
Shipbuilding	0.5157	0.6369	0.5178
Traffic transposition	0.6181	0.6417	0.6908
Marine tourism	0.5487	0.4812	0.5102

122.3.3 Jiangsu Marine-land Composite Industry Chain

According to the situation of correlation degree between marine and land industry, with marine industry as center, sequencing relying on correlation degree, combining with qualitative and quantitative methods, we can analyze the internal logic constitute of Jiangsu marine-land composition industry chain.

122.3.4 Composite Industry Chain with Marine Primary Industry as Center

The sequence of correlation between marine primary industry and land industry are: land second industry > land third industry > land primary industry. Composite industry chain is built gradually among three land industries with marine primary industry as center. Among them, machinery and equipment manufacturing industry, building industry of land second industry provide mechanism and engineering buildings for marine primary industry, while Jiangsu marine primary industry provides land second industry with raw materials such as food processing industry, chemical industry, medicine industry and textile industry, and so on.

Due to Jiangsu coastal unique geological formations of the coastal beach, as long with feature near the estuary of the Yangtze River, Jiangsu fishery industry and aquaculture industry in the marine industry is one of the leading marine industries in the long term. The correlation degree between marine fishery industry and land second industry is largest, up to 0.6747, than is land second industry, of which correlation degree is 0.5868. The same one between marine fishery industry and land third industry is 0.5524. Jiangsu marine fishery industry chain is long relatively, and is correlated largely with land industry. In addition, its radiation leading effect is strong, drove forward driven feed processing, fish processing, marine food, marine health products production, pulled backward shipbuilding, marine engineering, nautical instruments, fishing gear and aquaculture equipment, warehousing, marine development.

122.3.5 Composite Industry Chain With Marine Second Industry as Center

The sequence of correlation degrees between marine second industry and land industry is: land primary industry > land third industry > land second industry. Jiangsu marine second industry is the most related to land primary industry during real production process. What of land third industry related to marine second industry strongly are transportation, information consulting industry and so on. What of land second industry related to marine second industry strongly are metallurgical industry, power industry, chemical industry, etc.

- Marine chemical industries is most strongly related to land primary industry, of which correlation degree is 0.5655. The marine chemical is capable of pulling the chemical equipment, chemical raw materials industry development. The study found that the marine chemical industry and secondary industry has lower correlation degree with the land second industry instead, so Jiangsu coastal area marine chemical industry has not been fully integrated into the marine and land composite industry chain.

- Marine bio-pharmaceutical industry. Jiangsu marine bio-pharmaceutical industry is emerging marine industries with high technological content. Jiangsu marine bio-pharmaceutical research and production have reached a certain scale. The sequence of Jiangsu marine bio-pharmaceutical industry and land industry related degrees is land second industry > land primary industry > land third industry. The correlation degree of Jiangsu marine bio-pharmaceutical industry and land industry is lower, which reached 0.6493.
- Marine salt. Land three industries in Jiangsu Province is related to marine salt industry closely. Jiangsu marine salt industry is most highly related to land primary industry, whose correlation degree is 0.7793. Then is land third industry, whose degree is 0.6532, and correlation degree between marine salt industry and land second industry has also reached 0.6308. However, the output value of marine salt is declining yearly, dropped to 1.94 billion from $5.39 billion in 2000, marine saltworks gradually shrinking. Gradually declining output value of marine salt industry has inherent contradiction with the high correlation degree between marine salt industry and land industry. The results of this study show that the importance of marine salt industry in Jiangsu marine and land composite industry chain should be re-understood.
- marine shipbuilding industry. Jiangsu shipbuilding industry in recent years has been in the rapid development and became the largest industry in Jiangsu marine economy. Jiangsu shipbuilding industry is most highly related to land second industry, whose correlation degree is 0.6369. Jiangsu ship industry development led extendedly to the development of terrestrial iron and steel manufacturing, electronics, equipment manufacturing and chemical, light industry. The industry will drive forward extendedly water transportation, energy, transport, aquatic and marine resource development as well.

122.3.6 The Composite Industry Chain with Marine Third Industry as Center

The sequence of correlation degrees between marine third industry and land industry is:land second industry > land third industry > land primary industry, whose correlation degree are 0.5012, 0.4886, 0.4092. The marine industry has become an important factor to promote the economic development of the land, its association with land secondary industry is the most significant. marine transportation. Marine transportation industry is an important component of the marine land industry, the Port Group building focus on the coastal port of Lianyungang works gradually, and their level of development reflects Jiangsu economic outreach and the openness. In Jiangsu Province, between marine transportation and land each industry there is a very close relationship, which associated at the highest degree with land third industry, which is 0.6908. Then is land second industry, whose degree is 0.6417, and land primary industry whose correlation degree is lowest has also reached 0.6181. It can drive the development of electronic information technology, equipment manufacturing and other industries with forward extension, and will drive the development of warehousing, logistics and other industries with backward extension. seaside tourism. Tourism is one involving food, lodging, transportation, travel, shopping, entertainment, the six elements of the economic activities, this is the main reason for the higher its degree associated with land industry that industry is driven strongly. Jiangsu marine tourism industry is most highly related to land primary industry, whose correlation degree is 0.5487. Marine tourism is as a land of land industry to extend part of the ocean, the land land industry has more closely associate degrees reached 0.5102. It drove strongly, transportation dining, entertainment industry.

122.4 Conclusions and Policy Recommendations

(1) Main conclusion

Firstly, we have sorted out initially the constitution conditions of Jiangsu marine-land composite industry chain. By regression analysis, we have found that Jiangsu marine industry and land industry has a strong correlation, of which between marine chemical industry, marine transportation and land industry is more significant. Land second industry, land third industry and primary industry have formed composite industry chain gradually with marine primary industry as center. Land primary industry, land third and second industry have formed composite industry chain gradually with marine second industry as center. Land second industry, land third industry and primary industry have formed composite industry chain gradually with marine third industry as center.

Secondly, the leading industry of Jiangsu marine-land composite industry chain came clear. Marine fisheries, marine salt industry, marine vessels and marine transportation industry in traditional industries have strong industrial correlation at present, which can be seen as leading industry of Jiangsu marine industry. Marine bio-pharmaceutical industry as emerging industries in Jiangsu province is correlated strongly to land second industry, whose radiation is also strong, so can be identified as leading industry in Jiangsu marine industry.

(2) Political proposals

Firstly, market-oriented, with the gathering area or park as carriers, to integrate the Jiangsu marine-land composite industrial chain. Different government departments of Jiangsu province at all levels need to speed up the flow of energy flow, material flow, the flow of people and information flow between the elements in the marine and land industry, actively develop logistics parks, harbor industrial zone, and gradually expand and form a harbor center city to drive regional development in northern Jiangsu from riverside development to development pattern both along the river and coast.

Secondly, make sure the extension and upgrade of traditional marine industrial chain. Do a good job of deep processing and comprehensive utilization of marine aquatic products, to extend the industrial chain, increase product added value; with advanced technical support, to actively improve coast salt production along coastal economic belt, especially deep processing capacity to meet the demand for land economic market. Around the ship equipment, to actively digest national and foreign advanced technology, to focus on the development of ocean seagoing vessel and specialty shipbuilding and repair demolition, strengthen supporting industries and industry cooperation, and vigorously cultivate ship supporting industrial clusters, do effects to improve the port function, strengthen the construction of coastal ports of Lianyungang, Nantong Ocean Port and Lucian, Dafeng Port in Yancheng. For another problem for marine chemical industry, with the integration of resources as a means to vigorously develop petroleum chemical, salt chemical and agricultural chemical, marine chemical industry to fully integrate into the marine and land composite industry chain.

Thirdly, we must strengthen cooperation, and actively develop marine industries. Although marine industry takes up a small proportion of the output value of marine, but for the development of marine industry itself, which has a long industrial value chain and correlated strongly, to cultivate a strategic marine industry, which occupy the commanding heights of the marine industry in the future, while the development of the emerging marine industry will drive the upgrading of traditional marine industry. Development of marine high-tech industry should focus on the development of marine bio-pharmaceutical industry, to strengthen the linkage development of Jiangsu coast, gathering three regional R&D strength, and promote the transformation of scientific and technological achievements.

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Chapter 123
Efficient Subset Selection in Large-Scale Portfolio with Singular Covariance Matrix

Chunfu Jiang

Abstract In the classic mean-variance model, the covariance matrix is supposed to be positive definite or nonsingular. However, the degenerate portfolio can arise from multi-collinearity and correlation of assets returns in large-scale portfolio. In this paper, we investigate the issue of which assets can be removed from the original portfolio. We propose a new concept of efficient subset of portfolio for mean-variance optimizing investor. Applying the generalized inverse matrix, we derive some conditions for determining the efficient subset. In addition, a new three fund separation result is also obtained as an economic interpretation, which in fact gives an extension of the mean-variance spanning.

Keywords Large-scale portfolio · Efficient subset · Singular covariance matrix · Mean-variance spanning

123.1 Introduction

The mean-variance model for the portfolio selection problem pioneered by Markowitz is the most used and well-known tool for economic allocation of capital. In the previous literatures, there exists a common and important assumption of non-singular covariance matrix [5, 12, 16]. However, the degenerate portfolio issue can result from the potential multicollinearity and correlation with asset classes increasing and derivative markets booming. In fact, the degenerate portfolio with singular covariance matrix can also arise in the large-scale portfolio (see, for example, Eun [4], Fan [6], Markowitz [15]. Therefore, the portfolio selection with singular covariance matrix is a more general situation. Nevertheless, there is surprisingly little literature on such a situation since conventional treatment methods are no longer applicable.

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Buser [1] is the first to study the portfolio selection with singular matrix, and shows that the mutual fund separation theorem still holds through constructing technically two new funds. Ryan and Lefoll [21] point out that there is something wrong in the demonstration of Buser [1]. VöRöS [24] considers the problem of portfolio selection with special structure of covariance matrix. Korki and Turtle [13] develop the limiting investment opportunity set due to small risk assets in mean-standard deviation space when covariance matrix is singular or non-singular. In addition, using simple tensor algebra, Los [14] studies the multi-currency investment strategies with singular strategy risk matrix. Recently, we obtain the analytic solutions of optimal portfolio and portfolio frontier under mean-variance model with singular covariance matrix, and we extend the results of the previous literatures [10].

For the degenerate portfolio selection, Szegö [23] conjectures that there is either arbitrage portfolio or efficient subset of portfolio when the rank of covariance matrix is less than $n-1$, where n denotes the number of risky assets. Markowitz [15] also point out that one can not expect the covariance matrix to be positive definite when handling with the problem of large-scale portfolio, because there is likely to occur the efficient subset of portfolio. However, the definition of efficient subset of portfolio is not clearly given in current literatures. In fact the efficient subset discussed by Szegö [23] is only analogous to k fund separation theorem formulated by Ross [20], as well as the analysis of mean-variance spanning such as DeRoon and Nijman [3], Glabadanidis [7], Kan and Zhou [11].

The purpose of the present paper is to present a strict definition of the efficient subset of portfolio, and derive some equivalent conditions for determining the efficient subset by using the generalized inverse matrix. Corresponding to the mutual funds separation theorem, we also give a new three fund separation as an economic interpretation for the efficient subset.

The rest of the paper is organized as follows. Sect. 123.2 presents some definitions and notations on the problems of portfolio selection. Sect. 123.2 shows the equivalent conditions for determining the efficient subset of portfolio and the relation to mean-variance spanning. Sect. 123.4 presents a new three fund separation result. Sect. 123.5 gives some concluding remarks.

123.2 Preliminaries

Consider a portfolio selection problem with n assets (risky or riskless). The random return of the j-th asset is denoted by r_j. The expectation of return r_i and the covariance between r_i and r_j are denoted by $\mu_i = \mathrm{E}(r_i)$ and $\sigma_{ij} = \mathrm{Cov}(r_i, r_j)$, respectively. Let $\boldsymbol{r} = (r_1, r_2, \cdots, r_n)'$ denote the vector of random returns on the n assets. Let $\mu = (\mu_1, \mu_2, \cdots, \mu_n)'$ and $V = (\sigma_{ij})_{n\times n}$ denote the expectation and variance associated with the random return vector $\boldsymbol{r}$, respectively.

Let ω_j be the fraction of wealth invested in asset j. The investment weight vector $\omega = (\omega_1, \omega_2, \cdots, \omega_n)'$ is called a portfolio. The return of a portfolio ω is given by $r_\omega = \omega'\boldsymbol{r}$. The expected return and the risk of a portfolio ω are measured by the expectation and the variance of r_ω respectively, i.e., $\mu_\omega = \mathrm{E}(r_\omega) = \omega'\mu$, $\sigma_\omega^2 = \mathrm{Var}(r_\omega) = \omega' V \omega$.

Without loss of generality, let $S_n = \{1, 2, \cdots, n\}$ be the set of all n assets, and $S_k = \{1, 2, \cdots, k\}$ be the subset of S_n. The set of portfolio based on S_n is given by:

$$W = \left\{ \omega = (\omega_1, \omega_2, \cdots, \omega_n)' \,\middle|\, \mathbf{1}'\omega = 1 \right\}$$

and the set of portfolio based on subset S_k is given by:

$$W^k = \left\{ \omega^k = (\omega_1, \omega_2, \cdots, \omega_k)' \,\middle|\, \mathbf{1}_k'\omega^k = 1 \right\},$$

where $\mathbf{1} = (1, 1, \cdots, 1)'$ is an $n \times 1$ vector of unities and $\mathbf{1}_k$ is a $k \times 1$ submatrix of $\mathbf{1}$.

We assume the rank of covariance matrix V is arbitrary. If V is singular, in particular, then the portfolio ω satisfying $\omega' V = 0$ is called a risk-free portfolio. The set of risk-free portfolio on S_n is denoted by:

$$W_f = \left\{ \omega = (\omega_1, \omega_2, \cdots, \omega_n)' \,\middle|\, \mathbf{1}'\omega = 1,\ V\omega = 0 \right\}.$$

Since the covariance matrix V is nonnegative definite or singular, the generalized inverse matrix will be employed as an important tool of analysis. To keep this paper self-contained, we introduce the definition and some properties of generalized inverse matrix in the following.

For a real $m \times n$ matrix A, an $n \times m$ matrix X is called generalized inverse of A if $AXA = A$. The generalized inverse matrix of A is also called g-inverse, and usually denoted as A^-. As a special type of the generalize inverse, the Moore-Penrose inverse A^+ is defined to be the unique solution of the following Penrose equations: $AXA = A$, $XAX = X$, $(AX)' = AX$, $(XA)' = XA$.

A generalized inverse always exists but it is usually not unique. However, the Moore-Penrose inverse is unique, which is adopted as an important tool in statistics and econometrics. We refer the reader to Magnus and Neudecker [17] or Schott [22] for more details.

Now let us mention an immediate fact of generalized inverse which will be used in the sequel. Let c be a real $m \times 1$ vector. Then $c \in M(A)$ implies $AA^-c = c$, where the notation $M(A)$ stands for the vector space generated by the columns of matrix A.

123.3 Efficient Subset of Portfolio

123.3.1 Determination of Efficient Subset of Portfolio

In this section, we investigate the problem of efficient subset, that is, whether there is a subset of assets such that the mean-variance frontier obtained from the subset of assets is identical to the mean-variance frontier on the complete asset set.

Let $S_n = \{1,2,\cdots,n\}$ be the complete asset set, $S_k = \{1,2,\cdots,k\}$ be the benchmark assets set, and $S_n \setminus S_k = \{k+1,k+2,\cdots,n\}$ be the additional assets set, where '\' denotes minus operator of set. We also introduce some notations correspond to the two asset subsets as the following: $\boldsymbol{r}^k = (r_1,r_2,\cdots,r_k)'$, $\boldsymbol{r}^{n-k} = (r_{k+1},r_{k+2},\cdots,r_n)'$, and $\boldsymbol{\mu}^k = \mathrm{E}\left(\boldsymbol{r}^k\right)$, $\boldsymbol{\mu}^{n-k} = \mathrm{E}\left(\boldsymbol{r}^{n-k}\right)$, $V_{11} = \mathrm{Var}\left(\boldsymbol{r}^k\right)$, $V_{21} = \mathrm{Cov}\left(\boldsymbol{r}^k, \boldsymbol{r}^{n-k}\right)$, $V_{22} = \mathrm{Var}\left(\boldsymbol{r}^{n-k}\right)$. Following these notations, we can partition μ and V as:

$$\mu = \begin{bmatrix} \mu^k \\ \mu^{n-k} \end{bmatrix}, \quad V = \begin{bmatrix} V_{11} & V_{12} \\ V_{21} & V_{22} \end{bmatrix}.$$

Definition 123.1. Let W and W^k be the set of portfolio based on S_n and S_k respectively. If for any portfolio $\omega \in W$, there is $\omega^k \in W^k$ such that:

$$E\left(\boldsymbol{r}'\omega\right) \leq E\left((\boldsymbol{r}^k)'\omega^k\right), \quad \mathrm{Var}\left(\mathrm{r}'\omega\right) \geq \mathrm{Var}\left((\mathrm{r}^{\mathrm{k}})'\omega^{\mathrm{k}}\right),$$

then we call S_k the efficient subset of S_n.

Obviously, if S_k is the efficient subset of S_n, then the Definition 123.1 indicates the efficient frontier based on S_k is exactly the same as the efficient frontier based on S_n. Associated with mean-variance spanning, an equivalent definition of efficient subset can be given in the following.

Definition 123.2. For any efficient portfolio ω^k on S_k, if the expanded portfolio $\omega = ((\omega^k)',0)'$ is an efficient portfolio on S_n, then we call S_k an efficient subset of S_n, where 0 is a vector of zeroes with $n-k$ elements.

Remark 123.1. We can easily prove the equivalence of both definitions. Assume that S_k is an efficient subset of S_n and ω^k is any efficient portfolio on S_k. Then the expanded portfolio $\omega = ((\omega^k)',0)'$ is consequently a portfolio based on assets set S_n, that is, $\omega \in W$. According to Definition 123.2, the expanded portfolio ω is an efficient portfolio on S_n. Otherwise, there exists a portfolio $\omega^* \in W$ such that $\mu_\omega < \mu_{\omega^*}$ and $\sigma_\omega > \sigma_{\omega^*}$. On the other hand, for the portfolio ω^*, from Definition 123.1 there is another portfolio $\tilde{\omega}^k \in W^k$ such that $\mu_{\omega^*} \leq \mu_{\omega^k}$ and $\sigma_{\omega^*} \geq \sigma_{\omega^k}$. Note that $\mu_\omega = \mu_{\omega^k}$ and $\sigma_\omega = \sigma_{\omega^k}$. By this, we can easily derive: $\mu_{\omega^k} < \mu_{\tilde{\omega}^k}$, $\sigma_{\omega^k} > \sigma_{\tilde{\omega}^k}$, which immediately leads to a contradiction with the assumption on ω^k. In the same way, we can prove the converse. Hence, if ω^k is an efficient portfolio on S_k, then the condition that S_k is an efficient subset of S_n implies the expanded portfolio $\omega = ((\omega^k)',0)$ is an efficient portfolio on S_n, or equivalently, the efficient frontiers based on S_k and S_n are exactly identical.

Proposition 123.1. *Suppose that there is no risk-free portfolio. Then S_k is an efficient subset of S_n if and only if:*

$$V_{21}V_{11}^{+}\mu^k = \mu^{n-k}, \quad V_{21}V_{11}^{+}\mathbf{1}_k = \mathbf{1}_{n-k}. \tag{123.1}$$

Proof. In the case without risk-free asset or risk-free portfolio, the mean-variance model of Markowitz is fully equivalent to the expected utility maximization, i.e.:

$$\max_{\omega} \omega' \mu - \frac{\alpha}{2} \omega' V \omega, \quad \text{subject to } \ \omega' 1 = 1.$$

where $\alpha > 0$ denotes the risk aversion, and measures an investor attitude to risk [18]. The solution of the optimization problem leads to the so-called efficient portfolio. Using the generalized inverse of partitioned matrix in Theorem 7.11 [22] and the Lagrange multiplier procedure, we can obtain the optimal solution as the following:

$$\begin{aligned} \omega &= \frac{V^{-}\mathbf{1}}{\mathbf{1}'V^{-}\mathbf{1}} + \alpha^{-1}\left(V^{-} - \frac{V^{-}\mathbf{1}\mathbf{1}'V^{-}}{\mathbf{1}'V^{-}\mathbf{1}}\right)\mu \\ &= \theta \frac{V^{-}\mathbf{1}}{\mathbf{1}'V^{-}\mathbf{1}} + (1-\theta)\frac{V^{-}\mu}{\mathbf{1}'V^{-}\mu}, \end{aligned} \tag{123.2}$$

where $\theta = 1 - \alpha^{-1}\mathbf{1}'V^{-}\mu$, and V^{-} is any generalized inverse of V. The optimal portfolio formulated as Equation (123.2) is obviously an extension of the important mutual fund separation theorem in Okhrin and Schmid [18].

Applying the generalized inverse of partition matrix in Theorem 7.11 [22], we have:

$$\begin{aligned} V^{-} &= \begin{bmatrix} I & -V_{11}^{-}V_{12} \\ 0 & I \end{bmatrix} \begin{bmatrix} V_{11}^{-} & 0 \\ 0 & V_{22.1}^{-} \end{bmatrix} \begin{bmatrix} I & 0 \\ -V_{21}V_{11}^{-} & I \end{bmatrix} \\ &= \begin{bmatrix} V_{11}^{-} + V_{11}^{-}V_{12}V_{22.1}^{-}V_{21}V_{11}^{-} & -V_{11}^{-}V_{12}V_{22.1}^{-} \\ -V_{22.1}^{-}V_{21}V_{11}^{-} & V_{22.1}^{-} \end{bmatrix}, \end{aligned} \tag{123.3}$$

where $V_{22.1} = V_{22} - V_{21}V_{11}^{-}V_{12}$.

Therefore, if S_k is an efficient subset of S_n, then for any risk aversion coefficient α, there exists an optimal portfolio: $\omega = \left((\omega^k)', (\omega^{n-k})'\right)$ such that $\omega^{n-k} = 0$, which from Equations (123.2) and (123.3) implies:

$$V_{21}V_{11}^{-}\mathbf{1}_k - \mathbf{1}_{n-k} = 0, \quad V_{21}V_{11}^{-}\mu^k - \mu^{n-k} = 0. \tag{123.4}$$

Note that $1_k \in M(V_{11})$ and $\mu^k \in M(V_{11})$ is induced by the assumption of no arbitrage. Also note that $V \geq 0$ implies $M(V_{12}) \in M(V_{11})$. According to the properties of generalized inverse matrix, then the two formulas as the following: $V_{21}V_{11}^{-}\mathbf{1}_k$, $V_{21}V_{11}^{-}\mu^k$ are independent of choice of the generalized inverse V^{-}. Adopting the Moore-Penrose inverse V^{+} in Equation (123.4), in particular, we can immediately obtain the result of Proposition 123.1. □

Proposition 123.2. *Suppose that there is risk-free portfolio. Then S_k is an efficient subset of S_n if and only if:*

$$V_{21}V_{11}^{+}\eta^k = \eta^{n-k}, \tag{123.5}$$

where $\eta^k = \mu^k - \mu_\pi \mathbf{1}_k$, $\eta^{n-k} = \mu^{n-k} - \mu_\pi \mathbf{1}_{n-k}$.

Proof. Without loss of the generality, we suppose $\pi \in W_f$ is any risk-free portfolio. Then the mean-variance optimization problem can be given similarly by:

$$\max_{\omega} \omega'\eta - \frac{\alpha}{2}\omega' V \omega, \tag{123.6}$$

where $\eta = \mu - \mu_{\pi}\mathbf{1}$ denotes the associated excess return vector of n assets in S_n. In particular, if the risk-free asset with expected return r_f is available in S_n, then we have $\eta = \mu - r_f\mathbf{1}$.

In the same way, using the Lagrange multiplier method, the maximization problem (123.6) leads to the optimal portfolio:

$$\omega = \alpha^{-1}V^{-}\eta. \tag{123.7}$$

The weight of the risk-free portfolio π is given by $1 - \omega'\mathbf{1}$.

In particular, the alleged tangency portfolio is given by:

$$\omega_T = \frac{1}{\mathbf{1}'V^{-}\eta}V^{-}\eta. \tag{123.8}$$

We can demonstrate similarly that S_k is an efficient subset of S_n if and only if Equation (123.5) holds. Proposition 123.2 is thus established. □

123.3.2 Extend Mean-variance Spanning

Suppose an investor choose his portfolio from a set of k benchmark assets denoted by S_k. The issue of mean-variance spanning introduced by Huberman and Kandel [9] is whether one set of additional assets can improve the investment opportunity set of the benchmark assets. In general, if the mean-variance frontier of the benchmark assets coincides with the frontier of the benchmark plus the new asset classes, this is known as mean-variance spanning. The mean-variance spanning has recently received considerable attention in the literature. For instance, DeRoon and Nijman [3] provided a comprehensive survey of the question of mean-variance spanning and how it relates to other fundamental concepts like stochastic discount factors. Cheung et al [2] derived an analytical solution to the question that whether the investor should invest in the extra asset classes since spanning implies equal performance of the benchmark portfolio and the expanded portfolio.

If the benchmark assets can span the efficient frontier of all assets, it follows that the set of benchmark assets is an efficient subset of the set of all assets. Suppose that the covariance matrix $V > 0$, the necessary and sufficient conditions of mean-variance spanning were obtained by Huberman and Kandel [9] as the following:

$$V_{21}V_{11}^{-1}\mu^{k} = \mu^{n-k}, \quad V_{21}V_{11}^{-1}\mathbf{1}_k = \mathbf{1}_{n-k} \tag{123.9}$$

cited in later literatures such as Cheung et al [2], DeRoon and Nijman [3], Glabadanidis [7], Kan and Zhou [11], and so on. However, in more general cases, the covariance matrix can be singular. If we consider the problem of portfolio with the risk-free portfolio, for example, the covariance matrix of all assets is not invertible.

In that case, the conditions of mean-variance spanning have not been addressed in current literatures. Proposition 123.1 and Proposition 123.2 obviously extend the conditions of mean-variance spanning to the cases of singular covariance matrix and risk-free portfolio, respectively.

123.3.3 Portfolio Performance

For a given portfolio $\omega \in W$, the most popular measure of the portfolio performance is the Sharpe ratio [18, 19] defined as:

$$s(\omega) = \frac{\mu_\omega - r_f}{\sigma_\omega} = \frac{\omega' \eta}{\sqrt{\omega' V \omega}},$$

for the risk-free asset case, where $\eta = \mu - r_f \mathbf{1}$ denotes the expected excess returns vector of all assets in S_n. Similar to Gouriéroux and Jouneau [8], we can also use the following Sharpe performance measure $s = \eta' V^- \eta$.

Let η be partitioned as $\eta = ((\eta^k)', (\eta^{n-k})')'$ corresponding to S_k and $S_n \setminus S_k$, and denote $\eta_{2.1} = \eta^{n-k} - V_{21} V_{11}^- \eta^k$. If ω is efficient on S_n, then we can deduce that $s = s^2(\omega)$. Moreover, the above performance measure s can be decomposed as $s = s_1 + s_{2.1}$, where $s_1 = (\eta^k)' V_{11}^- \eta^k$, $s_{2.1} = (\eta_{2.1})' V_{11}^- \eta_{2.1}$.

According to Proposition 123.2, it follows that if S_k is an efficient subset of S_n, then the performance measures of efficient portfolio on the assets subset S_k and assets complete set S_n will be identical, which implies $s_{2.1} = 0$.

123.4 Three Fund Separation

The mutual fund separation theorem is the most important result in mean-variance analysis. The theorem shows that the portfolio frontier can be spanned by two fund portfolios in mean-variance space. In other words, the each frontier portfolio can be expressed as a linear combination of these two fund portfolios.

Assume that all individuals are risk-averse, and they choose their portfolios so as to maximize utility functions dependent only on the mean and variance of their portfolios. For k benchmark assets in S_k, considering the construction of optimal portfolio when the additional assets in $S_n \setminus S_k$ are added into S_k, we have the following proposition.

Proposition 123.3. *Suppose that there is no risk-free portfolio. Then there are two mutual funds constructed by the original assets in S_k only and one new mutual fund constructed by all assets in S_n such that the new mean-variance frontier can be spanned by three mutual funds. That is, the optimal portfolio weights in all assets can be expressed by a linear combination of three mutual fund portfolios, i.e.,*

$$\omega = \lambda A_k \begin{bmatrix} \omega_g^k \\ 0 \end{bmatrix} + \gamma B_k \begin{bmatrix} \omega_d^k \\ 0 \end{bmatrix} + \begin{bmatrix} -V_{11}^- V_{12} \\ I \end{bmatrix} \left(\lambda V_{22.1}^- \mathbf{1}_{2.1} + \gamma V_{22.1}^- \mu_{2.1}\right), \tag{123.10}$$

where $\lambda = \dfrac{1 - \mathbf{1}' V^- \mu/\alpha}{\mathbf{1}' V^- \mathbf{1}}$, $\gamma = 1/\alpha$, *α is the risk aversion.*

Proof. To express conveniently, we rewrite Equation (123.2) as:

$$\omega = \lambda V^- \mathbf{1} + \gamma V^- \mu, \tag{123.11}$$

where $\lambda = \theta/A$, $\gamma = (1-\theta)/B$, $A = \mathbf{1}'V^-\mathbf{1}$, $B = \mathbf{1}'V^-\mu$.

By simple computation from Equations (123.3) and (123.11), we have:

$$\begin{aligned} \omega = {} & \lambda \begin{bmatrix} V_{11}^- \mathbf{1}_k - V_{11}^- V_{12} V_{22.1}^- \mathbf{1}_{2.1} \\ V_{22.1}^- \mathbf{1}_{2.1} \end{bmatrix} + \gamma \begin{bmatrix} V_{11}^- \mu^k - V_{11}^- V_{12} V_{22.1}^- \mu_{2.1} \\ V_{22.1}^- \mu_{2.1} \end{bmatrix} \\ = {} & \lambda \begin{bmatrix} V_{11}^- \mathbf{1}_k \\ 0 \end{bmatrix} + \gamma \begin{bmatrix} V_{11}^- \mu^k \\ 0 \end{bmatrix} + \begin{bmatrix} -V_{11}^- V_{12} \\ I \end{bmatrix} \\ & \left(\lambda V_{22.1}^- \mathbf{1}_{2.1} + \gamma V_{22.1}^- \mu_{2.1}\right), \end{aligned} \tag{123.12}$$

as desired. In addition, it is easy to verify that: $\lambda A_k + \gamma B_k + \lambda A_{2.1} + \gamma B_{2.1} = 1$. The proof of Proposition 123.3 is thus completed. □

Suppose that the risk-free portfolio (or the individual risk-free asset) is available. Let ω^* be the optima weights of all assets. From Equation (123.7), we then have:

$$\omega^* = \omega + (1 - \mathbf{1}'\omega)\pi = \lambda \omega_T + (1-\lambda)\pi, \tag{123.13}$$

where $\lambda = \alpha^{-1}\mathbf{1}'V^-\eta$, and π is the risk-free portfolio given by:

$$\pi = \frac{P^\perp \mathbf{1}}{\mathbf{1}'P^\perp \mathbf{1}} + \left(P^\perp - \frac{P^\perp \mathbf{1}\mathbf{1}'P^\perp}{\mathbf{1}'P^\perp \mathbf{1}}\right)\xi, \tag{123.14}$$

according to Jiang and Dai [10]. Here $P^\perp = I - VV^+$ and ξ is an arbitrary column vector with dimension n.

For the tangency portfolio ω_T, using the generalized inverse of partition covariance matrix as Equation (123.3), we can rewrite ω_T as:

$$\omega = \lambda H_k \begin{bmatrix} \omega_T^k \\ 0 \end{bmatrix} + \lambda \begin{bmatrix} -V_{11}^- V_{12} \\ I \end{bmatrix} V_{22.1}^- \eta_{2.1}, \tag{123.15}$$

where

$$\lambda = \frac{1}{B - A\mu_\pi}, \quad H_k = B_k - A_k \mu_\pi, \quad A = \mathbf{1}'V - \mathbf{1},$$

$$B = \mathbf{1}'V - \mu, \quad \mu_\pi = \frac{\mu' P + \mathbf{1}}{\mathbf{1}'P + \mathbf{1}}, \quad \eta_{2.1} = \mu_{2.1} - \mu_\pi \mathbf{1}_{2.1}.$$

Here μ_π is the expected return of the risk-free portfolio π. Moreover, we can easily verify the following equality:

$$\lambda H_k + \lambda \times \mathbf{1}_{2.1}' V_{22.1}^{-} \eta_{2.1} = \frac{\mathbf{1}_k' V_{11}^{-} \eta^k + \mathbf{1}_{2.1}' V_{22.1}^{-} \eta_{2.1}}{\mathbf{1}' V^{-} \eta} = 1,$$

which implies from Equations (123.14) and (123.15) that the optimal portfolio is a linear combination of three mutual fund portfolios in the presence of risk-free portfolio. Particularly, if the additional assets are not correlated with any of the benchmark assets, that is $V_{12} = 0$, then Equation (123.15) can be simplified as:

$$\omega = \lambda H_k \begin{bmatrix} \omega_T^k \\ 0 \end{bmatrix} + (1 - \lambda H_k) \begin{bmatrix} 0 \\ \omega_T^{n-k} \end{bmatrix}. \tag{123.16}$$

Finally, let us consider a special case where an additional risk-free asset is included. Without loss of generality we can assume that the $n+1$-th asset is the risk-free asset. Then the associated expected returns vector and the covariance matrix can be written respectively as:

$$\mu_f = \begin{bmatrix} \mu \\ r_f \end{bmatrix}, \quad V_f = \begin{bmatrix} V & 0 \\ 0 & 0 \end{bmatrix}.$$

Let π_f be the risk-free portfolio for the case $n+1$. Since the vector ξ can be arbitrary, taking $\xi = \mathbf{1}_{n+1}$ in particular, we have:

$$\pi_f = \frac{1}{1 + \mathbf{1}' P^{\perp} \mathbf{1}} \begin{bmatrix} P^{\perp} \mathbf{1} \\ 1 \end{bmatrix}, \tag{123.17}$$

with the expected return derived by:

$$\mu_{\pi_f} = \frac{r_f + \mu' P^{\perp} \mathbf{1}}{1 + \mathbf{1}' P^{\perp} \mathbf{1}} = r_f,$$

where the second equality is due to the fact that $\eta \in M(V)$ under the assumption of no arbitrage.

If the original n risky assets in S_n are further assumed to be linear independent, i.e., V is positive definitive and consequently $P^{\perp} = 0$, then we obtain directly $\pi_f = [0, 1]'$ by applying Equation (123.17), which shows that the individual risk-free asset is exactly the unique risk-free portfolio in that situation.

The results of three fund separation show that additional assets can cause a portfolio re-balancing for an investor who holds an original efficient portfolio. From Proposition 123.2 above, we also easily know that one can not simply re-allocate between the two original funds and the new assets. In fact, the third fund composed with all assets in S_n is critical to derive the new optimal portfolio and to span the new frontier.

123.5 Concluding Remarks

The motivation of the present paper comes from a conjecture proposed by Szegö [23] that the efficient subset of portfolio may appear if the rank of covariance matrix is less than $n-1$. Applying the generalized inverse matrix, we derive the sufficient and necessary conditions for determining the efficient subset and its some properties as well, which presents a theoretical demonstration of that conjecture. At the same time, our results extend the conditions of mean-variance spanning to the case where the covariance matrix is assumed to be singular. We also propose a new concept of risk-free portfolio and its explicit solution is formulated. It is worth remarking that the individual risk-free asset can not be necessary for the mean-variance analysis or other situations where the risk-free asset is entailed when the risk-free portfolio is available.

In the present paper, a new three fund separation result is correspondingly obtained, and from which we can conclude that the difference between the original efficient frontier and the new frontier lies on the covariance of the additional assets with the benchmark assets. According to three fund separability, the new frontier in fact cannot usually be spanned by the new assets alone and the two original funds constructed by the old assets, unless the new assets are not correlated with any of the old assets.

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Chapter 124
The Study on Strategic Alliances Risk Control: An Analytical Framework

Yan Guo, Qiang Zhang and Bin Guo

Abstract Strategic alliances as a way to get to reduce costs, access to resources, and improve the overall competitiveness, getting on an important place in the various forms of organizations. However, despite the good prospects for the development, but the success rate is not quite high. This is because the alliance itself there is a risk, and a variety of risk management will affect the success or failure of the alliance. First, this article on the basis of foreign scholars study, drawing on transaction cost economics [30, 38] three control models in organization theory (Market control, Bureaucratic control, Clan control). Second, analyzed the strategic alliance faced major risks and risk control methods, integrated the three control models with two control strategies (performance evaluation strategy and trust strategy) to build an integrated risk management framework, in order to reduce the alliance risk, increasing alliance value targets and identify alliance risks and the appropriate control strategies and access control method.

Keywords Strategic alliances · Risk control · Control strategic · Management framework

124.1 Introduction

Since the 1980s, especially in recent years, competitive business environment continues to change significantly, with a high degree of competition and globalization, market characteristics, under this environment, companies compete separately deficiencies. Company recognized the advantages of cooperation with other companies,

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get more and more recognition. For many large companies that want to have a competitive advantage as well as a start-up company, strategic alliance is a good choice.

Das and Teng [9, 13] suggest that the strategic alliance is internal cooperation agreement in order to obtain strategic objectives and goals. For a company in the Alliance, the situation is different from the face alone the surrounding environment, which is very susceptible to relational risks from its partners in addition to the normal commercial risk. Das and Rahman [14] argued the opportunism behavior of the partners in an Alliance have bad influence, often lead to the end of the Alliance unplanned.

According to Anne and Gerard [2]: reasons for the failure of the strategic alliance is mainly two aspects, one is the partner selection problem, accounting for about 30% of the reason for the failure, and the other is a partnership, 70% of the accounting for the reasons for failure.

Risk reduction is one of the main objectives of the Alliance control, with larger differences between different control models take into account the impact on alliance performance, choice of different types of risk control model will be different. The paper first describes the possibility of risk factors and then introduced the three control models and application characteristics of two control strategies (strategic performance evaluation strategy and trust strategy) and the corresponding risk category, and finally put forward a comprehensive alliance risks control framework.

124.2 Risk Factors

In the organization, especially in the Alliance risk has caused widespread concern. March and Shapira [25] proposes that it's difficult to define risk objectively and comprehensively. Coleman [5] suggests that risk depends on the performance of other actors. Das and Teng [7] define risk as negative output changes. Alter and Hage [1] argue that a very important motivation of forming an Alliance is risk sharing. Brouthers [4] argue that high risk perception transfer risks to other companies. Strategic alliance is one way to reduce the risk. Ring and Van de Ven [35] suggest that Managers face two types of uncertainty in the company's internal process of cooperation: (a) Uncertainty about the future of the state of nature; (b) whether partners are able to rely on trust to solve the moral hazard and adverse selection.

There are two risks in the process of the formation of a strategic alliance: Relational risk and Performance risk. Relational risk refers to uncertainty of the level of cooperation between the partners, the probability of an outcome that does not have a satisfactory cooperation, the unique risk of Alliance, including inter-organizational relations issues those will prevent the alliance goals realize. Such as opportunism behaviors (to conceal and distort information to escape or unable to fulfill the commitments or obligations steal cooperation technology and poach key figures, etc.). Performance risk refers to fail to achieve alliance goals in the case of full cooperation [7, 12, 24]. This type of risk exists in all commercial operations. When the uncertainty of the environment enhance, for instance the adverse industry management policy, increased market volatility and Lack of capacity of partners, which will make managers generate higher performance risk prospective.

On the transaction cost economics theory Williamson [38, 39] suggest that risk may be subject to the following five factors: Opportunism, Bounded rationality, Uncertainty, Asset specificity and Transaction frequency. Five factors and the relationship between risk and performance risk relationship, as shown in Fig. 124.1.

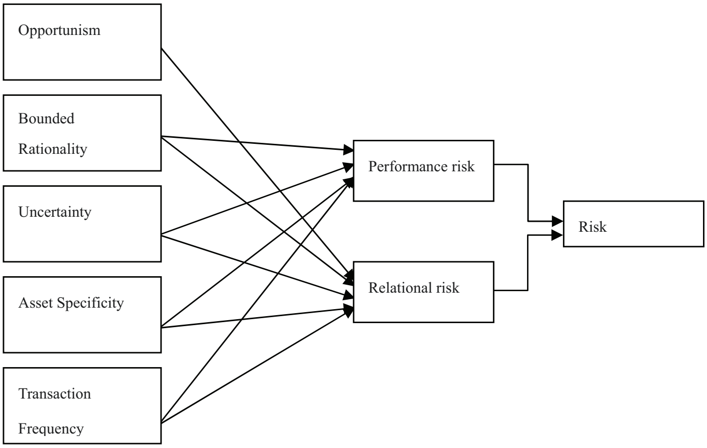

Fig. 124.1 The relationship between the risk factors and the risk types

124.2.1 Opportunism of the Alliance Partners

Opportunism is considered as chasing for self-interest, the opportunism cause expensive prior negotiation costs and ex post monitoring costs. Hennart [22], Parkhe [32] suggest that Opportunism behavior is an individual rationality that generates all non-optimal results, which will reduce the overall performance in an alliance. Opportunism behaviors have negative impact on an alliance including withholding, distorting or failing to fulfill promises or obligations, appropriation of the partner firm's technology or key personnel, late payments and so on.

In the Alliance, Partner opportunism is a major factor causing the relational risk. Das and Teng [7] argue that relational risk generated for cooperation, and opportunism behaviors occurs mainly on the relationship between the partners. Hagedoom [21] suggests that a motive to enter an Alliance is access to partner's knowledge and technology. Performance risk exists between the company and the environment, so opportunism behavior influence the latter is weak. Shared interests, same goals, partners significant investments to each other and rely on the performance of each of the parties will reduce opportunism behaviors.

124.2.2 Bounded Rationality

Managers may attempt a rational way to form an Alliance, but will be limited to behavioral and environmental uncertainty. Generally, they cannot identify all behavior of alternatives and only an incomplete understanding of the present and future environment variable will make their selection imperfect [28, 37]. This kind of limitations will inevitably lead to some restrictions for understanding the future uncertainty, which generate risks.

The formation of the alliance need to choose partners, if they can identify effectively alliance risks that may exist before the formation of an Alliance, will greatly improve Alliance probability of success. However, limited cognitive ability and bounded rationality makes all possible prediction about relational risk and performance risk becomes difficult. A specific performance of bounded rationality is information asymmetry. On the one hand to promote partners using any of asymmetric information, the other hand, information asymmetry cannot make partners match with each other perfectly, effective behavior becomes difficult.

124.2.3 Uncertainty

Earliest distinguish uncertainty and risk on economics perspective is Knight, who argue that respect to uncertainty risk is objectively calculate the probability, uncertainty cannot be objective distinguished. For Alliance on one side existing external risk (technical and market risks), on the other side, such risk-sharing in the alliance risks are lower than the face of competition alone (mainly performance risk), On the other hand, caused in inter-company cooperation motives inconsistent problems. Ouchi [31] suggest that usually only partially overlapping targets in cooperation, at this time the main impact is the relational risk. for an alliance, there is unavoidable the problem of opportunism behavior from partners, which will increase the uncertainty of the performance. These uncertainties could cause relational risk and performance risk. Langfield [24] proposes that two kinds of uncertainty: behavior uncertainty and environmental uncertainty, the former comes from difficult to predict the behavior and intentions of the alliance partners, the latter arising outside the control of Alliance but may affect the implementation of the cooperation agreement and the results. Two uncertain manners that imply a valid contract to govern the Alliance and predict all possible situations is impossible, and collaborators self-interest may take advantage of any identified loopholes in the contract.

124.2.4 Asset Specificity

Asset Specificity refers to some assets in addition to the purpose of the application in which it was agreed upon, the lack of applications for other purposes [38]. Chi

[6] proposes although market transactions is the default way of assets or services, some of them are not fully tradable. They may be tied to other assets or embedded into the organization, which cannot simply be access to through the market. When a company needs these assets, the company will take high specificity assets by way of mergers and acquisitions, authorization and forming alliances. Das and Teng [11] suggest that a company's important purpose is access to resources of other companies when take a strategic alliance. Due to lack of alternative resources, bring the company with key assets monopoly power. Such as additional services more than stipulated in the contract requiring. When this specific assets between the alliance partners, the status gap is very obvious, may also lead to relational risk and performance risk.

124.2.5 Transaction Frequency

Transaction frequency refers to the extent recurring of the transaction. Williamson [38] suggest that trading frequency provide an incentive for the governance of a company using hierarchical, because the level of governance to spend it easier to recover by multiple transactions. Das and Teng [7] argue that more Alliance experiences between partners, partners will have a lower perception of risk. This shows that if partners have a long history of cooperation, the relational risk is considered relatively low risk. High frequency of trading can lead to high transaction costs which may encourage partnerships adopt forms of governance, rather than through the use of contracts to manage Alliance [19]. Partners familiar with each other, have a better understand of conditions may exist. In contrast, Alliance between the partners never worked or transactions with each other, and do not have good history of cooperation the relational risk will be higher.

124.3 Control Modes and Strategies

There are three options for organizational governance structure of the transaction cost economics: Market Form, Hierarchical Form and Hybrid Form. Three trading characteristics (Asset Specificity, Uncertainty, Transaction frequency) determine the appropriate governance model. Transaction costs economics assumes that managers adopt appropriate governance arrangements to minimize transaction costs. Transaction costs, including the search costs to find partners and ready to perform the monitoring of a contract or agreement, including mandatory application of punishment, specialized investment losses, when relationship ends specialized investment losses. Ouchi [30, 31] on the basis transaction cost economics divided organizational governance mechanisms into Markets Control, Bureaucracy Control and Clan Control. Market control mainly depends on market prices as the main decision information, to valuate performance subsidiary personnel using industry suppliers, customers and other market data or performance data, the method to achieve purpose of control through the market mechanism, is called market control. Profit center, cost center and investment center is common control method. Bureaucracy control can be referred to as rule, authority or behavior control. Through establish strict complete written regulations and procedures to regulate the behavior of employees.Business plan, a written budget system, reporting requirements, operating standards, performance assessment system, etc. Rule is an important constituent element of the control method, management rules set by organization with the terms of the contract, to control the operation of various departments. Bureaucratic control must have a clear definition of task, authority relations, bureaucracy, obey the rules organization members. Clan control is focused on development of the members of common value, beliefs, as well as goal of cooperation in proper organizational behavior recognition and a high degree of commitment to behavior of partners. Das and Teng [9, 12] divide organizational control into Formal control and Social Control. Formal control includes behavior control and output control. Behavior control measuring behavior, ensure process is appropriate, output control measurements rely on accurate and reliable partner performance assessment. Social control corresponds to Clan control. When organization does not have specific task-related behavior and output, focused on the development of members of common values, beliefs, and goals, so that proper behavior is to strengthen and reward, which have played an active role in other aspects organization partners.

124.3.1 Control Strategies

Eisenhardt [15] proposes Performance evaluation strategy, the strategy is to promote the desired behavior by assessing the completion of objectives, another common strategy is Trust strategy, contains goodwill trust and competence trust, facilitate generate the desired behavior [27]. Fig. 124.2 is a diagram shows the relationship between control strategy and risk.

Performance evaluation strategy refers to monitor and control the process and reward performance results in order to guide the desired behavior. The strategy involves the decomposition of goal-setting and performance measurement, testing and providing feedback and can be applied only when the performance is measurable. Performance can be measured on the basis of the results of the individual behavior. Performance evaluation strategy can be applied through two control methods, behavior control, and output control, which together called formal control. Task programmability refers to managers understand appropriate behavior will occur in the transfer process. Output measurable refers to the ability to measure the precise and target output.

Behavior control is to ensure that the process of cooperation is appropriate. The alliance partners have a relatively clear understanding required to perform a specific task behavior and ultimately based on these behaviors to determine in advance the standard behavior control can be effectively exercised. Such as rules and standard

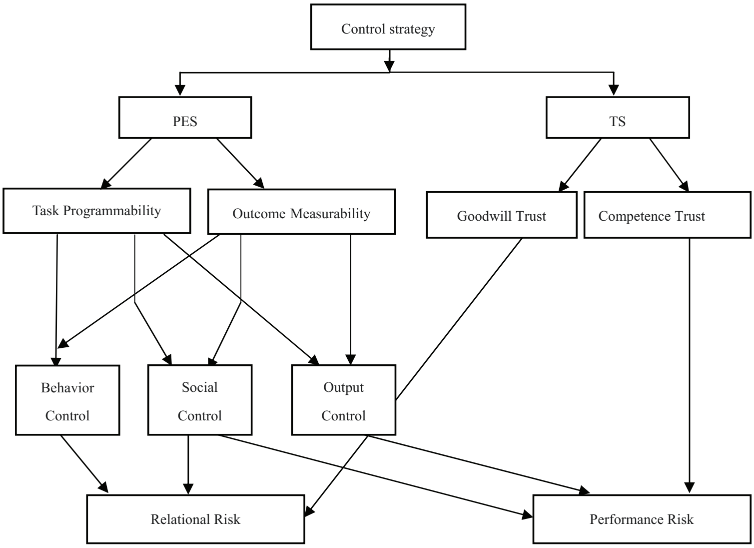

Fig. 124.2 Control strategies, control modes and risk relationship diagram

operating procedure, individual determined behavior and testing. Behavior control can reduce opportunism behavior, so to reduce risk of alliances. For example by providing punitive measures, rules, and procedures to reduce opportunism behavior, at the same time behavior control can get determined output, which may have an effect.

Output control is the control mode relies on members' accurate performance evaluation. When only limited knowledge transfer and may accurate result measuring, the mode will be adopted. Output control including the development of objectives, plans, budgets and control report. Output control as a basis performance measure, can reduce performance risk. When "Task programmability" and "Outcome Measurability" are as the major factors, Performance evaluation strategy is effective [30]. When managers believe that performance risk is high, they will through behavior control to detect opportunism behavior, and to monitor the performance of the alliance through output control. Even if the performance risk is low, the output the control will be used as monitoring the overall performance of the Alliance. When there is a high environmental uncertainty, asset specificity, output control may be poor for reducing partners' opportunism behavior and detect invalid degree of co-operative behavior.

Social control usually refers to a development of common values beliefs as well as members of the target in order to appropriate behavior can be strengthened and be rewarded. Social control by introducing a confidence-building process can reduce relational risk and improve performance risk. What affect social control activities including frequent interaction, meeting, disputes negotiations, the Code of Conduct, senior manager style. When uncertainty is high (Low Task programmability and Low Outcome Measurability), social control can reduce possibility opportunism behavior by encouraging the development of sharing value, to reduce the relational risk. Social control can also encourage partners to accept common goal to reduce performance risk, the formation of common goal is nature of overall performance.

Trust Strategy: Nooteboom et al [27] by adding trust between partners extends the transaction cost economy, and as the source of Alliance control. Sako [36] and Van de Ven [34] argue that Trust and Alliance are highly relevant, and risk management is an important aspect of Alliance. Competence trust is technically competent performance role expectations [3] is based on the partners the ability to execute trades, such as technical and management.

Das and Teng [12] suggest that competence trust is based on partners' resources such as capital, human capital, physical property, market forces and technology. Competence trust is high is based on partners' resources such as capital, human capital, physical property, market forces and technology, which can reduce performance risk. Goodwill trust is "expect other party has a moral obligation and responsibility to demonstrate a special concern for interests of others something greater than themselves in social relations" when partners expect mutual commitment, Goodwill trust is exist, that trust is based on "in good faith" and "honest". Through the establishment of trust between individuals and teams and jointly deal the problems, can generate Goodwill trust [12]. The closer alliance partners working relationship, the more likely cultivate Goodwill trust. With increased trade between members, get each other's more information, opportunism behavior will be less. Solve problem together will make members a better understanding of different perspectives, methods, perspectives, which will form a goodwill trust.

Goodwill trust and Competence trust can ensure deal with risk, because they promote the common goal behavior. Das and Teng [12] propose that In an Alliance Goodwill trust can reduce perception of relational risk rather than performance risk. Nooteboom [26] suggest that Goodwill trust can reduce the possibility of opportunism behavior. When partners honest, rather than the performance of opportunism behavior, they feel guarantee. Das and Teng [12] suggest that when one party's competence have a higher successful completion the matter, can also reduce performance risk. Competence trust give a company one kind of trust other partners in alliance can complete given task and then the performance of risk perception will be relatively low.

124.4 Comprehensive Risk Management and Control Framework

Bounded rationality, uncertainty, asset specificity, frequency of transactions will have some effect on the risk of strategic alliances in the relational risk and performance risk. After Identify risk expected category of strategic alliance, according specific ways of cooperation in above statement in control model selection, according specific ways of cooperation, the control model that suitable for application can be selected from above framework. For example when the cooperation has high task programmability, behavior control in Performance Evaluation Strategy can be applied to reduce the relational risk. While the cooperation has high Outcome Measurability, Output Control plays a better role in the performance risk. When the task programmability is low and outcomes are not easy to measure, social control can effectively reduce the effect of alliance risk.

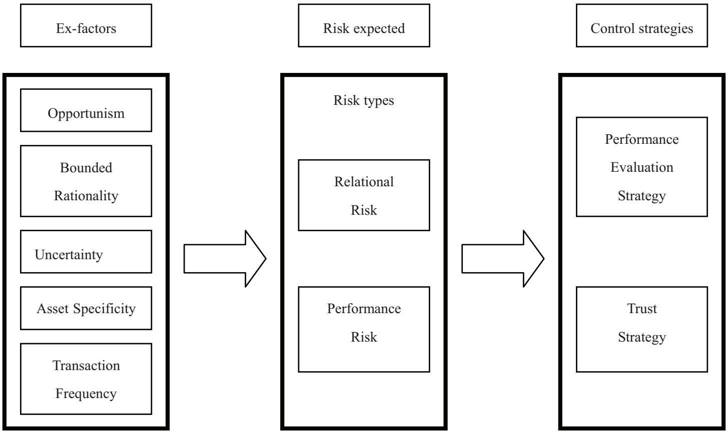

Fig. 124.3 The strategic alliance comprehensive risk management control framework

124.5 Summary

This article combine Williamson's transaction cost theory and Ouchi's extended control model, analyze the risk ex-factors of strategic alliance and the relationship between the factors and their corresponding risk. On the basis of the risk control model, introduce two risks control strategy: performance evaluation strategy as well as trust strategy, then build a comprehensive risk management and control framework of the strategic alliance, which can help alliance analyze the special risk category. In strategic alliances, help managers to reduce risk, achieve their goals.

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Chapter 125
An Improved SA-based BP-ANN Technique for Annual Runoff Forecasting under Uncertain Environment

Qiurui Liu

Abstract In this paper, the author presents an integrated approach combining the simulated annealing method and the feed forward neural network to forecast the annual runoff in power system under uncertain environment. The type of neural network used in this method is a multi-layer pre-trained by the SA. Finally, we use the SA-based ANN to see if we actually could reduce the error of annual runoff forecasting. The proposed Simulated Algorithm-based Error Back Propagation Artificial Neural Net (SA-based BP-ANN) annual forecasting scheme was tested using data obtained from a case study including 24 h time periods. The result demonstrated the accuracy of the proposed annual runoff forecasting.

Keywords Forecasting · Fuzzy · BP-ANN · SA

125.1 Introduction

Annual runoff forecasting plays an important role in power systems. Accurate annual runoff forecasting has a significant influence on the operational efficiency of a power system, such as unit commitment, annual hydro-thermal maintenance scheduling hydro-thermal coordination, demand side management, interchange evaluation, security assessment and others. Improvements in the accuracy of annual runoff forecasts can result in significant financial savings for utilities and co-generators.

Various forecasting techniques have been proposed in the last few decades. Those models include: time series, multiple linear regression, auto regressive moving average (ARMA) and expert system (ES). The time series model uses the historical load data for extrapolation of future loads. It is a non-weather sensitive approach. It

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must assume that the runoff is a stationary time series and has normal distribution characteristics. In fact, the accuracy of the model is decreased because it neglects the uncertain factors that influence the runoff, such as precipitation and human utilization. In order to make it more complicated by using the historical data, we take the complex nature environment and the multiple sources of uncertainty in consideration in this paper.

In literature, fuzzy sets theory [3, 4] provides an alternative approach for dealing with the uncertainty and provide a very efficient framework to reduce scheduling computational complexity with respect to the same problem formulated in a probabilistic way. Instead of probability distributions, these quantities make use of membership functions, based on possibility theory. Fuzzy sets concepts enrich traditional Operational Research in various applications. In particular, fuzzy sets theory has been exploited in the forecasting applications to model the uncertainty.

It is rather efficient for the artificial neural net (ANN) to perform the desired computations and can make significant improvement in the the efficiency of the method by utilize the operating experiences and offline analysis of historical records [6]. The artificial neural net has powerful function mapping, each given net can express quite complex function relationship, which cannot be expressed by mathematics formula, especially the non-linear relationship. Many interesting applications of neural nets in the power field have been reported, such as load forecasting [7], load dispatch [22, 23], power system stabilizer design [8], capacitor control [9], unit commitment [6], torsional oscillation analysis [10], and security assessment [11, 12]. While the disadvantage of ANN is the computing time, large scale of the samples and the searching process may be entrapped in the local extreme point. What's more, it's difficult to determine the number of the hidden layer and the pitch point. These disadvantages limit the application of the ANN in the the scheduling of the hydropower station. To deal with this difficulties, we try to adopt the Simulate Anneal (SA) algorithm to help to improve the computing ability of the ANN in our scheduling problem. SA is a well-established stochastic neighborhood search technique. The efficiency of SA in solving combinatorial optimization problems is very well known [18, 19]. And for the combination of the ANN and SA, there have been some research. Debasis and Jayant had introduced a ANNSA technique for solving nonlinear optimal control problems [16]. Nayaka and Sharma presented an approach combining the feedforward neural network and the simulated annealing method to solve unit commitment problem [17] by considering the load demand.

In this paper, firstly, fuzzy random method is used to deal with the uncertain data. Secondly, the SA is implied to determine the parameters of ANN. Then, a improved SA-based BP-ANN is proposed to forecast the annual runoff. The main contribution of our paper is the following two points: (1) considering the imprecision in the forecasting problem and deal with it by fuzzy theory; (2) proposed an improved SA-based BP-ANN to solve the problem and compared the efficiency.

125.2 Dealing with Uncertainty for Annual Runoff Forecasting

The nature uncertainties of the stream flow is mostly caused by the climate, the season, the human factor which is the regional authority allocates water rights to the sub-areas and so on. According to [13], the runoff is judged using three different scenarios: low level, medium level, high level with probabilities p_1, p_2 and p_3 respectively. However, for each flow level, it is very difficult for the decision makers of the hydropower station to get specific stream flow data, so they are vaguely defined [13] as:

$$\tilde{\bar{F}} = \begin{cases} (a_1, b_1, c_1) \text{ with probability } p_1, \\ (a_2, b_2, c_2) \text{ with probability } p_2, \\ (a_3, b_3, c_3) \text{ with probability } p_3. \end{cases} \quad (125.1)$$

125.2.1 Transforming Fuzzy Random Variables into Fuzzy Numbers

Firstly, the definition for the fuzzy expected value of the fuzzy random variables from Kruse and Meyer [15] is used to transfer the fuzzy random variable to a fuzzy interval.

Suppose that the description of stream flow can be viewed as a fuzzy random variable χ taking on the values:

$$\tilde{F}_1 = (a_1, b_1, c_1),\ \tilde{F}_2 = (a_2, b_2, c_2),\ \tilde{F}_3 = (a_3, b_3, c_3), \quad (125.2)$$

where $\tilde{F}_1$, $\tilde{F}_2$, $\tilde{F}_3$ denote the three stream flow level, so the probability distribution:

$$\begin{aligned} &P(\{\omega \in \Omega | \chi(\omega) = \tilde{F}_1\}) = p_1,\ \ P(\{\omega \in \Omega | \chi(\omega) = \tilde{F}_2\}) = p_2, \\ &P(\{\omega \in \Omega | \chi(\omega) = \tilde{F}_3\}) = p_3, \end{aligned} \quad (125.3)$$

where Ω represents the three levels and involve fuzzy logic.

Then, suppose that $\theta(\chi)$ is the induced fuzzy parameter of χ, if $\theta(\chi) = E^f[X|P]$, $\forall \alpha \in [0,1]$,

$$\begin{aligned} \inf(\theta(\chi))_\alpha &= E^f(\inf \chi_\alpha | P) = p_1 \inf(\tilde{F}_1)_\alpha + p_2 \inf(\tilde{F}_2)_\alpha + p_3 \inf(\tilde{F}_3)_\alpha, \\ \sup(\theta(\chi))_\alpha &= E^f(\sup \chi_\alpha | P) = p_1 \sup(\tilde{F}_1)_\alpha + p_2 \sup(\tilde{F}_2)_\alpha + p_3 \sup(\tilde{F}_3)_\alpha. \end{aligned}$$

Thus, the fuzzy expected value of the fuzzy random variable $\tilde{\bar{F}}$ is:

$$E^f[\tilde{\bar{F}}] = (a_e, b_e, c_e),$$

where $a_e = \inf(\theta(\chi))_0$, $b_e = \inf(\theta(\chi))_1 = \sup(\theta(\chi))_0$, $c_e = \sup(\theta(\chi))_0$.

125.2.2 Expected Value Operator for the Fuzzy Numbers

Secondly, an expected value operator can be used to convert the fuzzy number $E^f[\tilde{\tilde{F}}]$ into a deterministic one based on [13] and [14].

Let $\tilde{N} = (A,B,C,D)$ denote a fuzzy number, functions $f_{\tilde{N}}(X)$ and $g_{\tilde{N}}(X)$, the left and the right side of $\tilde{N}$, respectively, where $f_{\tilde{N}}(X)$ is an increasing function and $g_{\tilde{N}}(X)$ is a decreasing function. The expected value of the fuzzy number $\tilde{N}$ is then defined as:

$$E(\tilde{N}) = \frac{1}{2}\left[\left(B + \int_A^B f_N(x)\mathrm{d}x\right) + \left(C + \int_C^D g_N(x)\mathrm{d}x\right)\right].$$

Thus, the expected value of the fuzzy number $E^f[\tilde{\tilde{F}}]$ [13].

125.3 The Hybrid ANN-SA Algorithm for HULDP

For forecasting problem, the BP-ANN is widely adopted extensively in many application for its outstanding advantages in the computing. BP-ANN came into sight in the middle of 80's by Rumelhart et al [5]. But it has shortage itself [21], the uncertainty in training process. Different from the custom method which used multi-layer net and more nerve cell and increase training time and complexity of net at the same time, we adopted SA to help to select the parameters and improve the studying velocity of BP-ANN. The improved SA-based BP-ANN method for the annual runoff forecasting are described as follows.

125.3.1 SA-based BP-ANN Algorithm for Forecasting

The design of an artificial neural network involves three lawyers: input layer, implicit layer and output layer. The nodes in the input layer receive input signals from the outside world and directly pass the signals to the nodes in the next layer. There are J input samples for the hydro scheduling program, i.e. input sample $F = (f_1, f_2, \cdots, f_j, \cdots, f_J)$ contain N years runoff. In implicit layer, the output vector is $U = (u_1, u_2, \cdots, u_k, \cdots, u_K)$ (K is the number of neuron in the implicit layer). In output layer, the output vector is $O = (o_1, o_2, \cdots, o_m, \cdots, o_M)$ (M is the number of neuron in the output layer); the expected output vector is d.

Producing neural net configuration by getting initial weight data and threshold value of different neural net structure.

For each neuron j in the hidden layer and output layer, the neuron output is given by:

$$o_j = \frac{1}{1 + \exp[-(net_j + \theta_j)]}, \tag{125.4}$$

where θ_j is a bias and net_j is the input signal to neuron j $(j = 1, 2, \cdots, J)$, expressed as:

$$\text{net}_j = \sum_k w_{jk} o_k. \tag{125.5}$$

The summation is performed over all nodes k in the preceding layer that are connected with neuron j. w_{jk} is the connection weight from neuron k to neuron j and o_k is the output of neuron j. The connection weights w_{jk} are first initialized to random values.

The fitness function of SA to train the network, which measures the performance of each parameters is defined as [20]:

$$\text{fitness} = -\sqrt{\frac{\sum_{j=1}^{J}\sum_{m=1}^{M}(d_m - o_{jm})^2}{J \times M}}, \tag{125.6}$$

where d_m is the expected output, o_{jm} is the predicted output of the network, M is the number of output nodes, and J is the number of training set samples. The larger the fitness, the better is the set of weights and thresholds. Thus a SA-based BP-ANN is developed, of which the goal is to obtain a set of weights and thresholds that maximizes the fitness function.

The connection weights from any input unit j to a hidden unit k is v_{jk}. Weight between the k^{th} neuron of the implicit layer and the m^{th} neuron of the output layer is vector w_{km}.

The type of S function has been used as in implicit layer to avoid the phenomenon of super saturation. A commonly used approach is the generalized delta rule [5], as described below:

$$E = \sum_{m=1}^{M}(d_m - o_m)^2. \tag{125.7}$$

After the error function E is computed, the connection weights can be updated using the gradient descent method. By the way of adjusting weight value constantly, error E will be changed in order to attain the scheduled accuracy. Adjusting weight value formula of BP algorithm is as follow:

$$\begin{cases} \Delta w_{km} = \alpha\delta_m^o u_j = \eta\alpha(d_m - o_m)o_m(l - o_m)u_k, \\ \Delta v_{jk} = \alpha\delta_k^u f_j = \alpha\left(\sum_{m=1}^{M}\delta_m^o w_{jk}\right)u_k(1 - u_k)f_j, \end{cases} \tag{125.8}$$

α are the learning rate (step size) and momentum constant, respectively,

The process of error back propagation is to calculating output layer e_m as follow:

$$e_j = \sum_{m=1}^{M}\delta_{mj}w_{mj}. \tag{125.9}$$

125.4 Application

In allusion to the performance of the proposed runoff forecasting scheme, the trained artificial neural network were tested with data obtained from a sample study performed on the Jialing River, to predict the annual runoff. Jialing River is a mountainous and seasonal river with the average annual runoff of 26.553 billion m^3. The Jialing River will be an annual regulate river when every stage is developed. This ensures the accuracy of the data and promises the practical operation of hydropower stations. Located in the middle stream of Jialing River, northeast of the Nanchong city. Xiaolongmen Hydraulic Power Plant is the 11th stage of the Jialing River. Here, we take the annual runoff forecasting of the Xiaolongmen Hydraulic Power Plant as an example.

A total of 50 historical annual runoff records of the Xiaolongmen Hydraulic Power Plant were collected [2]. The testing data was from 1960 to 2009. As the Table 125.1 shows, the predicted annual runoff, measured value and the forecasting error were listed.

From this result, we could obtain that the annual runoff forecasting error rate of the proposed SA-based BP-ANN is in a range of −32.19% to 15.98%. And the minimal error rate of the SA-based BP-ANN is 0.16%. Table 125.1 also shows the error rate of the time series method. The error rate of the time series method is in a range of −49.856% to 59.298% with the minimal error rate of 0.165%. Therefore, there is a significant increase in the accuracy of the SA-based BP-ANN forecasting results compared with the time series.

125.5 Conclusion

From the above statement, it can be concluded that this paper has presented a developed SA-based BP-ANN technical method for the annual runoff forecasting under uncertain environment. The fuzzy random approach rejects the use of determine value nor the probability distributions for the historical data but relies on membership functions. The application of fuzzy variables makes the proposed multiple objective model more suitable for describing vague situations in the real world. What's more, the main advantage of the proposed SA-based BP-ANN method is that it provides an efficient and systematic workable method for the forecasting process. Finally, the Xiaolongmen Hydraulic Power Plant on the Jialing River is used as a practical example to demonstrate the practicality and efficiency of the proposed method. The results and a sensitivity analysis are presented to highlight the performance of the SA-based BP-ANN method, which is very effective and efficient as compared to time series algorithms. The area for future research has many aspects: for example, investigate other uncertainties and more efficient heuristic methods to handle the forecasting problem more reasonably and effectively. Each of these areas is very important and equally worthy of attention. A detailed analysis and further research are necessary to reveal more properties for solving these problems.

Table 125.1 The results of the annual runoff of the Xiaolongmen hydraulic power plant from 1950 to 1999

Year	Measured (billion m^3)	Predicted (billion m^3)	Error (billion m^3)	Error rate (%)	Time series error rate (%)
1950	21.777	18.2419	−3.5351	−16.23	−17.236
1951	26.877	27.8955	1.0185	3.79	3.939
1952	35.98	38.9996	3.0196	8.39	38.596
1953	25.153	23.3436	−1.8094	−7.19	−6.711
1954	28.806	30.8306	2.0246	7.03	7.56
1955	28.961	30.9381	1.9771	6.83	7.327
1956	33.368	38.5544	5.1864	15.54	22.76
1957	20.674	16.5478	−4.1262	−19.96	−25.634
1958	34.095	39.1024	5.0074	14.69	25.869
1959	21.922	17.0557	−4.8663	−22.20	−21.111
1960	20.988	15.7743	−5.2137	−24.84	−22.843
1961	42.342	48.1037	5.7617	13.61	59.298
1962	29.717	31.2775	1.5605	5.25	5.542
1963	32.67	37.0274	4.3574	13.34	15.391
1964	41.22	45.6917	4.4717	10.85	43.382
1965	20.76	14.5245	−6.2355	−30.04	−30.79
1966	26.438	23.8041	−2.6339	−9.96	−9.06
1967	33.914	39.0195	5.1055	15.05	17.722
1968	30.661	32.0029	1.3419	4.38	4.577
1969	14.769	10.0847	−4.6843	−31.72	−49.856
1970	20.268	15.5512	−4.7168	−23.27	−27.575
1971	14.817	12.4208	−2.3962	−16.17	−45.552
1972	16.824	11.6745	−5.1495	−30.61	−35.226
1973	27.262	29.4654	2.2034	8.08	8.793
1974	20.685	16.0911	−4.5939	−22.21	−18.173
1975	31.898	36.9765	5.0785	15.92	28.52
1976	27.217	28.9066	1.6896	6.21	6.619
1977	20.544	15.3917	−5.1523	−25.08	−20.051
1978	21.379	17.5769	−3.8021	−17.78	−15.099
1979	16.121	11.4411	−4.6799	−29.03	−34.998
1980	25.726	27.5191	1.7931	6.97	7.492
1981	47.016	51.9198	4.9038	10.43	94.988
1982	24.243	22.0834	−2.1596	−8.91	−8.179
1983	38.608	44.0294	5.4214	14.04	47.434
1984	35.027	40.6252	5.5982	15.98	27.702
1985	25.342	22.4954	−2.8466	−11.23	−10.098
1986	15.529	13.1541	−2.3749	−15.29	−44.348
1987	19.324	13.9816	−5.3424	−27.65	−27.534
1988	25.975	26.0178	0.0428	0.16	0.165
1989	32.382	36.8275	4.4455	13.73	24.851
1990	29.253	31.925	2.672	9.13	10.052
1991	15.866	10.8838	−4.9822	−31.40	−40.905
1992	26.858	27.966	1.108	4.13	4.303
1993	25.468	25.0752	−0.3928	−1.54	−1.519
1994	15.377	10.9325	−4.4445	−28.90	−40.449
1995	16.441	13.1049	−3.3361	−20.29	−33.644
1996	12.014	9.0845	−2.9295	−24.38	−49.823
1997	10.402	7.0535	−3.3485	−32.19	−54.278
1998	25.554	27.5923	2.0383	7.98	18.769
1999	21.003	20.0865	−0.9165	−4.36	−4.181
Average	25.6171	25.133464	−0.376836	−6.02	−2.407

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Chapter 126
Joint Purchasing Decisions Based on the Shortage Cost of the Automotive Industry

Rui Wang and Yue Shen

Abstract With the market competition increasingly fierce, the profit of the enterprise space is being compressed. Therefore, an important issue that enterprises face is how to expand the profit source of enterprises. The procurement is a very important part of the business management process, but the cost of procurement remains high in traditional purchasing mode. Hence, corporate managers pay high attention to how to use the scientific procurement mode to reduce procurement costs. This paper adopts the quantitative method of mathematical model to analysis the joint procurement decision-making under this new procurement mode and a simple example is illustrated.

Keywords Shortage costs · Purchasing alliance · Joint procurement · Decision-making

126.1 Introduction

With the continuous development of the world economy and people's living standards, consumer demand is becoming increasingly personalized and diversification as well. New product life cycles are getting shorter and shorter and the competition which enterprises from all walks of life face in the market environment has become more and more severe. With the intensified competition in the market, the prices of raw materials continue to rise and the profit margin space is increasingly compressed. Therefore, the greatest primary task of enterprises is how to improve the market competitiveness and expand the source of profit. The procurement is a very important part of the business management process, but the cost of procurement remains high in traditional purchasing mode. In this case, the joint procurement mode is concerned by business managers, experts and scholars.

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Lal and Staelin [1] were the first to research the optimal pricing policy problem that contains of a seller and a set of homogeneous buyers, and to expand it to heterogeneous buyers situation. Drezner and Wesolowsky [2] also focused on the situation of multi buyers, and gave a solution to the problem when the seller provides a single quantity discount scheme. Aksoy and Merengue [3], Stair [4] and Eijs [5] used indirect group strategy to seek a kind of optimal combination about basic cycle and order frequency. When implementing multi suppliers to purchase, Ruengsak and Nguyen [6] studied the allocation policy about purchasing varieties and quantity in suppliers. Karabat and Sayin [7] researched the supply chain about single supplier and multi buyers. Supplier obtains buyers' cost information, while supplier shares his own cost parameter information with buyers.

According to whether to consider the shortage cost, the second part of the paper establishes two decision-making models, one is a single retailer alone purchases to a supplier, the other one is a joint purchasing alliance which consists of multiple retailers purchases to a supplier. And the paper gives ideas for solving two procurement decision-making models. In the third part, the procurement decision-making models are validated by a case of the auto industries and the total costs are compared in both cases. Concluding remarks are made in part four.

126.2 Model Formulation

126.2.1 Separate Order

This part consists of two models, one is separate order model and the other one is joint purchasing alliance for joint procurement decisions model.

(1) Problem description

Considering retailers purchase a variety of goods to suppliers separately and supply market has a lot of suppliers. Each supplier is able to provide all the goods required by the retailers. Out-of-stock situations can occur in the procurement process and retailers make decisions independently, then to minimize the total cost which consists of ordering costs, purchasing costs, storage costs, transportation costs and shortage costs in a year.

(2) Model assumptions

(a) Basic assumptions

- Procurement cycle is the same for all goods;
- Retailers know the demand of each commodity, and the demand is a constant. This means that the demand is uniformly;
- The model allows goods shortage to occur and replenish, and using the method of "appointment shortage". It means that registering the unmet needs as shortage, and compensating them as long as the new goods arrived;
- Order lead time is known, and it is a constant;

- Delivery lead time is zero, this means that the goods will be compensated as long as retailers send out the shortage requests;
- A one-time order quantity has no minimum and maximum limit;
- Ordering costs are the same, and they are irrelevant to order quantity. Ordering costs are repeatedly settlement in accordance with the procurement cycle, rather than a one-time settlement;
- Purchasing costs don't vary with quantity changes, it means that there is no quantity price discounts;
- Unit storage costs of all goods and unit transportation costs are the same;
- Transport prices of unit commodity is irrelevant to the distribution of goods in quantity.

(b) Notations

m : The number of varieties of goods which a retailer purchases;
i : A variety of goods which a retailer purchases;
g : The number of suppliers;
C_d : Ordering cost which a retailer purchases;
P_{ig} : Unit price for goods i which is supplied by supplier g;
R_i : Retailer's demand rate for goods i;
D_i : Total annual demand for goods i;
Q_i : Total demand in one cycle for goods i;
Q_{1i} : Storage for goods i;
C_{si} : Unit cost of storage for goods i;
G_i : Single weight for goods i;
H_g : The distance between retailer and supplier g;
C_v : Unit mileage transport costs for goods transport;
K_i : Unit shortage cost for goods i;
S_i : The number of shortage for goods i in a procurement cycle;
T : Procurement cycle;
t : The time of shortage.

(3) Modeling

According to a retailer's total costs for one year (365 days) are ordering costs + purchasing costs + storage costs + transportation costs + shortage costs, then:
(a) Without considering shortage costs

- A retailer's ordering costs in a procurement cycle T are: C_d.
- A retailer's purchasing costs in a procurement cycle T are $\sum_{i=1}^{m} P_{ig} R_i T$.
- A retailer's storage costs in a procurement cycle T are $\frac{1}{2}\sum_{i=1}^{m} R_i C_{si} T^2$.
- A retailer's transportation costs in a procurement cycle T are $C_v H_g \sum_{i=1}^{m} G_i R_i T$.
- A retailer's total costs for a year are:

$$TC = \frac{365}{T}\left(C_d + \sum_{i=1}^{m} P_{ig} R_i T + \frac{1}{2}\sum_{i=1}^{m} R_i C_{si} T^2 + C_v H_g \sum_{i=1}^{m} G_i R_i T\right). \qquad (126.1)$$

(b) Considering shortage costs

- A retailer's ordering costs in a procurement cycle T are C_d.
- A retailer's purchasing costs in a procurement cycle T are $\sum_{i=1}^{m} P_{ig} Q_i$.
- A retailer's storage costs in a procurement cycle T are $\frac{1}{2}\sum_{i=1}^{m} C_{si} Q_{1i} t$.
- A retailer's shortage costs in a procurement cycle T are $\frac{1}{2}\sum_{i=1}^{m} K_i (Q_i - Q_{1i})(T - t)$.
- A retailer's total costs for a year are (Without transportation costs):

$$TC = C_d + \sum_{i=1}^{m} P_{ig} Q_i + \frac{1}{2}\sum_{i=1}^{m} C_{si} Q_{1i} t + \frac{1}{2}\sum_{i=1}^{m} K_i (Q_i - Q_{1i})(T - t). \tag{126.2}$$

- A retailer's transportation costs for a year are $C_v H_g \sum_{i=1}^{m} G_i D_i$.
- Then the total costs are:

$$TC = C_d + \sum_{i=1}^{m} P_{ig} Q_i + \frac{1}{2}\sum_{i=1}^{m} C_{si} Q_{1i} t + \frac{1}{2}\sum_{i=1}^{m} K_i (Q_i - Q_{1i})(T - t) + C_v H_g \sum_{i=1}^{m} G_i D_i. \tag{126.3}$$

(4) Solution procedure

The solution of minimize total costs of goods which are purchased separately are:

(a) Without considering shortage costs

Make $\frac{d_{Tc}}{d_T} = 0$, then a retailer's purchasing cycle is: $T = \sqrt{2C_d / \sum_{i=1}^{m} R_i C_{si}}$. Put T into Equation (126.1), then the annual total costs are:

$$TC = 365\left(\sqrt{2C_d \sum_{i=1}^{m} R_i C_i} + \sum_{i=1}^{m} P_{ig} R_i + C_v H_g \sum_{i=1}^{m} G_i R_i\right). \tag{126.4}$$

(b) Considering shortage costs

The average value of total costs of the goods which are stored within the unit time is:

$$\overline{TC} = \frac{C_d}{T} + \frac{\sum\limits_{i=1}^{m} P_{ig} Q_i}{T} + \frac{\sum\limits_{i=1}^{m} C_{si} Q_{1i} t}{2T} + \frac{\sum\limits_{i=1}^{m} K_i (Q_i - Q_{1i})(T - t)}{2T}. \tag{126.5}$$

Q_i, Q_{1i}, T, t are decision variables and they meet:

$$Q_i = D_i T, \quad Q_{1i} = D_i t. \tag{126.6}$$

Then the total costs of the model are:

$$\min \overline{TC} = \frac{C_d}{T} + \frac{\sum\limits_{i=1}^{m} P_{ig} Q_i}{T} + \frac{\sum\limits_{i=1}^{m} C_{si} Q_{1i} t}{2T} + \frac{\sum\limits_{i=1}^{m} K_i (Q_i - Q_{1i})(T - t)}{2T},$$
$$\text{s.t.} \begin{cases} Q_i = D_i T, \\ Q_{1i} = D_i t, \\ Q_i \geq 0, Q_{1i} \geq 0, T \geq 0, t \geq 0. \end{cases} \tag{126.7}$$

By the Equation (126.6) can be obtained:

$$T = \frac{Q_i}{D_i}, t = \frac{Q_{1i}}{D_i}. \tag{126.8}$$

Put Equation (126.8) into Equation (126.7) can be obtained:

$$\overline{TC} = \frac{C_d \sum_{i=1}^{m} D_i}{\sum_{i=1}^{m} Q_i} + \sum_{i=1}^{m} P_{ig} D_i + \frac{\sum_{i=1}^{m} C_{si} Q_1^2}{2\sum_{i=1}^{m} Q_i} + \frac{\sum_{i=1}^{m} K_i (Q_i - Q_{1i})^2}{2\sum_{i=1}^{m} Q_i}, \tag{126.9}$$

the partial derivative of Q_i, Q_{1i} in the Equation (126.7) are:

$$\frac{\partial \overline{TC}}{\partial Q_i} = \frac{\sum_{i=1}^{m} K_i}{2} - \frac{\left(\sum_{i=1}^{m} C_{si} + \sum_{i=1}^{m} K_i\right) Q_{1i}^2}{2\sum_{i=1}^{m} Q_i} - \frac{\sum_{i=1}^{m} P_{ig} \sum_{i=1}^{m} D_i}{\sum_{i=1}^{m} Q_i^2}. \tag{126.10}$$

$$\frac{\partial \overline{TC}}{\partial Q_{1i}} = \frac{\left(\sum_{i=1}^{m} C_{si} + \sum_{i=1}^{m} K_i\right) \sum_{i=1}^{m} Q_{1i}}{\sum_{i=1}^{m} Q_i} - \sum_{i=1}^{m} K_i. \tag{126.11}$$

By the following equations:

$$\begin{cases} \frac{\partial \overline{TC}}{\partial Q_i} = 0, \\ \frac{\partial \overline{TC}}{\partial Q_{1i}} = 0. \end{cases}$$

With Equation (126.8) and Equation (126.9) can get optimal solution as follows:

$$Q_i^* = \sqrt{\frac{2\sum_{i=1}^{m} D_i C_d \left(\sum_{i=1}^{m} C_{si} + \sum_{i=1}^{m} K_i\right)}{\sum_{i=1}^{m} C_{si} \sum_{i=1}^{m} K_i}}, \; Q_{1i}^* = \sqrt{\frac{2\sum_{i=1}^{m} D_i C_d \sum_{i=1}^{m} K_i}{\sum_{i=1}^{m} \left(C_{si} \sum_{i=1}^{m} C_{si} + \sum_{i=1}^{m} K_i\right)}},$$

$$T^* = \sqrt{\frac{2C_d \left(\sum_{i=1}^{m} C_{si} + \sum_{i=1}^{m} K_i\right)}{\sum_{i=1}^{m} D_i \sum_{i=1}^{m} C_{si} \sum_{i=1}^{m} K_i}}, \; Q_{1i}^* = \sqrt{\frac{2C_d \sum_{i=1}^{m} K_i}{\sum_{i=1}^{m} C_{si} \sum_{i=1}^{m} D_i \left(\sum_{i=1}^{m} C_{si} + \sum_{i=1}^{m} K_i\right)}}.$$

Then, the optimal value is:

$$TC^* = \sqrt{\frac{2\sum_{i=1}^{m} D_i C_d \sum_{i=1}^{m} C_{si} \sum_{i=1}^{m} K_i}{\sum_{i=1}^{m} C_{si} + \sum_{i=1}^{m} K_i}} + \sum_{i=1}^{m} P_{ig} D_i. \tag{126.12}$$

The annual total costs which add transportation costs are:

$$TC^* = \sqrt{\frac{2\sum_{i=1}^{m} D_i C_d \sum_{i=1}^{m} C_{si} \sum_{i=1}^{m} K_i}{\sum_{i=1}^{m} C_{si} + \sum_{i=1}^{m} K_i}} + \sum_{i=1}^{m} P_{ig} D_i + C_v H_g \sum_{i=1}^{m} G_i D_i. \qquad (126.13)$$

126.2.2 Joint Purchasing Alliance for Joint Procurement Decisions

(1) Problem description

Considering a joint purchasing alliance composed by a number of retailers purchases a variety of goods to a supplier and supply market has a lot of suppliers. Each supplier is able to provide all the goods required by the joint purchasing alliance. Out-of-stock situations can occur in the procurement process and the joint purchasing alliance make decisions to minimize total costs which consist of ordering costs, purchasing costs, storage costs, transportation costs and shortage costs in a year.

(2) Model assumptions

(a) Basic assumptions

- Procurement cycle is the same for all goods;
- Retailers know the demand of each commodity, and the demand is a constant. This means that the demand is uniformly.
- The model allows goods shortage to occur and replenish, and using the method of ”appointment shortage”. It means that registering the unmet needs as shortage, and compensating them as long as the new goods arrived;
- Order lead time is known, and it is a constant;
- Delivery lead time is zero, this means that the goods will be compensated as long as the retailer sends out the shortage requests;
- A one-time order quantity has no minimum and maximum limit;
- Ordering costs are the same, and they are irrelevant to order quantity. The ordering cost is repeatedly settlement in accordance with the procurement cycle, rather than a one-time settlement;
- There is quantity price discounts;
- Unit storage costs of all goods and unit transportation costs are the same;
- Transport prices of unit commodity is irrelevant to the distribution of goods in quantity.

(b) Notations

m : The number of varieties of goods which a retailer purchases;
i : A variety of goods which a retailer purchases;
n : The number of retailers;
j : One of the retailers;
g : The number of suppliers;
C_{dT} : Order costs of joint purchasing alliance;
C_d : Order costs when retailers purchase respectively;
P_{ijg} : Unit price for goods i of retailer j which is supplied by supplier g;
r_i : The price discounts for goods i when the joint purchasing alliance purchase, $(0 \le r_i \le 1)$;
R_{ij} : The retailer j's demand rate for goods i;
D_{ij} : Retailer j's total annual demand for goods i;
Q_{ij} : Retailer j's total demand in one cycle for goods i;
Q_{1ij}: Retailer j's storage for goods i;
C_{sij} : Retailer j's unit cost of storage for goods i;
H_{jg} : The distance between retailer j and supplier g;
C_v : Per unit distance transport costs for goods transport;
G_{ij} : Single weight for goods i which retailer j purchases;
K_{ij} : Unit shortage cost for goods i which retailer j purchases;
S_{ij} : The number of shortage for goods i which retailer j purchases in a procurement cycle;
T : Procurement cycle;
t : Time of shortage.

(3) Modeling

According to a retailer's total costs for one year (365 days) are ordering costs + purchasing costs + storage costs + transportation costs + shortage costs, then:
(a) Without considering shortage costs

- A joint purchasing alliance's ordering costs in a procurement cycle T are $C_{dT} = C_d$.
- A joint purchasing alliance's purchasing costs in a procurement cycle T are $\sum_{i=1}^{m}\sum_{j=1}^{n} P_{ij}R_{ij}(1-r_i)T$.
- A joint purchasing alliance's storage costs in a procurement cycle T are $\frac{1}{2}\sum_{i=1}^{m}\sum_{j=1}^{n} R_{ij}C_{sij}T^2$.
- A joint purchasing alliance's transportation costs in a procurement cycle T are $C_vH_z\sum_{i=1}^{m}\sum_{j=1}^{n} R_{ij}G_{ij}T$.
- A joint purchasing alliance's total costs for a year are:

$$TC = \frac{365}{T}\left(C_d + \sum_{i=1}^{m}\sum_{n=1}^{n} P_{ij}R_{ij}(1-r_i)T + \frac{1}{2}\sum_{i=1}^{m}\sum_{j=1}^{n} R_{ij}C_{sij}T^2 + C_v\sum_{i=1}^{m}\sum_{j=1}^{n} R_{ij}H_{jg}G_{ij}T\right). \tag{126.14}$$

(b) Considering shortage costs

- A joint purchasing alliance's ordering costs in a procurement cycle T are: $C_{dT} = C_d$.
- A joint purchasing alliance's purchasing costs in a procurement cycle T are $\sum_{i=1}^{m}\sum_{j=1}^{n} P_{ijg}(1-r_i)Q_{ij}$.
- A joint purchasing alliance's storage costs in a procurement cycle T are $\frac{1}{2}\sum_{i=1}^{m}\sum_{j=1}^{n} C_{sij}Q_{1ij}t$.
- A joint purchasing alliance's shortage costs in a procurement cycle T are $\sum_{i=1}^{m}\sum_{j=1}^{n} K_{ij}(Q_{ij}-Q_{1i}j)(T-t)$.
- A joint purchasing alliance's total costs for a year are (Without transportation costs):

$$TC = C_d + \sum_{i=1}^{m}\sum_{n=1}^{n} P_{ij}(1-r_i)Q_{ij} + \frac{1}{2}\sum_{i=1}^{m}\sum_{j=1}^{n} C_{sij}Q_{1ij}t + \sum_{i=1}^{m}\sum_{j=1}^{n} K_{ij}(Q_{ij}-Q_{1ij})(T-t).$$

- A joint purchasing alliance's transportation costs for a year are:

$$C_v \times \sum_{i=1}^{m}\sum_{j=1}^{n} G_{ij}D_{ij}H_{jg}.$$

- Then the total costs are:

$$\begin{aligned} TC = \ & C_d + \sum_{i=1}^{m}\sum_{n=1}^{n} P_{ij}(1-r_i)Q_{ij} + \frac{1}{2}\sum_{i=1}^{m}\sum_{j=1}^{n} C_{sij}Q_{1ij}t \\ & + \sum_{i=1}^{m}\sum_{j=1}^{n} K_{ij}(Q_{ij}-Q_{1ij})(T-t) + C_v\sum_{i=1}^{m}\sum_{j=1}^{n} G_{ij}D_{ij}H_{jg}. \end{aligned} \tag{126.15}$$

(4) Solution procedure

According to the above solving ideas, the optimal solution is:

(a) Without considering shortage costs

Make $\frac{d_{Tc}}{d_T} = 0$, then the joint purchasing alliance's purchasing cycle is:

$$T = \sqrt{\frac{2C_d}{\sum\limits_{i=1}^{m}\sum\limits_{j=1}^{n} R_{ij}C_{sij}}}. \tag{126.16}$$

Put the T into Equation (126.14), and then the annual total costs are:

$$TC = \sqrt{2C_d\sum_{i=1}^{m}\sum_{j=1}^{n} R_{ij}C_{sij}} + \sum_{i=1}^{m}\sum_{j=1}^{n} P_{ij}R_{ij}(1-r_{ij}) + C_v\sum_{i=1}^{m}\sum_{j=1}^{n} R_{ij}H_{jg}G_{ij}. \tag{126.17}$$

(b) Considering shortage costs

$$Q_i^* = \sqrt{\frac{2\sum_{i=1}^{m}\sum_{j=1}^{n} D_{ij}C_d\left(\sum_{i=1}^{m}\sum_{j=1}^{n} C_{sij} + \sum_{i=1}^{m}\sum_{j=1}^{n} K_{ij}\right)}{\sum_{i=1}^{m}\sum_{j=1}^{n} C_{sij}\sum_{i=1}^{m}\sum_{j=1}^{n} K_{ij}}}, \tag{126.18}$$

$$Q_{1i}^* = \sqrt{\frac{2\sum_{i=1}^{m}\sum_{j=1}^{n} D_{ij}C_d\sum_{i=1}^{m}\sum_{j=1}^{n} K_{ij}}{\sum_{i=1}^{m}\sum_{j=1}^{n} C_{sij}\left(\sum_{i=1}^{m}\sum_{j=1}^{n} C_{sij} + \sum_{i=1}^{m}\sum_{j=1}^{n} K_{ij}\right)}}, \tag{126.19}$$

$$T^* = \sqrt{\frac{2C_d\left(\sum_{i=1}^{m}\sum_{j=1}^{n} C_{sij} + \sum_{i=1}^{m}\sum_{j=1}^{n} K_{ij}\right)}{\sum_{i=1}^{m}\sum_{j=1}^{n} D_{ij}\sum_{i=1}^{m}\sum_{j=1}^{n} C_{sij}\sum_{i=1}^{m}\sum_{j=1}^{n} K_{ij}}}, \tag{126.20}$$

$$t^* = \sqrt{\frac{2C_d\sum_{i=1}^{m}\sum_{j=1}^{n} K_{ij}}{\sum_{i=1}^{m}\sum_{j=1}^{n} D_{ij}\sum_{i=1}^{m}\sum_{j=1}^{n} C_{sij}\left(\sum_{i=1}^{m}\sum_{j=1}^{n} C_{sij} + \sum_{i=1}^{m}\sum_{j=1}^{n} K_{ij}\right)}}. \tag{126.21}$$

Total costs (without transportation costs) are:

$$TC^* = \sqrt{\frac{2\sum_{i=1}^{m}\sum_{j=1}^{n} D_{ij}C_d\sum_{i=1}^{m}\sum_{j=1}^{n} C_{sij}\sum_{i=1}^{m}\sum_{j=1}^{n} K_{ij}}{\sum_{i=1}^{m}\sum_{j=1}^{n} C_{sij} + \sum_{i=1}^{m}\sum_{j=1}^{n} K_{ij}} + \sum_{i=1}^{m} P_{ijg}D_{ij}(1-r_i)}. \tag{126.22}$$

Total costs (with transportation costs) are:

$$TC^* = \sqrt{\frac{2\sum_{i=1}^{m}\sum_{j=1}^{n} D_{ij}C_d\sum_{i=1}^{m}\sum_{j=1}^{n} C_{sij}\sum_{i=1}^{m}\sum_{j=1}^{n} K_{ij}}{\sum_{i=1}^{m}\sum_{j=1}^{n} C_{sij} + \sum_{i=1}^{m}\sum_{j=1}^{n} K_{ij}}} + \sum_{i=1}^{m} P_{ijg}D_{ij}(1-r_i) + C_v\sum_{i=1}^{m}\sum_{j=1}^{n} G_{ij}D_{ij}H_{jg}.$$

126.3 Numeric Example

126.3.1 Background

There are three automobile manufacturing enterprises in the same region. A is FAW-Volkswagen Chengdu Branch, B is FAW Toyota Motor Co., Ltd, and C is Chengdu Plateau automotive industry Co., Ltd. (See Tables 126.1 $\sim$ 126.3).

Table 126.1 Unit price, discount price, single weight, and unit shortage cost of goods X, goods Y and goods Z

	Unit price (yuan/piece)	Discount price (yuan/piece) 90%	Single weight (kilogram)	Unit shortage cost (yuan/piece · day)
X	32.5	30	2.5	2
Y	56.5	50	1.2	5
Z	79.0	71	8.0	9

Table 126.2 Three retailers' demand rates about goods X, goods Y and goods Z (unit: pieces/day)

	X	Y	Z
A	822	1025	526
B	274	336	138
C	83	92	36

Table 126.3 The distance between the retailers and the supplier (unit: kilometer)

	A	B	C
Supplier (g)	32	54	16

126.3.2 *Calculation and Results*

(1) Separate order (see Table 126.4)

Table 126.4 Each company's annual total cost (unit: yuan)

	A	B	C	Sum
Annual total cost (without shortage costs)	48880917	15739787	4744004	69364708
Annual total cost (with shortage costs)	50649589	16732850	5295337	72677776

(2) The joint procurement alliance joint procurement to suppliers (see Table 126.5)

Table 126.5 Each company's annual total cost (unit: yuan)

	Joint procurement alliance S
Annual total cost (without shortage costs)	63628114
Annual total cost (with shortage costs)	66941182

126.3.3 Comparison and Analysis

The following conclusions can be drawn from the above calculated data and the comparison in Table 126.4 and Table 126.5:

- The total costs of the procurement alliance are less than retailers purchase respectively when Joint procurement alliance takes joint procurement decisions. It is mainly because the establishment of a joint purchasing formed the scale effect, which enhance the union negotiating capacity and bargaining power in the procurement process, so the joint procurement alliance can get joint procurement price discounts. The member companies of the joint procurement alliance share part of ordering costs in the joint procurement process, so that ordering costs can be brought down.
- Shortage costs affect total costs. Whether the enterprises purchase respectively or jointly, total costs without considering shortage cost are less than total costs with considering shortage cost. So shortage cost is an important factor in the procurement process which needs to consider seriously.

126.3.4 Conclusions

The practical application and theoretical studies of joint procurement have been developing rapidly. Relatively speaking, the theoretical studies are far behind the use of practice. This paper mainly discusses the decision-making problem about joint purchasing alliance employs joint procurement in allowable stock-out condition.

This paper establishes two decision-making models, one is a single retailer alone purchases to a supplier, the other one is a joint purchasing alliance which consists of multiple retailers purchases to a supplier. Total costs without considering shortage costs are less than total costs with considering shortage costs. Whether or not to consider the shortage costs, procurement costs of joint purchasing alliance are less than the single retailer.

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Chapter 127
Market Entry Barriers in China's Industrial Markets

Yongge Niu and Fumin Deng

Abstract China, a country that is in the course of economic transition and on high-speed development stage, its firm attributes, the external economic environment, and the law system are largely different from those in the developed countries. The relative importance and underlying dimensions of thirty-eight barriers to entry in industrial markets were examined through a survey of business executives from 83 China's firms.

Keywords Entrants · Market entry barriers · Industrial markets · China

127.1 Introduction

Since 2012 China has become the world's second largest economy. It is of little surprise that China continues to be an attractive destination for business investment and expansion. Therefore, whether or when to enter a new China's market or industry is one of the vital decisions that multinational firma and business executives must often make [16]. Executives of multinational corporations considering entering China could benefit from understanding their local Chinese counterparts' perceptions of barriers to market entry in China [8].

Niu et al [8] examined the relative importance of twenty-two barriers that were integrated a broader list of barriers [6] into Chinese context through surveying the business executives of firms from industrial markets, consumer goods markets, and service markets. Karakaya [5] assessed the importance of twenty-five barriers to market entry in the U.S. industrial markets. The research is differentiated from previous studies because of its focus on barriers to entry in China's industrial markets. Therefore, this research has the following objectives:

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Assess the relative importance of a broad list of barriers to entry in China's industrial markets. Identify the underlying dimensions of barriers to entry in China's industrial markets.

127.2 Literature Review

A barrier to entry, according to Von weizsacker's [15], can be thought of as a cost of producing which must be borne by a firm which seeks to enter an industry or market but is not borne by firms already in that industry or market. Karakaya and Stahl [6] stresses that barriers to entry are various elements of industry structure, can impose disadvantages on entrants relative to incumbents, and give incumbents inherent advantages over potential entrants. Some of entry barriers are created by the natural industry attributes, for instance, the market capacity influences the smallest effective economies of scale, and postulates eventually the number of competitors. However, most of the barriers are created deliberately by incumbents, and its purpose is to prevent potential entrants, such as the establishment of intimate relationships between a firm and a member of distribution channels by means of exclusive contracts, and incumbent's expected retaliation to market entry. The barriers to entry that incumbents have constructed implies that potential competitors must expend additional resources (except for a similar entry condition) to compete effectively in the marketplace.

The presence of market entry barriers gives incumbents inherent advantages over potential entrants [11], and enables the incumbents to have above-average profitability [17], but also decreases the likelihood, scope, or speed with which potential competitors can come into the markets [13]. For these reasons, market entry barriers, which have been core theory in industry economics and business management, can not be evaded.

Marketing scholars apply the concept of entry barriers with updated relevant terms in recent marketing literature. For example, Peter and Donnelly [10] use brand equity as opposed to product differentiation [2] to refer to the difference in advertising effectiveness and a brand's ability to capture customer loyalty. Marketing scholars have embraced the resourced- and knowledge-based perspectives which have led to some recent studies on examining the importance of entry barriers [3–8, 16].

127.3 Methodology

127.3.1 Instrument

The instrument contained thirty-eight barriers to market entry. Participants are asked, "Based on experience of your firm when entering an industrial market that you had not previously served, please indicate how well each of the following market entry barriers your firm encountered." Responses were measured on seven-point scales ranging from "not important at all" (scored as 1) to "extremely important" (scored as 7).

A pretest of the questionnaire was conducted through six in-depth interviews with CEOs and marketing executives. Participants were asked to identify items that were confusing, questions that were difficult to respond to, and any other problems they encountered. With the information from this pretest, the questionnaire was reworked until a final version was elaborated.

127.3.2 Location and Sample

Three provinces, Guangdong, Sichuan, and Guizhou, are selected as the location for data collection. The 2011 Telecom yellow pages from the three provinces are source for sample information. A total of 800 industrial firms from chemical, pharmaceutical, coal, metallurgy, mining, energy, architectural, electronics, and Machinery manufacturing industries were randomly selected. The researchers and a group of research assistants first contacted the Vice-Presidents of Marketing via telephone to invite them to participate in the survey. A thank-you note was sent to each informant who agreed to participate before surveys were sent to them via an e-mail attachment. In total, we received 96 completed questionnaires. After discarding incomplete or erroneous surveys, 83 responses were usable, with an effective response rate of 10.4%. The 83 responses reflected three market entry types in terms of firms' self-reported market entrant classification [12] (there are 24 market pioneers, 47 early followers, and 12 late entrants). Sales for the responding firms ranged from $ .79 million to $ 28 billion, with average sales being $1.32 billion.

Non-response bias was examined following the procedures developed by Armstrong and Overton [1]. The results suggest that non-response bias was not a problem in this study and that our sample can be considered as fairly representative of the population.

127.4 Analysis and Results

127.4.1 Relative Importance

The importance of the 38 barriers was calculated by assessing the mean responses, standard deviation, and percentage of respondents rating the barriers on one of the three of "most important" categories. Table 127.1 ranks the barriers based on their importance as perceived by the respondents. As shown in Table 127.1, the social relationship resources barrier received the highest rating in terms of importance for

Table 127.1 Perceived importance of barriers to market entry

	Mean[a]	Std. deviation	% of respondents[b]
Social relationship resources built by incumbents	5.59	1.26	84.3
Magnitude of market share held by incumbents	5.16	1.48	69.9
Brand identification advantage held by incumbents	5.16	1.63	69.9
Access to distribution channels	5.14	1.59	73.5
Managerial experience of incumbents	5.10	1.55	71.1
Amount of high-quality talents held by incumbents	5.06	1.58	66.3
Incumbents with cost advantages due to economies of scale	4.98	1.61	62.7
Environment protection formulated by government	4.96	1.86	62.7
Capital intensity of the market	4.95	1.51	62.7
Number of firms in a market	4.93	1.62	66.3
Policy on business standards formulated by government	4.92	1.82	60.2
Macro-control policies formulated by government	4.87	1.96	56.6
Blank on business management system	4.87	1.72	61.4
Amount of sunk costs involved in entering a market	4.81	1.56	63.9
Brand name or trademark of incumbents	4.78	1.91	65.1
High profit rates earned by incumbents	4.77	1.54	63.9
Capital requirements to enter a market	4.77	1.71	62.7
R & D expense involved in entering a market	4.77	1.83	61.4
Incumbents possessing strategic raw materials	4.77	1.82	60.2
Government licensing requirements	4.77	2.14	57.8
Incumbent with cost advantages due to economies of scope	4.76	1.57	59.0
Customer loyalty advantage held by incumbents	4.73	1.63	61.4
Customers' costs associated with switching from one supplier to another	4.73	1.67	61.4
Incumbents with superior production processes	4.73	1.73	60.2
Absolute cost advantages held by incumbents	4.71	1.76	59.0
Amount of selling expense involved in marketing a product	4.61	1.56	57.8
Nonfeasance or random feasance on market regulation conducted by government	4.59	1.90	59.0
Incumbents with proprietary product technology	4.58	2.01	53.0
Trade secrets held by incumbents	4.52	1.87	59.0
Low prices charges by incumbents	4.49	1.76	45.8
Omission or poor reliability on business information	4.43	1.71	50.6
Incumbents with cost advantages due to learning curve	4.33	1.72	48.2
Expected post-entry reaction of incumbents	4.30	1.62	41.0
Incumbents with relatively easy access to raw materials	4.28	1.88	47.0
Low efficiency on mediation of trade dispute	4.19	1.82	45.8
Amount of cost of establishing branch office in a new location	4.01	1.65	42.2
Incumbents with government subsidies	3.76	2.02	34.9
Heavy advertising by firms already in the market	3.69	1.86	30.1

Notes:

a. Measured on a seven point scale ranging from not important at all (coded as 1) to extremely important (coded as 7).

b. Percent of respondents who rated the importance of barriers 5, 6, or 7 on seven-point scale where 7 is extremely important.

deterring market entry (mean = 5.59), followed by the brand identification advantage barrier and magnitude of market share held by incumbents barrier (the mean is the same, i.e., 5.16; the Std. deviation is 1.48 and 1.63 respectively). Similarly, the first one was rated as five, six, or seven on a seven-point scale by 84.3 percent of the respondents, the last two was 69.9 respectively. These three barriers are followed by access to distribution channels (mean = 5.14), managerial experience of incumbents (mean = 5.10), and amount of high-quality talents held by incumbents (mean = 5.06). The lowest barriers to entry as scored by the respondents are heavy advertising by firms already in the market (mean = 3.69), incumbents with government subsidies (mean = 3.76).

127.4.2 Underlying Dimensions

To identify the internal structure of the 38 barriers and examine the comparability of the structure of industrial market barriers with that of western countries and China's overall environment as presented in the literature [5, 8], the underlying dimensions are determined by conducting a factor analysis. A principal component extraction method and varimax rotation was conducted to aid in interpretation the results. The analysis shows a Kaiser-Meyer-Olkin measure of sampling adequacy value of 0.72 and a significance level of Bartlett's test of sphericity of .00, indicating that the data are suitable for the application of factor analysis. In deciding how many factors should be extracted, a Scree plot test was also utilized. The Scree plot test and the analysis of the factor structure matrix suggested selection of the ten-factor solution. Table 127.2 reports the Varimax-rotated factor loadings, shares of explained total variance, and reliability coefficients for the factors. All ten factors had eigenvalues greater than 1.00, and the ten-factor solution reflects an interpretable, meaningful and rich structure with the each communality exceeding the recommended .50 threshold, except "the amount of cost of establishing branch office in a new location" (see Table 127.22) [14]. The ten factors extracted account for 75.33 percent of the variance in the data. Except for the tenth factor that includes one item hence without a coefficient *alpha*, all factors' reliability coefficients calculated employing Cronbach's *alpha* were above .50, which is considered to be acceptable for an exploratory study [9].

The first factor explains 12.26 percent of the variance and it is labeled as "business survival environments". A total of seven barriers to entry compose this factor and they appear to be business survival environments. As one can note, these barriers are typically the ones that all types of entrants must face with because every firm has difficulty in changing these barriers to entry.

Table 127.2: Rotated factor matrix showing the underlying dimensions of barriers to entry

	Factor										
	1	2	3	4	5	6	7	8	9	10	A

Table 127.2: Continued

Macro-control policies formulated by government	.84	.13	−.08	.09	.06	−.08	.07	.02	.14	.05	.77
Nonfeasance or random feasance on market regulation conducted by government	.78	.03	−.03	.08	.14	.26	−.13	−.00	.05	.29	.81
Policy on business standards formulated by government	.77	.15	.08	.07	−.10	−.10	.35	.09	.16	−.15	.83
Omission or poor reliability on business information	.75	.09	.01	.21	.09	.34	−.15	.03	.06	.16	.79
Environment protection formulated by government	.68	.11	.28	−.07	−.03	.02	.44	.17	.08	−.13	.80
Government licensing requirements	.62	−.01	.45	−.04	.15	−.04	−.05	−.07	−.13	.20	.68
Low efficiency on mediation of trade dispute	.53	.10	.17	.05	.09	.46	.27	.23	−.06	.25	.74
Percent of variation: 12.26%; Cronbrach's alpha=.88; factor-based score mean=4.68 (SD=1.44)											
Amount of selling expense involved in marketing a product	.08	.83	.06	.18	.06	.19	.11	.01	.10	.00	.80
Capital requirements to enter a market	.18	.73	.09	−.05	.18	.04	.28	.18	.14	.19	.77
Capital intensity of the market	.09	.71	.18	−.08	.27	.01	.35	−.01	.06	.15	.76
Social relationship resources built by incumbents	.20	.67	.10	.20	.03	−.10	.02	.45	−.14	−.07	.77
Amount of cost of establishing branch office in a new location	.03	.46	−.00	.09	.12	.25	.26	.34	−.11	−.06	.49
Percent of variation: 9.64%; Cronbrach's alpha=.84; factor-based score mean=4.78 (SD=1.21)											
Trade secrets held by incumbents	.06	−.02	.83	.22	.08	.20	.01	.22	.11	.05	.84
Incumbents with proprietary product technology	−.03	.10	.78	.22	.00	.26	.15	.04	−.03	−.11	.77
Incumbents possessing strategic raw materials	.16	.20	.63	.08	.17	.08	−.06	.01	.44	.07	.74
Incumbents with government subsidies	.17	.10	.54	.07	.34	.05	.05	−.26	.28	.34	.72
Absolute cost advantages held by incumbents	.03	.21	.50	.05	.41	.05	−.26	.31	.13	.15	.67
Percent of variation: 8.98%; Cronbrach's alpha=.83; factor-based score mean=4.47 (SD=1.47)											
Brand identification advantage held by incumbents	−.06	.07	.16	.85	.12	.04	.03	.17	−.07	.13	.82
Customer loyalty advantage held by incumbents	.10	−.03	.12	.82	.18	−.02	−.02	.07	.18	−.13	.79
Expected post-entry reaction of incumbents	.41	.27	.11	.63	.17	.07	.06	−.27	.16	−.08	.79

Table 127.2: Continued

Magnitude of market share held by incumbents	.15	−.02	.12	.57	.24	−.04	.00	.17	.54	.13	.76
Brand name or trademark of incumbents	.05	.27	.31	.53	−.05	.14	.14	.09	−.09	.50	.77
Heavy advertising by firms already in the market	.11	.05	.35	.43	.25	.14	.27	.17	−.16	.39	.69
Percent of variation: 8.76%; Cronbrach's alpha=.84; factor-based score mean=4.63 (SD=1.26)											
Low prices charges by incumbents	.01	.20	.08	.09	.79	.12	.08	−.04	.19	.15	.75
Customers' costs associated with switching from one supplier to another	.04	.05	.16	.29	.79	.12	.13	.08	−.02	−.01	.76
Access to distribution channels	.43	.28	.21	.09	.55	.11	.04	.16	−.14	−.42	.86
Incumbents with cost advantages due to economies of scale	.22	.18	−.05	.16	.54	.12	−.07	.18	.41	−.03	.61
Percent of variation: 7.21%; Cronbrach's alpha=.78; factor-based score mean=4.84 (SD=1.29)											
Incumbents with superior production processes	.08	−.06	.24	−.09	.16	.81	.02	.16	.09	.13	.80
Incumbents with cost advantages due to learning curve	.02	.33	.21	.23	.20	.66	−.05	.10	.29	−.06	.78
High profit rates earned by incumbents	.18	.34	.49	.08	−.05	.53	−.09	−.10	.00	.08	.70
Incumbent with cost advantages due to economies of scope	.20	.43	.18	.01	.28	.46	.07	.27	.21	−.05	.67
Percent of variation: 6.56%; Cronbrach's alpha=.81; factor-based score mean=4.65 (SD=1.31)											
Amount of sunk costs involved in entering a market	.21	.26	.02	−.07	.07	−.02	.79	.06	.05	.01	.75
R&D expense involved in entering a market	−.05	.36	−.07	.29	.07	.03	.75	.06	.09	.12	.82
Percent of variation: 5.95%; Cronbrach's alpha=.79; factor-based score mean=4.79 (SD=1.54)											
Managerial experience of incumbents	.03	.06	.08	.07	.13	.33	.31	.72	.22	.21	.85
Amount of high-quality talents held by incumbents	.11	.36	.10	.17	.05	.08	−.03	.70	.05	.06	.69
Percent of variation: 5.49%; Cronbrach's alpha=.71; factor-based score mean=5.08 (SD=1.38)											
Incumbents with relatively easy access to raw materials	.06	.01	.17	.03	.12	.20	.14	.04	.77	−.09	.70
Number of firms in a market	.31	.24	−.02	.41	−.07	.07	.07	.00	.42	.38	.66
Percent of variation: 5.40%; Cronbrach's alpha=.51; factor-based score mean=4.60 (SD=1.35)											

Table 127.2: Continued

Blank on business management system	.47	.09	.08	−.02	.11	.12	.02	.22	−.03	.73	.84
Percent of variation: 5.07%; Cronbrach's alpha=—; factor-based score mean=4.92 (SD= 1.82); Cumulative percent variation: 75.33%											

Notes: A: Communalities. Extraction method: Principal component analysis. Rotation method: Varimax with Kaiser normalization. Factor loadings of items on dimensions to which they belong are revealed in bold.

The second factor accounts for 9.64 percent of the variance and it is labeled as "financial requirements and social relationship". This factor is composed of five barriers to entry. Both financial requirements and social relationship are merged to form a factor, the major reason is that it costs a lot of money to build a social relationship resource.

The third factor explains 8.98 percent of the variance and it is labeled as "absolute cost advantage of incumbents". A total of five barriers to entry make up this factor and the first four barriers to entry are the sources of absolute cost advantages.

The fourth factor accounts for 8.76 percent of the variance and it is labeled as "product differentiation". This factor is composed of six barriers to entry. As one notes, all but one of barriers, expected post-entry reaction of incumbents, is related to brand or customer loyalty.

The fifth factor interprets 7.21 percent of the variance and it is labeled as "incumbents' capability in modifying price". A total of four barriers to entry compose this factor and they appear to be incumbents' capability in modifying price.

The sixth factor explains 6.56 percent of the variance and it is labeled as "profit expectation of entering firms". This factor includes four barriers to entry and we name this factor according to Karakaya's study [5].

The seventh factor accounts for 5.95 percent of the variance and it is labeled as "sunk costs and R&D". A total of two barriers to entry make up this factor.

The eighth factor accounts for 5.49 percent of the variance and it is labeled as "incumbents with strong management capabilities". This factor is composed of two barriers to entry.

The ninth factor explains 5.40 percent of the variance and it is named as "seller concentration". A total of two barriers to entry make up this factor.

The tenth factor includes only one barrier and is accordingly designated as "blank on business management system". This factor accounts for 5.07 percent of the variance.

127.4.3 Differences among the Ten Factors

This study tested how the order of entry influences the separate perceived importance of ten factors. The one-way analysis of variance (ANOVA) test was performed.

The evaluations made by the three groups of entrants concerning the ten factors were not significantly different at $\alpha = .05$.

Further examination of the factor scores indicates that the factor 8 (mean = 5.08) and factor 10 (mean = 4.92) are perceived as the two highest barrier factors by most respondents. The lowest factor as scored as factor 3 (mean = 4.47), and factor 9 (mean = 4.60) (see Table 127.2).

127.5 Discussion and Donclusions

127.5.1 The Five Highest and the Five Lowest Barriers to Entry

According to the mean ratings of the barriers as perceived by most executives in this research, the five highest barriers to entry are social relationship resources built by incumbents (mean = 5.59), magnitude of market share held by incumbents (mean = 5.16), brand identification advantage held by incumbents (mean = 5.16), access to distribution channels (mean = 5.14), and managerial experience of incumbents (mean = 5.10). The social relationship resources is ranked as the first highest barrier to entry because these is a unique culture value (i.e., mianzi, and guanxi) in establishing the trade relationship. There are absolute cost advantage held by incumbents, financial requirements, incumbents with a superior production process in China's industrial markets, and they are not perceived as important as in U.S. industrial markets [5]. The incumbent firms have some of these advantages because of in the market or being early entrants. This result is in accord with the conclusion in the western countries, that is, pioneer firms and early entrants possess certain advantages over late entrants [5, 7, 12]. Similarly, the lowest barriers to entry in China's industrial markets are incumbents with relatively easy access to raw materials (mean = 4.28), low efficiency on mediation of trade dispute (mean = 4.19), amount of cost of establishing branch office in a new location (mean = 4.01), incumbents with government subsidies (mean = 3.76), and heavy advertising by firms already in the market (mean = 3.69). Among the five lowest barriers to entry, except for the two last added barriers (low efficiency on mediation of trade dispute, and amount of cost of establishing branch office in a new location), the rest of these lowest barriers is the same as Karakaya's research [5] conclusions.

127.5.2 Meaning of the Underlying Dimensions

The appearance and content of the first factor and tenth factor reflect that the characteristics of the transition economy have significant effect on firms' market entry decisions. Due to the particularity of the blank on business management system, a firm should take it as a special question when making a market entry decision. In terms of business survival environment, only a barrier to entry, government licensing requirements, appears in Karakaya [5] and Karakaya and Stahl [7]. However, this study adds six barriers to entry to the business survival environment.

The second factor includes two components, that is, financial requirements and social relationship. The main executives perceived more importance on the social relationship than on the financial requirements. China features a society of etiquette and favor, thus, a firm need to invest some special assets in maintaining the established relationship between firms. Because the relationship features in relative fastness, only when late entrants invest extremely high costs the firms break the relationship. In addition, the financial requirements is often more important in industrial markets compared to consumer goods markets owing to the high cost of equipment in many industrial markets. However, the barrier to entry is not much of importance in China's industrial markets, further validating Niu et al's conclusion [8].

In this study the incumbent advantages include four factors, that is, absolute cost advantage of incumbents, product differentiation, incumbents' capability in modifying price, and incumbents with strong management capabilities, which is similar to two factors [5] finds in industrial markets (i.e., firm specific advantages and product differentiation). Here, the incumbent advantages have been extended, this situation results in that the entrants could clearly identify the particular appearance of the firm specific advantages in China's industrial markets. Meanwhile, the extended advantages enrich the theoretical framework of market entry barriers.

The sixth factor, profit expectations of entering firms, which is consistent with the factor [5] finds in industrial markets, can affect a firm's entry decision in both positive and negative ways. If the incumbent firms are enjoying high profit margins, this situation may encourage new market entry. Because the firms already in the market expect that the new market entry would occur, and the potential entrants may want to have a piece of pie, the incumbents would conduct a strong retaliation to discourage the market entry, resulting in an increased promotional expenditures or price competing.

The sunk costs and R&D are merged into the seventh factor, which is a unique factor compared to western countries. It is quite obvious that the firm's capabilities on R&D are of relatively low in China. Late entrants are most afraid that the R&D investment becomes invalid if the incumbents produce speedy more superior science and technology.

The ninth factor, seller concentration, is also unique factor compared to western countries. The number of firms in a market is rated the tenth important barrier, which is ranked higher than average in importance. However, the incumbents with relatively easy access to raw materials is the lowest barrier. The orders the two barriers ranked in overall barriers to entry are very similar to Karakaya's results [5].

127.6 Limitations and Future Research

According to Karakaya's research method [5], the extant study employed a small sample of 83 industrial firms and the results may not represent the population. Future studies of this type of research could attempt to increase the sample size. In addition, this study included nine major industries from the three provinces, and future studies could increase the number of industries from overall China's geographical domain to examine the conclusions. A larger sample size would allow researchers to examine the differences in the relative importance of barriers to entry in different industries.

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Chapter 128
On the Key Factors for Firms' Sustainable Growth — A Perspective Based on "Industrial Strategic Inflection Point" and Resource-based View

Changyi Zhao, Xiaowen Jie and Xin Gu

Abstract With resource-based view as the theoretical support, against the research background of "industrial strategic inflection point", this paper selects from theoretical plane four key resource factors influencing enterprise performance i.e. innovative ability, human capital, physical capital and slack resources, and discusses their relations with sustainable growth of enterprises, laying a theoretical foundation for further empirical research.

Keywords Industrial strategic inflection point · Sustainable growth of enterprises · Resources · Performance

128.1 Introduction

In an age dominated by knowledge and information, the growth of enterprises, the "cells" promoting economic development of mankind, is now facing unprecedented challenges. On the one hand, globalization of competition provides enterprises even broader development platforms for enterprises; on the other hand, it brings in a lot of competitors for local enterprises. While globalization of resources provides enterprises more diversified channels to acquire resources, it causes increasingly shortage of resources against a background of ever intensifying competition. If the 1997 Asian financial crisis was said to be only a regional disaster, the 2008 financial storm triggered by American subprime lending crisis evolved into a global economic crisis. In this volatile, sophisticated and ever-changing environment, the survival of enterprises is facing extremely severe test. Therefore, how to realize sustainable growth in a dynamic environment has become imperative key issue for enterprises.

In the business community, cases of corporate development have proved that at certain stage of development, enterprises will encounter the "strategic inflection

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point" [1, 2], which serves as a dividing line as to whether enterprise can realize sustainable growth or not. Scholars in the theoretical research field of strategic inflection point have confirmed, through the study and analysis of a large number of case, that after crossing the "industrial strategic inflection point", the performance of enterprises will be dramatically impacted. Today's China is just in a period of strategic opportunities to realize later-starter privileges through implementation of leapfrog mode of development strategy. Faced with the opportunity and also the pressure of global economic transformation, especially global industrial restructuring, upgrading and relocation, Chinese enterprises are more likely to encounter strategic inflection point. Some Chinese enterprises with considerable scale and strength have stepped into an awkward period of strategic confusion at this transformational stage in a volatile and complex global environment. Thus, against the background of globalization, it is more necessary for Chinese enterprises to think about approaches to cross one after one strategic inflection points and finally walk out of the strategic confusion [3–5], so as to achieve sustainable growth and become winners in international competition.

In theoretical study of enterprise growth, scholars maintain that the growth of enterprises is history-dependent, for the formation of international conditions of enterprises can not be done overnight. While enterprises' resources are the sources for their heterogeneity, the sustainability of resources is the fundamental factor to sustain their heterogeneity. Then, what key resource factors are influencing the performance of enterprises after the industrial strategic inflection point? And how? In the light of resource-based view, this paper will select some key resource factors influencing the performance of enterprises after the industrial strategic inflection point and make in-depth analysis on the ways they exert their impact.

128.2 Theoretical Background

Resource-based view provides most influential analytical framework for understanding strategy management. The core idea of resource-based view is that sustainable competitiveness of enterprises comes from their valuable, rare, inimitable, irreplaceable resources and capacities which are deemed as tangible and intangible assets of enterprises, including management capabilities, organizational processes, information and knowledge owned by enterprises [6].

Regarding theoretical basis of resource-based view, Barney [7] provided three different explanations: (1) theory of competitive advantage based on SCP (structure-conduct-performance) analytical paradigm; (2) neoclassical microeconomics theory; and (3) evolutionary economics theory. Although Barney's resource-based view is built on theory of competitive advantage based on SCP analytical paradigm, for different research purposes, the above three basic theories are all involved [7, 12].

128.2.1 Resource-based View Based on SCP Analytical Paradigm

The theoretical research focus in this field lies in the analysis of the relationship between resource-based view and SCP paradigm [6, 13, 14], while empirical research has to do with the interpretation of influence of industrial characteristics and enterprise characteristics on performance [15–17]. Research results in this field have proven that although there are some differences between industries, the influence of enterprises' own characteristics on performance is greater than that of industrial characteristics.

128.2.2 Resource-based View Based on Neoclassical Microeconomics Theory

Scholars in this field are dedicated to describing and measuring the features of inelastic resources and capacities [14, 18, 19], or the so-called "resource mining theory". Empirical research attempts to measure the characteristics of these enterprise resources and capacities and conduct analysis on their correlation with enterprise performance [20]. The research results in this field have disclosed that the performance of enterprises basing their strategies on path dependence, ambiguous causality, social complexity and intangible assets is better than those enterprises basing their strategies on tangible assets. Scholars are concerned about how to create economic rent for enterprises by tapping their own valuable, rare and resources difficult to imitate.

128.2.3 Resource-based View Based on Evolutionary Economics Theory

Scholars in this field are concerned about how enterprise capacity changes over time and the competition revelation [21] from the changes of the enterprises. While empirical research adopts the evolutionary point of view [22]. This branch of thinking is also called "capacity building theory".

Although the focuses of these three fields differ with varied theoretical backgrounds, they have the same prerequisites and assumptions: The resources and capacities enterprises possess differ. On the one hand, this difference is the basis for the heterogeneity of enterprises; on the other hand, lasting continuation of such differences enable some enterprises to constantly take the lead among other enterprises. Therefore, resource-based view can adopt different theoretical bases, while the key for decision on the selection of relevant theoretical basis lies in empirical background of the applications. Barney suggested that those who conduct comparative research on enterprise characteristics and industrial characteristics may adopt resource-based view related to competitive advantage theory which is based on SCP paradigm; those who conduct research on definite sources of sustained competitive advantages of enterprises can adopt resource-based view based on neoclassical microeconomics theory; those who conduct research on how resources and capacities evolve over time may adopt resource-based view based on evolutionary economics.

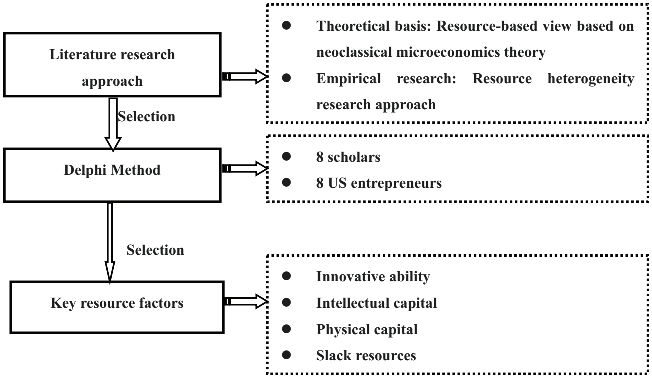

Fig. 128.1 Key resource factors selection process

The purpose of this article is to explore and analyze the key resource factors influencing sustainable growth of enterprises, that is, the key resource factors impacting the changing of performance of enterprises after the "industrial strategic inflection point". Therefore, it is relevant to adopt the resource-based view based on neoclassical microeconomics theory, which maintains that only inelastic resources can bring economic rent for enterprises. According to this principle, upon existing literature (esp. on the basis of independent variables selection by resource heterogeneity research method), considering the characteristics of collectable data, and by consulting related experts and entrepreneurs, we have adopted Delphi Method and chosen four resources as four dimensions for analysis in the part of resource-based view. Respectively, they are innovative ability, intellectual capital, physical capital and Slack resources[1]. As shown in Fig. 128.1.

[1] With regard to selection of resource dimensions, this study has adopted the Delphi Method and selected 8 noted scholars in the field of strategy management and 8 American entrepreneur representatives. The 8 scholars are famous scholars from China and America specializing in the research on resource-based view, industrial organization theory, organization transformation theory, entrepreneurship theory and strategic transformation theory.

128.3 Four Key Resource Factors and Sustainable Growth of Enterprises

(1) Innovation ability and performance change after the "industrial strategic inflection point"

Drucker [23] was one of the first scholars to propose the significance of innovation capability in organizational development. He believed that enterprises could only survive with innovation capability in volatile environment [23]. Innovation is the foundation and key for the organizational survival [24, 25]. According to different types of knowledge contained, abilities can be classified as the following: functional ability, the ability of enterprises used to develop technological knowledge [26]; and integration ability, the ability of enterprises to assimilate external knowledge and integrate different departments and different capacities. Innovative ability is in fact high-level integration ability [27]. Enterprises with innovative ability can integrate key resources and abilities to inspire innovation [28, 29]. Innovative ability is the ability to understand, develop and commercialize products, systems and processes. It exerts influence on the performance of enterprises after the industrial strategic inflection point. Some scholars maintain that if enterprises input too much time, capital and energy in innovative ability, they might the shortage of time, capital and energy in the development of existing production lines, resources and capabilities. Still some other scholars believe that if the innovative ability of enterprises is too far ahead, their market acceptance will be affected and their investment in innovation might be all in vain (e.g. Motorola's failure in iridium project), and consequently the performance of enterprises will be affected. Although in existing research there are different opinions regarding the relationship between innovative ability and performance, we maintain that the greater innovative ability enterprises have, the better performance will be achieved after the industrial strategic inflection point.

- The ability to comprehend the innovation of product, system and process can improve the performance of enterprises after the industrial strategic inflection point. The comprehension of product, system and process is virtually the perception of industrial development trend. This perception determines the thinking of an enterprise on what kind of product it should choose. The advent of the industrial strategic inflection point means fundamental change in the dominant industrial design. Thus, continued efforts in innovation in product, system and process enable enterprises to be environment change sensitive all the time and keep alert to environment alterations. Then they can create new products at suitable moments and take the lead in revolution. Or near the coming of industrial strategic inflection point, enterprises can make timely adjustment of their strategic directions so as to adapt themselves to changes. Enterprises with greater ability in innovation usually have more forward-looking and foresighted understanding of product, system and process, whereby they can promote performance after industrial strategic inflection point. Through more market research and development to understand customer, adopting flat organizational structure to maintain smooth information communication, and mastering abundant social network resources, enterprises with better innovative ability can achieve far better performance after the industrial strategic inflection point.

- The ability of innovatively developing product, system and process can help improve the performance of enterprises after industrial strategic inflection point. The innovation of product, process and system development is to implement the understanding of product, process and system within the organization. During the process of innovative development, the adjustments enterprises make to product, system and process based on market demand make enterprises more flexible, whereby enterprises can change timely at the dawn of strategic inflection point and consequently promote performance after it. By learning through doing, enterprises can improve their learning skills and reduce the negative impact of organizational inertia, constantly explore new paths based on existing resources and abilities or develop brand-new resources and abilities and set up real-time upgrading knowledge base, and find innovative staff and form innovation-orientated corporate culture. Enterprises with greater abilities in innovation will achieve better performance after the industrial strategic inflection point.
- The ability to commercialize innovation of product, system and process can improve enterprise performance after the industrial strategic inflection point. Market-oriented innovation of product, process and system refers to the process of commercializing the understanding and development of product, system and process and receiving market acceptance and recognition. The market is the standard to judge the properness of the understanding and development of product, system and process by enterprises, as well as the place in which enterprises implement innovation, take the lead in changes, feel the changes, and adapt themselves to changes.

As a result, we believe that the innovative ability is in positively correlated to performance after the industrial strategic inflection point, the greater the innovative ability, the better the performance after industrial strategic inflection point.

(2) Human capital and performance change after the “industrial strategic inflection point”

The concept of human capital originated from Petty [38] who maintained that people and land were all valuable, and values embodied in individuals are human capital. In later research, scholars proposed definitions of human capital based on capability and investment and integrated human capital. We will follow the definition by Shultz [30] which defined human capital as the combination of knowledge, skill and ability owned by employees of enterprises. Enterprises stressing human capital investment will have some drawbacks in the face of industrial transformation. Corporate training for human capital (enabling employees to develop following the expected directions as enterprises expect) such as regular technical training and aptitude test will make human capital focus on existing technological paradigm and make it difficult for them to timely sense and adapt to new industrial technology paradigm, which will to some extend weaken the ability of enterprises to perceive external changes. However, we believe that compared with enterprises lack of human capital, enterprises with high-quality human capital can have better performance after the industrial strategic inflection point.

- Possession of high-quality human capital means enterprises have more innovative and capable talents who are experts at different posts of the enterprises. The different knowledge and unique skills they own are the sources of corporate dominant knowledge base and also help build diversified knowledge structures for enterprises. Different knowledge structures enable enterprises to integrate knowledge of all fields when considering industrial competition plan for the future. Without being shackled by single knowledge structure, they can create strategic inflection point and take the lead in changes. When faced with fundamental transformation, these enterprises can look at changes from different perspectives and look for solutions in a wider scope, actively responding to change [31].
- With regard to high-quality human capital, the more abundant the knowledge is, the greater the creative ability. With stronger learning ability, high-quality employees are more readily to accept and understand new knowledge. Therefore, they are more flexible in terms of learning ability and absorption capacity. Before the advent of the industrial strategic inflection point, learning ability and absorption ability can help enterprises to predict and understand environment change more easily and timely learn and assimilate new knowledge to cope with change.
- Smart and capable employees are more willing to think and dare to question existing industrial dominant paradigm, shape enterprises' understanding of technology frontier, strengthen abilities of enterprises to absorb and distribute dominant knowledge, enabling enterprises to view industrial development from brand-new perspective, lead in change as well as adapt to change [32].
- Different people possess different social networks and interpersonal relations. High-quality human capital can bring enterprises high-quality, pluralistic social networks and relations that enable enterprises to keep extensive information exchanges, keep close watch on change in external environment, improve alertness level and timely sense the coming of strategic inflection point.
- High-quality human capital can provide enterprises with different thoughts. Before the advent of industrial strategic inflection point, the tension generated by the clashes of different thoughts enable enterprises to find opportunities to change, predict change and lead in change. Before the coming of strategic inflection point, different thoughts existing inside organization can help enterprises to form positive tension and organizational inertia tolerating conflicts, whereby enterprises can understand change more easily, transform timely and adapt to change.

Thus, with plural knowledge structure, relatively strong and resilient learning and absorbing abilities, with rethinking of industrial technology boundary and existing paradigm, with high-quality social network resources, and with the formation of positive tension and organizational inertia tolerating conflicts, enterprises with high-quality human capital can have better performance after the industrial strategic inflection point.

(3) Physical capital and performance change after the "industrial strategic inflection point"

Physical capital is the property owned by enterprises in the current mechanism, it is the sum total of all tangible assets of the enterprises which can be bought and sold. It refers to long-existing production material forms, such as machinery, equipment, workshops, buildings, transportation facilities, etc [33]. Physical capital is also the basis for corporate existence, providing necessary goods and facilities. Some studies suggest that enterprises with more abundant physical capital usually have greater production scale and capacity, and consequently greater market control [34]. When they experience industrial change, their performance will not be influence much. Yet, we believe that the more physical capital enterprises own, the worse performance they will have after the industrial strategic inflection point.

- The more investment in physical capital, the higher the sunk cost. At the time when industrial competition base experiences fundamental change, giving up possession of physical capital will undoubtedly increase the hidden costs in the transition, which will definitely reduce the motivation of enterprise transformation. Even aware of the coming of the strategic inflection point, enterprises of such kind are usually reluctant to fact the reality and change. Therefore, the existence of sunk cost causes worse performance after the industrial strategic inflection point for enterprises with seemingly abundant physical capital.
- Enterprises mainly depending on physical capital to create value and profit usually tend to pay more attention to investment in physical capital. In order to increase or maintain market share, they often keep on updating physical capital and technological level so as to constantly improve product quality and diversity. Yet, the coming of strategic inflection point means fundamental change of industrial competition base. Enterprises with lasting, quick and large amount of investment in "old" system are actually getting farther and father away from the "new" system. Thus, the superstition in the productivity of existing physical capital brings worse performance to enterprises with seemingly abundant physical capital after the industrial strategic inflection point.
- In enterprises with rich physical capital, the mental models of the top management are usually confined to existing success model based on physical capital and form organizational inertia. When industrial basis experience fundamental change, such enterprises often stick to the inherent mode of thinking, losing motivation to change and even obstructing change. Obviously, because the top management are confined to mental models based on existing physical capital, enterprises with seemingly more abundant physical capital will usually have worse performance after the industrial strategic inflection point.

So, with the existence of sunk cost, superstition in productivity based on the "old" system, as well as the adhesiveness of the mental models of the top management, enterprises with abundant physical capital will have worse performance after the industrial strategic inflection point.

(4) Slack resources and performance change after "industrial strategic inflection point"

Slack resources refer to potential resources that can be used in redirection or redistribution to help realize corporate development goals. There are different kinds of Slack resources, such as financial resources and social resources. There are also different forms of Slack resources, such as resources for free use or redirection and resources unable to be used freely or redirected. As to the significance of Slack resources to corporate development, there are different opinions in academic circle. Some scholars hold that the existence of Slack resources will increase the corporate cost for managing and storing them on the one hand, which requires rather strong corporate management capacity. Yet, according to X-Efficiency Theory, the enterprise itself has low efficiency in resource management, which will virtually increase the burden for the enterprise. On the other hand, excessive resources options will make it difficult for the management to choose correctly and effectively utilize existing resources. They might even make mistaken strategic decision due to optimism about abundant Slack resources. Still some other scholars argue that the influence of Slack resources on future corporate performance is unclear. Enterprises with excessive expenditure in declining industry will encounter negative impact of Slack resources on future corporate performance [35]. However, we maintain that Slack resources have positive impact on corporate performance. The more Slack resources enterprises possess, the better corporate performance after the industrial strategic inflection point.

- Enterprises with more Slack resources can loosen internal control to enable corporate R&D to have more project options and financial support. The enterprises have more resources to engage in experiment on new products and more chances to develop new products to achieve innovation. Particularly in declining industry, the more resources enterprises possess, the better their innovative ability [36]. Therefore, through test of new products and innovation, enterprises with rich Slack resources will have better performance after the industrial strategic inflection point.
- Enterprises with more Slack resources can enable the management to be more adventurous in decision-making due to the sufficiency and diversification of resources. They will proactively attempt to develop new products, create new market and implement new strategy. In an environment of uncertainty, they can be more prepared for industrial strategic inflection point, or even create industrial strategic inflection point to lead in change, or to timely sense the industrial strategic inflection point and adapt to change. Therefore, through promoting adventure spirit, enterprises with abundant Slack resources can have better performance after the industrial strategic inflection point.
- The management of enterprises with more Slack resources can have more options in making strategic decisions with greater elasticity. The vision of the management is not limited only to current products, market or industry. Indeed, they will proactively think about the future development road for the industry, instead of passively change with the coming of the industrial strategic inflection point. Although they cannot predict change, in the advent of industrial strategic inflection point, they can still proactively seek diversified and integrated solution and response due to the existence of Slack resources [37].

- Slack resources serve as a cushion for enterprises. The more Slack resources enterprises have, the more corporate ability they will possess to combat impact. At the time of drastic industrial transformation, Slack resources provide enterprises with practical or potential resources enabling them to have the opportunity and the ability to think and select or change measure and strategy to cope with change. Meanwhile, they also provide enterprises free space to rethink about resource distribution. Therefore, through increasing impact resistance, enterprises with rich Slack resources can have better performance after the industrial strategic inflection point.
- Enterprises with more Slack resources can have more resources to invest in information technology to make environment analysis. With strengthened information acquisition technology and more extensive sources of information, the enterprises can become more sensitive to internal as well as external changes. Therefore, through increasing sensitivity to environment, Slack resources can exert positive impact on enterprises after the industrial strategic inflection point.

Thus, through increasing new product tests and innovation opportunities, promoting adventure spirit of corporate management, providing diversified strategic decision-making, increasing corporate anti-impact ability, increasing sensitivity to environment through information technology, enterprises with more Slack resources will have better performance after the industrial strategic inflection point.

In summary, we believe that after the “industrial strategic inflection point”, enterprises with greater innovative ability, higher quality human capital and more Slack resources can have better performance; while those with more physical capital have poorer performance.

128.4 Conclusions and Implications

With resource-based view as its theoretical basis, this paper holds that some key resource factors of enterprises will affect their sustainable growth, i.e. the performance after the “industrial strategic inflection point”. To find out the resources that are key ones in influencing the performance of enterprises after the “industrial strategic inflection point”, as well as to analyze the relationship between the two, this paper chooses resource-based view based on neoclassical microeconomics theory, upon existing research, uses Delphi Method to select out four key resource factors influencing corporate performance after the “industrial strategic reflection point” i.e. innovative ability, human capital, physical capital and Slack resources. By combining related theories, this paper makes in-depth analysis of the influence of the four key resource factors on corporate performance after the “industrial strategic inflection point”. It maintains that enterprises with relatively stronger innovative ability, higher quality human capital and relatively abundant Slack resources can have better corporate performance after the “industrial strategic inflection point”; while enterprises with relatively more physical capital usually will have poorer corporate performance after the "industrial strategic inflection point", providing theoretical basis for further empirical research.

This paper has selected four key resource factors influencing sustainable corporate growth and analyzed deep from theoretical plane their relations with change of corporate performance after the "industrial strategic inflection point". In future studies, we will base on this to set up models and propose relevant research assumptions. Through empirical research and verification of assumptions, we will endeavor to identify key resource factors influencing the change of corporate performance after the "industrial strategic inflection point", analyze operable decision-making behavior and strategic change measures to store, formulate and integrate relevant resources for Chinese enterprises and provide meaningful guidance to help realize sustainable corporate growth through proactively responding to "industrial strategic inflection point".

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Chapter 129
Multi-objective Dynamic Layout Problems for Unequal-area Workshop Facilities Based on NSGA-II

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Abstract Workshop facility layout is directly related to the reasonable flow of the logistics and information of the entire production system, which has a great impact on production capacity and safety. For multi-type and batch production systems, it is a critical and complex issue for research and investigation. The production mode of mass customization asks for the dynamic, multi-objective and multi-constraints specifications of the workshop facilities layout problem. In this study, a multi-objective dynamic optimization model is established based on three optimization objectives including the total cost (the materials handling cost and the rearrangement cost), non-logistics strength relationship and the required total area. In order to find Pareto solutions, an adaptive non-dominated sorting multi-objective genetic algorithm is designed for the specific model. Finally, a numerical example is applied to demonstrate that the proposed method is quite effective.

Keywords Multi-objective dynamic layout problem · Workshop facilities · NSGA-II

129.1 Introduction

For multi-type and batch production systems, workshop facility layout problem (WFLP) is becoming increasingly important for affecting the production and operation efficiency [1]. Nowadays, researches on WFLP have been transformed from single objective static layout problems to multi-objective dynamic layout ones. In traditional WFLP, the facilities' layout in the manufacturing system is always assumed to be unchanged in a long period, which aimed to reduce the materials handling costs mainly through planning the item, the processing path, equipment and

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facilities etc. According to the statistics survey, a reasonable facility layout can reduce 10% $\sim$ 30% of the manufacturing costs, of which 20% $\sim$ 50% are materials handling costs [2]. In the mass customization production system, product demands fluctuate more often and product life-cycle becomes shorter, which lead to the fact that the re-layout of workshop facilities cycles are getting shorter for the minimum total cost (the materials handling cost and the rearrangement cost). It is recorded that 1/3 of the enterprises in the United States need to restructure the production workshop and layout [3]. In China, more and more enterprises set up the Departments of Industrial Engineering to design reasonable and economic layout for workshop facilities.

There mainly exist three methods for WFLP, including the experience layout, the combined quantitative and qualitative layout and the mathematical quantitative layout. Since there are many disadvantages in carrying out the layout planning in practical examples with the first two methods, many researches have been done in solving WFLP with mathematical quantitative methods. The basic idea of the mathematical quantitative layout method is to build the mathematical optimization model and solve it with an algorithm based on some assumptions. The mathematical optimization models are mainly composed of QAP models, Graph models and MIP models. These models are usually solved through operations research optimization methods, which are only suitable for small-scale single-objective WFLPs. When there are many workshop facilities, it becomes difficult to obtain the optimal solution with exact optimization methods, thus, the heuristic algorithms were developed to obtain satisfactory Pareto solutions, including genetic algorithms, ant colony algorithm and particle swarm optimization etc. Although many scholars have gained a lot in solving WFLPs with genetic algorithms, however, they mainly concentrated on single-objective WFLPs. Since WFLPs are meant to be multi-objective optimization problems, it is quite appropriate to adopt multi-objective genetic algorithms, including Multi-objective Genetic Algorithms (MOGA), Vector Evaluation Genetic Algorithms (VEGA), Niche Pareto Genetic Algorithm (NPGA), Strengthen Pareto Genetic algorithm (SPGA), Non-dominated Sorting Genetic Algorithm (NSGA). The NSGA is proposed by Srimivas and Deb in 1994, and it was pointed out that its performance is better than NPGA and VEGA some comparisons [4, 5]. NSGA-II was improved based on NSGA, which greatly improved the performance of the NSGA algorithm [6].

Based on the statement before, this study presents a multi-objective dynamic layout optimization method based on NSGA-II for workshop facilities with multi-rows and equal-rowledges. Sect. 129.2 will describes the characteristics of the multi-objective dynamic workshop facilities layout problem (MDWFLP). Sect. 129.3 establishes a multi-objective optimization model and Sect. 129.4 designs an adaptive NSGA-II algorithm to solve the proposed model. A numerical example will be illustrated in Sect. 129.5 to verify the effectiveness of the method and Sect. 129.6 concludes the paper with some future research recommendations.

129.2 Key Problem Statement

In order to solve the proposed MDWFLP through a mathematical modeling method, the problem's inherent characteristics must be reflected in the modeling and solving processes. The MDWFLP's characteristics can be mainly summarized as the following three parts.

129.2.1 Description on Multi-objective Characteristics

The layout optimization objectives mainly focus on reducing transporting distances, time or costs. With the researches on FLP continuing, a single-objective FLP cannot achieve the overall efficiency, thus, more and more scholars began to study the multi-objective layout problem. The FLP's objectives cover from the minimum material handling costs, the minimum facilities restructuring costs to the maximum utilization of facilities workshop area etc. In this study, the total costs including the material handling costs and the rearrangement cost, the logistics relationship strength and the total areas for the required working-units are proposed as the optimization objectives [1].

129.2.2 Description on Dynamic Characteristics

The dynamic characteristics for FLP are mainly reflected in the facilities' rearrangement and reconstruction. Due to the various material flows and information flows, the facilities in workshop have to be rearranged or re-built accordingly for saving costs for facilitating more production processes. Especially in the multi-type and batch production systems, different facilities are often required for producing products at different periods. In this study, the facilities' rearrangements at different periods are taken into consideration [1].

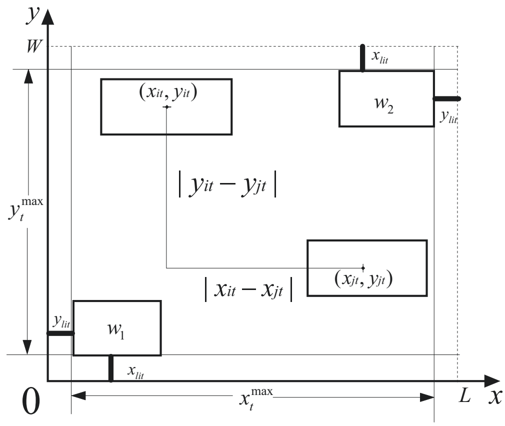
129.2.3 Description on Multi-constraints Characteristics

There are many constraints for MDWFLPs, which have to be taken into consideration while obtaining Pareto solutions. These constraints mainly include (1) space constraints, such as workshop's allocation, facilities amount; (2) location constraints, for example, facilities cannot overlap and the direction of facilities should be right etc.; (3) budget constraint, that is, for the whole MDWFLP, the total costs have to be within a certain amount; (4) equilibrium constraints, which means that the facilities' amount in a new period is equal to that of the previous period add or delete a facilities' amount; (5) coupling constraint, which means the rearrangement costs happens when any facilities need to be relocated at the beginning of a new period; (6) time constraints, such as machine production capacity, facilities reconstruction, production delay. All these constraints will have effect on the final solutions [1].

129.3 Modelling

According to the problem statement before, a multi-objective mathematical formulation is presented for the MODWFLP. First, the assumptions and the notations are given as follows, and Fig. 129.1 denotes some parameters correspondingly.

Fig. 129.1 Parameters representations used in this study



129.3.1 Assumption

- The rowledges of all the working-units are assumed to be equal.
- The horizontal distance from the leftmost and the rightmost working-units to the wall are assumed to be equal at different periods, and The horizontal distance from the upmost and the downmost working-units to the wall are assumed to be equal at different periods.
- The transporting costs to transport materials between working-units are assumed to be equal.
- The arrangement cost for all the working-units are different.

129.3.2 Notations

Subscripts and sets

Ω : Set of the working-units, $i, j \in \Omega = \{1, 2, \cdots, N\}$;
Φ : Sets of periods, $t \in \Phi = \{1, 2, \cdots, T\}$;

Parameters

L, W	:	the length and the width of the plant floor;
N	:	the total number of the working-units;
r	:	the planning rows for all the working-units;
(l_{it}, w_{it})	:	the length and width of working-unit i at period t, $w_{it} = w_{jt}$;
(x_{ijt}, y_{ijt})	:	the horizontal and vertical distance between the centers of working-units i and j at period t;
x_{lit}	:	the horizontal distance from the leftmost and the rightmost working-units to the wall at period t;
y_{lit}	:	the vertical distance from the upmost and the downmost working-units to the wall at period t;
$(x_t^{\max}, y_t^{\max})$	:	the maximum horizontal and vertical distance for all the working-units planning at period t;
c_{ijt}	:	the unit transporting cost between working-units i and j at period t, $c_{ij1} = c_{ij2}$, and C denotes the unit transporting cost matrix;
d_{ijt}	:	the rectilinear distance between working-units i and j at period t, and D denotes the distance matrix;
q_{ijt}	:	the logistics quantity between working-units i and j at period t, and Q denotes the logistics quantity matrix;
a_{ijt}	:	the adjacency degree between working-units i and j at period t, and A denotes the adjacency matrix;
r_{ijt}	:	the relevancy degree between working-units i and j at period t, and R denotes the relevancy matrix;
R_{it}	:	the arrangement cost for rearranging working-unit i at period t;

Variables

$$(x_{it}, y_{it}, r_{it}) \begin{cases} (x_{it}, y_{it}) : & \text{the coordinates of working} - \text{unit } i \text{ at period } t; \\ r_{ti} & = \begin{cases} 1, \text{ which means working-unit } i \text{ is rearranged at the} \\ \quad \text{beginning of period } t, \\ 0, \quad \text{otherwise.} \end{cases} \end{cases}$$

129.3.3 Global Optimization Model for MODWFLP

Based on multi-type and batch production systems' requirements, the total cost minimization is put forward as the first optimization objective in Equation (129.1). In the study, two decisive parts are taken into account, including the materials' transporting costs and the rearrangement costs in different periods, both of which are important while planning the MODWFLP. Secondly, it is necessary to put relevant working-units together so as to facilitate the production and supervision operations. In this case, the logistics relevancy maximization is proposed as the second objective, in which the multiple of the adjacency degree and the relevancy degree between working-units i and j is applied as the measurement in Equation (129.2). In order to make the calculation process less complicated, the adjacency degree between any two working-units is transformed as $a_{ijt} = 1$ when $d_{ijt} \in \left(0, \frac{d_t^{\max}}{6}\right]$; $a_{ijt} = 0.8$ when $d_{ijt} \in \left(\frac{d_t^{\max}}{6}, \frac{d_t^{\max}}{3}\right]$; $a_{ijt} = 0.6$ when $d_{ijt} \in \left(\frac{d_t^{\max}}{3}, \frac{d_t^{\max}}{2}\right]$; $a_{ijt} = 0.4$ when $d_{ijt} \in \left(\frac{d_t^{\max}}{2}, \frac{2d_t^{\max}}{3}\right]$; $a_{ijt} = 0.2$ when $d_{ijt} \in \left(\frac{2d_t^{\max}}{3}, \frac{5d_t^{\max}}{6}\right]$ and $a_{ijt} = 0$ when $d_{ijt} \in \left(\frac{5d_t^{\max}}{6}, d_t^{\max}\right]$ [7]. Besides, production systems' attempts to maximize the workshop utilization. An appropriate workshop facility layout can develop the production systems' efficiency and save the workshop investment cost. Thus, the minimization of the workshop's total area is presented as the third objective in Equation (129.3). In order to achieve optimal feasible solutions for the proposed MODWFLP, some constraints have to be met, including the non-overlapping constraints in Equations (129.4) $\sim$ (129.6) which prevent the overlap of any working-units, the area constraints in Equations (129.7) $\sim$ (129.8) which ensure that the facilities are within the boundaries of the workshop, the rectilinear distances constraints in Equations (129.9) $\sim$ (129.12) which determine that the distances between any two working-units are rectilinear. In addition, Equation (129.13) represents the rectilinear distance between any two working-units in Equation (129.1) and the Equation (129.14) is applied to transform the distances between working-units into the adjacency degrees. Finally, non-negative constraints in Equations (129.15) $\sim$ (129.17) is proposed to obtain non-negative variables.

Based on the descriptions above, the whole optimization model for the MODWFLP can be formulated as follows:

$$\min f_1 = \sum_{t=1}^{T}\sum_{i=1}^{N}\sum_{j=1}^{N} c_{ijt} \times q_{ijt} \times d_{ijt} + \sum_{t=2}^{T}\sum_{i=1}^{N} R_{ti} r_{ti}, \tag{129.1}$$

$$\max f_2 = \sum_{t=1}^{T}\sum_{i=1}^{N}\sum_{j=1}^{N} a_{ijt} \times r_{ijt}, \tag{129.2}$$

$$\min f_3 = \sum_{t=1}^{T} x_t^{\max} \times x_t^{\max}, \tag{129.3}$$

subject to

$$X_{ijt} \geq \frac{1}{2}(l_{it} + l_{jt}) - |x_{it} - x_{jt}|, 1 \leq i < j \leq N, \tag{129.4}$$

$$Y_{ijt} \geq \frac{1}{2}(w_{it} + w_{jt}) - |y_{it} - y_{jt}|, 1 \leq i < j \leq N, \tag{129.5}$$

$$X_{ijt} Y_{ijt} = 0, X_{ijt} \geq 0 \ \ and \ \ Y_{ijt} \geq 0, 1 \leq i < j \leq N, \tag{129.6}$$

$$x_t^{\max} \le L, \tag{129.7}$$
$$y_t^{\max} \le W, \tag{129.8}$$
$$x_{pijt} \ge x_{it} - x_{jt}, \forall i, j > i, \tag{129.9}$$
$$x_{pijt} \ge x_{jt} - x_{it}, \forall i, j > i, \tag{129.10}$$
$$y_{pijt} \ge y_{it} - y_{jt}, \forall i, j > i, \tag{129.11}$$
$$y_{pijt} \ge y_{jt} - y_{it}, \forall i, j > i, \tag{129.12}$$
$$d_{ijt} = |x_{it} - x_{jt}| + |y_{it} - y_{jt}|, \tag{129.13}$$
$$d_t^{\max} = L + W - 2(x_{lit} + y_{lit}), \tag{129.14}$$
$$x_{it}, y_{it}, l_{it}, w_{it} \ge 0, \forall t, i, \tag{129.15}$$
$$x_{pijt}, y_{pijt} > 0, \tag{129.16}$$
$$r_{it} = 0 \ \ or \ 1. \tag{129.17}$$

129.4 Adaptive Non-dominated Sorting Genetic Algorithm-II Technique for MODWFLP

Layout problems for unequal-area facilities have been proven to be NP-hard problems, thus, some traditional exact algorithms are proven to be inapplicable for the large-scale layout problems. In this study, the adaptive Non-dominated Sorting Genetic Algorithm-II (ANSGA-II) technique, a multi-objective optimization algorithm, is applied to obtain satisfactory solutions for MODWFLP. Numerous researchers have used it for many multi-objective problems with fast non-dominated sorting approach, fast crowded distance estimation procedure and simple crowded comparison operator [7–9]. Based on the standard NSGA-II's procedures and the MODWFLP's characteristics, the proposed ANSGA-II will make some adjustments in the calculation process, the encoding method, the population initialization and the evolution process etc. Therefore, the flowchart of the ANSGA-II can be illustrated as follows:

Step 1. Define population size (*Popsize*), crossover rate (*CR*), mutation rate (*MR*), and generations amount (T), and initialize $t = 1$.

Step 2. Generate the initial feasible population P_t. The layout planning is determined when the workshop facility rows and the working-units' sequence are decided. Thus, $P = [(h_1, h_2, \cdots, h_{row-1}), (w_1, w_2, \cdots, w_M)]$ is used to encode the individuals.

Step 3. For each individual, decode the distance matrix D and adjacency matrix A and evaluate f_1, f_2 and f_3.

Step 4. Rank all individuals based on their non-dominant values.

Step 5. Calculate the crowding distances for all individuals in P_1.

Step 6. Execute the selection operation with the roulette mechanism.

Step 7. Execute the Execute crossover and mutation operations to create new *Popsize* individuals Q_t. Then, set $t = t + 1$.

Step 8. Evaluate f_1, f_2 and f_3 for each individual in R_t.

Step 9. Combine the initial individual P_t with the new individuals Q_t to produce the intermediate population R_t.
Step 10. Rank the individuals and calculate the crowding distances in $R(t)$.
Step 11. Determine the Pareto set at the current generation t based on the rank values and the crowding distances.
Step 12. If $t < T$, NSGA-II goes to Step 6 and set $t = t+1$; otherwise, the algorithm stops and outputs the Pareto set.

129.5 Numerical Example

In order to demonstrate the efficiency of the proposed method, an example from a multi-type and batch production workshop with 7 working-units, 3 rows and 3 periods is tested in Matlab 7.0. Besides, $L = 60$, $W = 25$, $x_{lit} = y_{lit} = 2$. For all working-units, $c_{ijt} = 1$ when $i \neq j$, $c_{ijt} = 0$ when $i = j$ and $R_{1t} = 95$, $R_{2t} = 70$, $R_{3t} = 45$, $R_{4t} = 75$, $R_{5t} = 65$, $R_{6t} = 80$, $R_{7t} = 35$. More relevant data are collected in Tabs. 1∼3. It should be noted that Popsize= 50, $T = 200$, $SR = 0.7$, $CR = 0.5$ and $MR = 0.6$. At last, some evolved Pareto solutions set will be obtained, which provide choices for decision makers to select satisfactory to carry out the layout planning.

Table 129.1 Working-units' lengths and widths at different periods

Periods	Period 1							Period 2							Period 3						
Working-units No.	1	2	3	4	5	6	7	1	2	3	4	5	6	7	1	2	3	4	5	6	7
Length	10	8	6	12	7	6	0	10	8	12	6	0	0	8	10	10	12	6	7	6	8
Width	5	5	5	5	5	5	0	5	5	5	5	0	0	5	5	5	5	5	5	5	5

Based on the method and the collected data, some evolved Pareto solutions are achieved. For example, (1) $f_1 = 1554714.68$, $f_2 = 1968.4$, $f_3 = 75.3$; (2) $f_1 = 1446573.55$, $f_2 = 69.8$, $f_3 = 2003.5$; (3) $f_1 = 1446872.55$, $f_2 = 71.4$, $f_3 = 2015.6$.

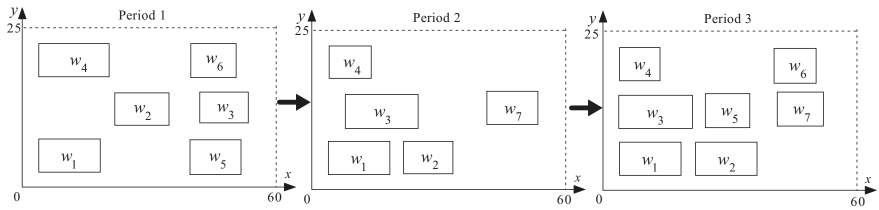


Fig. 129.2 Layout planning for MDWFLP's Pareto solution (1)

Table 129.2 The logistics quantity between working-units i and j at period t

Working-units		Working-units No.							Working-units No.						
		1	2	3	4	5	6	7	1	2	3	4	5	6	7
Working-units No.	1	–	15320	9600	4235	5570	0	0	–	8970	8225	0	0	0	6550
	2	–	–	15475	4690	5460	3795	0	–	–	8765	6630	0	0	5675
	3	–	–	–	0	0	5765	0	–	–	–	9850	0	0	4690
	4	–	–	–	–	4550	3570	0	–	–	–	–	0	0	3995
	5	–	–	–	–	–	2560	0	–	–	–	–	–	0	6770
	6	–	–	–	–	–	–	0	–	–	–	–	–	–	4115
	7	–	–	–	–	–	–	–	–	–	–	–	–	–	–

Working-units		Working-units No.						
		1	2	3	4	5	6	7
Working-units No.	1	–	14560	4655	3180	5400	4335	7640
	2	–	–	6950	5595	3795	6695	7850
	3	–	–	–	5570	9840	4495	7950
	4	–	–	–	–	3595	6990	4775
	5	–	–	–	–	–	4775	4990
	6	–	–	–	–	–	–	3995
	7	–	–	–	–	–	–	–

Table 129.3 The rectilinear distance between working-units i and j at period t

Working-units		Working-units No.							Working-units No.							Working-units No.						
		1	2	3	4	5	6	7	1	2	3	4	5	6	7	1	2	3	4	5	6	7
Working-units No.	1	–	27	17	15	18	6	7	–	25	18	14	18	6	7	–	28	19	16	12	6	7
	2	–	–	16	12	8	10	5	–	–	15	14	8	10	5	–	–	12	12	8	10	5
	3	–	–	–	7	6	5	9	–	–	–	8	5	14	15	–	–	–	13	15	12	12
	4	–	–	–	–	12	10	9	–	–	–	–	14	13	15	–	–	–	–	15	11	12
	5	–	–	–	–	–	15	10	–	–	–	–	–	7	15	–	–	–	–	–	16	13
	6	–	–	–	–	–	–	12	–	–	–	–	–	–	8	–	–	–	–	–	–	13
	7	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–

Corresponding to Pareto solution (1), Fig. 129.2 shows the feasible layout planning for the multi-type and batch production workshop at three different periods.

129.6 Conclusions and Future Research

This study proposed a multi-objective dynamic layout optimization method based on NSGA-II for workshop facilities with multi-rows and equal-rowledges. In order to achieve satisfactory solutions, an adaptive NSGA-II was developed. It was reflected from the numerical example that the proposed method was effective in solving MDFLPs and was proved to have some contributions in practical engineering applications. However, researches on MDWFLPs are still continuing, thus, some future researches recommendations are given as follows:

To begin with, few researches on MDWPLPs take human factors into consideration. In fact, human judgments are usually involved in the layout process. In this case, uncertainty theory can be introduced to handle some subjective and objective uncertainties.

Besides, it is common that the MDWFLPs were solved through a single algorithm, and there are only few researches on hybrid algorithms. The hybrid algorithms can eliminate or diminish the shortcomings of each algorithm and solve the problems better. Thus, it should be a new research area of combining different intelligent algorithms into hybrid algorithms for solving MDWFLPs.

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Chapter 130
Applied Graph Theory & Topology for 3 Phase Power System Under Faulted Studies

Tedja Santanoe Oepomo

Abstract This manuscript will provide a step by step method on how a graph theory and topology can be utilized to construct a Z-loop matrix for the study of faulted 3 phase power systems. The growing demand for reliable electrical power supply has forced the pace developments in electrical power system analysis using computer. In this, power system analysis plays a significant role for the analysis of faulted power system, eventually for power system protection and control. By applying theoretical rules in graph theory, an algorithm to construct Z-loop without generating loop incidence matrix for network analysis/circuit analysis was studied. It has more than just minor special cases with those used in network analysis and circuit computer design. This paper describes a new algorithm to construct a loop impedance matrix without generating loop incidence matrix by means of a certain topological relationship, linear graph, or simply graph theory. A linear graph is a graph in which edges/branches are connected only at the points, which are identified as nodes of the graph. Finally numerical sample project was presented by the use of the loop impedance matrix to solve network analysis studies.

Keywords Power system · Faulted studies · Graph theory · Topology · Z-loop construction

130.1 Introduction

In the year 1847 G. Kirchoff published the paper in which he uses graph theoretical concepts to characterize electrical network. Since then, graph theory has been used in electrical network theory and analysis. An electrical network system is a collection of physical components and devices interconnected electrically. Thus, network

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analysis, the basis of network theory, plays a central and essential role in system analysis. By an electrical network or simply a network, we mean a representation of a system as a set of interconnected idealized components or devices characterized in terms of voltage source associated with them. Since network elements are idealized approximations of physical devices and systems, in order for them to represent various properties they must obey the Kirkchhoff laws of voltages and currents. Thus, for our present purpose it will be sufficient for us to use a graphical representation of any network in terms of line segments or arcs called edges or branches and points called nodes or terminals, as long as, it is an accurate replica of the relationships of currents and voltages throughout the network.

The ease of handling mutual inductance coupling especially raises interest in the loop analysis approach. The formation of loop current equations by analyst is of course a possibility, but this involves considerable time and effort for large network systems.

The motives lead to exploring the possibility of forming loop current relationship from raw system of data using a PC. As will be seen shortly, the heart of the matter is concerned with the generation of a matrix, which contains in useable form the information regarding network configuration, which is required to establish the required number of independent loop equations. The logic required obtaining such a matrix be described for general network system configuration.

In developing a procedure for finding network relations by topological methods, we are solely interested in the network geometry and, therefore, represent all elements as lines with small circle at the ends to designate the terminals. Such representation is called a graph of the network. The graphs with which we will be concerned consist of these lines, which we call branches or edges, and the small circle, which we refer to as nodes, as in Fig. 130.1, which shows a typical network graph. To apply the Kirchoff laws to edges/branch voltages and currents we need to interpret these laws in geometrical and algebraic language. In a current graph the net current intersecting any node is zero, as a function of time. While, in a voltage graph the net voltage around any loop is zero, as a function of time.

130.1.1 Over View of Graph Theory

By stating these laws in terms of function of time, we allow for the possible of generalized functions; that is, the net current or voltage is zero in the distribution sense. Applying this convention to the net current around node 1 in Fig. 130.1, the current law yields that [2, 3, 19]:

$$-i_{10-1} + i_{1-9} - i_{4-1} + i_{1-6} = 0, \tag{130.1}$$

where a positive sign indicates that currents are assumed to flow from the low numbered node to the high numbered node in each branch/edge and a negative sign indicates that currents are assumed to flow from the high numbered node to the low numbered node in each branch/edge.

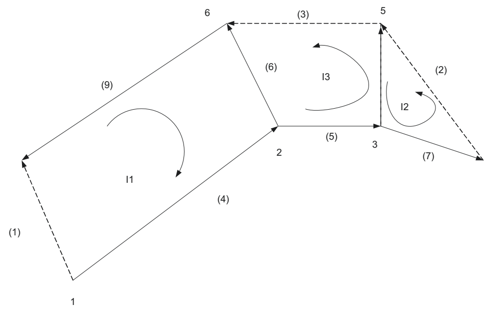


Fig. 130.1 Circuit illustrating properties of graph of a network

130.1.2 Statement of the Problem

The following paragraph is used to show a very simple power system network and how the graph theory is used to develop the algorithm to construct Z-loop and then using it for calculating currents and voltages when a node or bus at that power system network is faulted. The power system network in Fig. 130.2 is used to perform our analysis. It is significant to know that there is no difference in the problem encountered in 3-phase and single point-to-ground fault calculations, other than that inductive mutual coupling is normally negligible in the positive-sequence network but not in the zero sequence network.

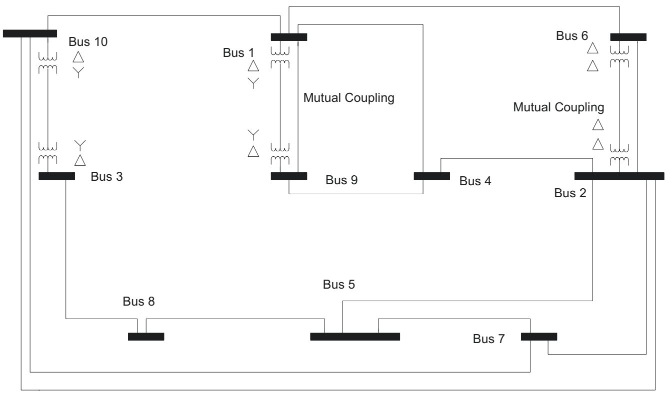


Fig. 130.2 Typical power system network

To simplify our analysis, the above-mentioned Fig. 130.2 can be used as an example to figure out how the new algorithm can be applied. Fig. 130.2 shows a typical power system; further observation of Fig. 130.2 indicates that Fig. 130.3 is a one-line diagram or network graph of Fig. 130.2 [7, 8, 13, 18].

130.1.3 Z-loop Construction Algorithm

The procedure to be followed in constructing a loop-circuit network by rows consists of three parts. The first part is concerned with the construction of Table 130.1 in which the node numbers are chosen in numerical order. The second part is concerned with the separation of the network edges/branches into tables of tree branches/edges, Table 130.2, and of link branches/edges, Table 130.3. The last part is concerned with the formation of Table 130.4 from the previous Tables. In this last table, we will find all nodes numbers that have been used in Table 130.2, tree branches/edges. The method of selection of links and tree branches/edges is the same regardless of the complexity of the electrical system network and the same PC computer software will solve the problem for all cases. The concepts that must be kept in mind in analyzing the data are best explained by using a specific configuration as indicated in Fig. 130.3.

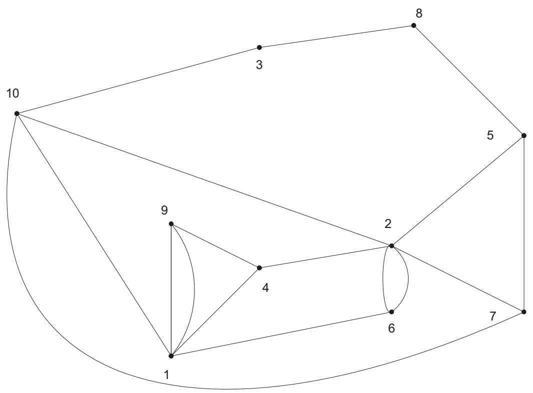


Fig. 130.3 Network graph showing edges/branches and nodes for Fig. 130.2

130.2 A Z-loop Construction Algorithm

The procedure to be followed in constructing a loop-circuit network by rows consists of three parts. The first part is concerned with the construction of Table 130.1 in which the node numbers are chosen in numerical order. The second part is concerned with the separation of the network edges/branches into tables of tree branches/edges, Table 130.2, and of link branches/edges, Table 130.3. The last part is concerned with the formation of Table 130.4 from the previous Tables. In Table 130.4, we will find all nodes numbers that have been used in Table 130.2, tree branches/edges. The method of selection of links and tree branches/edges is the same regardless of the complexity of the electrical system network and the same PC computer software will solve the problem for all cases. The concepts that must be kept in mind in analysing the data are best explained by using a specific configuration as indicated in Fig. 130.3 [3, 4, 9].

Table 130.1 Ordered list of node numbers

First node	Second node	Line number	First node	Second node	Line number
1	4	0	2	7	0
1	6	0	2	10	0
1	9	0	3	8	0
1	9	1	3	10	0
1	10	0	4	9	0
2	4	0	5	7	0
2	5	0	5	8	0
2	6	0	7	10	0
2	6	1			

Table 130.2 Tree branches/edges

First node	Second node	Line number
1	4	0
1	6	0
1	9	0
1	10	0
2	4	0
7	10	0
2	5	0
3	8	0

130.2.1 Formation of Table 130.1

Each branch/edge is listed just once, with the lower numbered node being listed first and the higher numbered node second. This in effect will set up the positive direction for every branch/edge, as we will consider the positive direction to be from the lower numbered node to the higher numbered node. Further, it should be noted that in listing the branches/edges of Table 130.1, we first choose all branches/edges emanating from node 1, then all those from node 2, then 3, etc. In the scramble input data, the line numbers are zero when there are no parallel lines. The numbers are positive integer if there are other lines parallel to the first one (see Fig. 130.4).

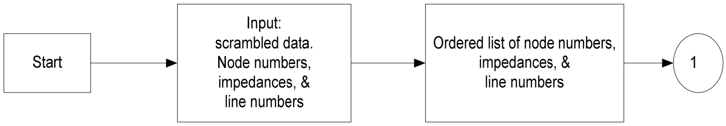


Fig. 130.4 Flow diagram for formation of Table 130.1

130.2.2 Formation of Table 130.2, Table 130.3, and Table 130.4

Having form Table 130.1, we prepare to construct Tables 130.2 $\sim$ 130.4. Table 130.2 is the listing of tree branches/edges, Table 130.3 contains link branches/edges, and Table 130.4 is an auxiliary device that is used to establish the order in which successive nodes are examined. Begin by saying that all branches/edges from node 1 are tree branches/edges and must be listed in Table 130.2 unless there are parallel branches/edges. Since there is parallel branches/edges between node 1 and 9, the second 1 and 9 branch/edges closes a loop, so it must be listed as a link branch/edge in Table 130.3. In Table 130.4, we now place number 4, 6, and 9, which are the new nodes we meet in moving along the foregoing branches/edges.

Table 130.3 Link branches/edges

First node	Second node	Line number
1	9	1
4	9	0
2	6	0
2	6	1
2	10	0
2	7	0
5	7	0
5	8	0

Table 130.4 Additional device

V	V	V	V	V	V	V	V	V
4	6	9	10	2	3	7	5	8

We now consider the first new node we have encountered, namely 4, which is listed first in Table 130.4. We go back to Table 130.1, ignoring node 1 since branches/edges through node 1 have already been accounted for, and hunt for all branches/edges through 4. The first one we find is branch/edge 2 4. Since node 2 has not been used before, branch 2 4, which connects 2 and 4, cannot possibly close a loop. It is therefore entered in Table 130.2 as a tree branch. Node 2 is placed in Table 130.4 just to the right of node 10. The next branch/edge is 4 9. Remember that node 9 appears to the right of 4 in Table 130.4 and therefore we have previously used node 9; 4 9 must close a loop, so it is a link and should be entered on Table 130.3. There are no more 4's in Table 130.1, so we never have to consider 4 again. This is shown in Table 130.4 by putting a check mark above the 4.

The next node in Table 130.4 is 6, so we will return to Table 130.1 to find all branches/edges through node 6. Again we ignore 1's. The first branch containing a 6 is 2 6, but Number 4 appears to the right of 6 in Table 130.4; therefore, both nodes 2 and 6 have been encountered before, so 2 6 is entered as a link in Table 130.3. The next 6 is encountered as 2 6, which is parallel branch/edge to the first 2 6 branch; therefore, it is too must be entered into Table 130.3 as a link. There are no more 6's, so a check mark is put in the first line of Table 130.4 above 6.

The next number appearing in Table 130.4 is 9, so we must find all 9's in Table 130.1. The first 9 appears is 4 9. Now since 4 appears to the left of 9 in Table 130.4, branch/edge 4 9 has been considered before, so it should be passed over. We have now exhausted the 9's, so we check off 9 in Table 130.4 and pick up the next number appearing there.

We must now find all 10's appearing in Table 130.1. We first encounter 2 10, 2 appears to the right of 10 in Table 130.4, therefore, 2 10 must be entered in Table 130.3 as a link. The next 10 in Table 130.1 appears as 3 10; since node 3 does not appear in Table 130.4, it is written in Table 130.4 and branch/edge 3 10 is entered into Table 130.2 as a tree branch/edge. The next 10 appears in Table 130.1 as 7 10; the branch 7 does not appear in Table 130.4, so it is written in Table 130.4, and branch/edge 7 10 entered into Table 130.2 as a tree branch/edge. This exhausts the 10's, so a check is placed above the 10 in Table 130.4.

In the foregoing manner, we now consider all the 2's in Table 130.1, then all 3's, 7's, 5's and 8's. Table 130.3 now contains all the link branches/edges and Table 130.2 contains all the tree branches/edges. Fig. 130.3 is redrawn in Fig. 130.5. In Fig. 130.5, the tree branches are indicated in solid lines and the link branches as dotted line.

130.2.3 Procedure for Selecting Loops

The attempt to find logic for the formation of loops in many ways seems more natural than attempting to find logic for formation of a loop incidence matrix by columns or rows. The author has studied this method and presents the result of these studies in the following paragraph. To begin, the information on Table 130.2 and

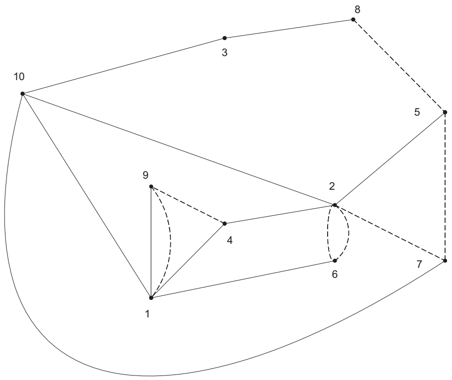


Fig. 130.5 Link and tree edges/branches. Note: Solid lines are tree branches/edges; dashes lines are link branches/edges

Table 130.3 is used in the construction of the loops. The block of data in Table 130.2 and Table 130.3 simply show for each node of the network, the manner in which that node is connected to other nodes. For instance node 1 is connected to node 9 by link branch/edge 1 9, and node 5 is connected to node 7 by link branch/edge 5 7.

It was stated earlier that the positive direction for current, voltage drop, or voltage source will be assumed to be from the low numbered node to the high numbered node for every link branch/edge as well as tree branch/edge. Begin at the top of Table 130.3 and note that node 1 is connected to node 9 by means of link branch/edge 1 9. Then hunt for a tree branch/edge through node 9 in Table 130.2. Obviously, the tree branch/edge 1 9 does not close a loop because the first number of the link branch/edge 1 9 is equal to the last node number of the last tree branch/edge. After this, we choose a second link branch/edge, that is, link branch/edge 4 9, then hunt for a tree branch/edge through node 9 in Table 130.2. We get a tree branch/edge 9 1. Obviously, tree branch/edge 9 1 has not yet closed a loop, so we hunt for a second tree branch/edge through node 1 in Table 130.2. Obviously, tree branch/edge 1 4 close a loop because the first node number of the link branch/edge 4 9 is equal to that last node number of the last tree branch/edge, 1 4. Finally we get Table 130.5.

130.2.4 Algorithm for Generation of the Loop Incidence Matrix

The product $C^t Z_{bb} C$ usually generates the loop impedance matrix Z_{loop} so the matrix multiplication must be carried out in this case. By use of certain topological relationship and the fact that the transforming matrix is a loop incidence matrix where only 1, -1, and/or 0 can appear as elements, a set of theoretical rule can be stated for the generation of this matrix avoiding matrix multiplication. Compared with the conventional generation by multiplication of $C^t Z_{bb} C$, a set-theoretical generation of the loop impedance matrix in a PC affords many important advantages, such as reduction in memory and mathematical operations.

(1) Without mutual coupling

Table 130.5 Loop table

First node	Second node	Line number	First node	Second node	Line number
Loop 1:			Loop 2:		
1	9	1	4	9	0
9	1	0	9	1	0
1	4	0	1	4	0
Loop 3:			Loop 4:		
2	6	0	2	6	1
6	1	0	6	1	0
1	4	0	1	4	0
4	2	0	4	2	0
Loop 5:			Loop 6:		
2	10	0	2	7	0
10	1	0	7	10	0
1	4	0	10	1	0
4	2	0	1	4	0
			4	2	0
Loop 7:			Loop 8:		
5	7	0	5	8	0
7	10	0	8	3	0
10	1	0	3	10	0
1	4	0	10	1	0
4	2	0	1	4	0
2	5	0	4	2	0
			2	5	0

which are, at the same time, the currents in the connecting branches/edges. The matrix of the set of independent equations is the loop impedance matrix Z_{loop}. With aid of the branch loop incidence matrix C, The object of the loop method is to form a set of independent equations for the vector of the loop currents i, this matrix can be calculated in accordance with the following equation from the branch impedance matrix Z_{bb}, whose diagonal elements are the impedance of the individual branches/edges and otherwise contain only zero:

$$Z_{\text{loop}} = C^t Z_{bb} C. \tag{130.2}$$

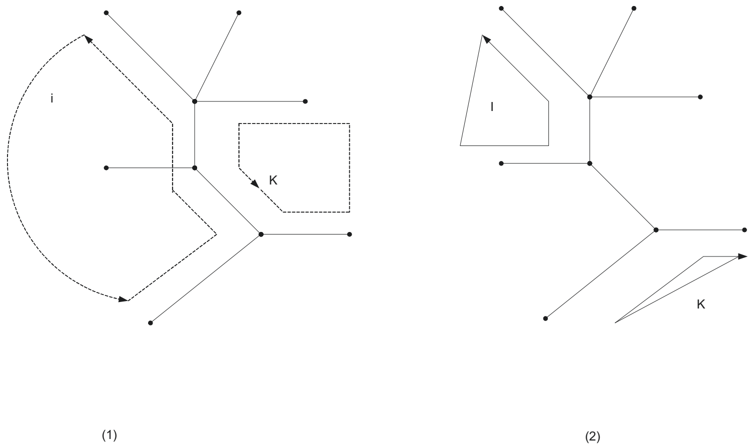
That means that Z_{loop} is produced by a multiplication with the branch/edge loop incidence matrix C. C is defined as: numbers $+1$, -1, or 0 are to be entered in the i^{th} row and j^{th} column, depending on whether, in the j^{th} loop, the i^{th} branch/edge has the same or opposite direction with respect to the loop or is not contained in it. Since the individual element of the loop impedance matrix Z_{loop} is calculated in accordance to the equation:

$$Z_{\text{loop}}^{i,k} = \sum_{r=1}^{b} C_{r,i} Z_{bb} C_{r,k}. \tag{130.3}$$

Taking into account the fact that in Z_{bb}, only the diagonal elements differ from zero. Z_{loop} receives a contribution in the sum of the right-hand side only when both incidence matrix element $C_{r,i}$ and $C_{r,k}$ are not equal to zero. The incidence element $C_{r,i}$ and $C_{r,k}$ describe the mutual orientation of i^{th} the and the k^{th} loops with respect to r^{th} the branch/edge. It is interesting to know that this mutual coordination, where it exists, that is, where there is branch/edge common to both loops, is for topological reasons independent of the branch/edge considered.

The rules for determination of element $Z_{i,k}$ would be as follows:
(a) In the main diagonal, the element $Z_{i,k}$ is equal to the sum of all impedance, which belongs to i^{th} loop — self-impedance.
(b) Off the main diagonal, the element $Z_{i,k} = Z_{k,i}$ is equal to the algebraic sum of all tree impedance, which simultaneously belongs to i^{th} and k^{th} loops. The sign of the particular tree branch/edge in this sum is either positive or negative, depending on whether the i^{th} or k^{th} loops run in the same or opposite directions to each other through particular tree impedance — self impedance.

Since for a given loop pair - i^{th} and k^{th} loop — mutual orientation is independent of the branch/edge common to them. There is a loop-loop incidence matrix M whose elements are numbers 1, -1, or 0. Those elements are to be entered in the i^{th} row and the k^{th} column, depending on whether they are via the part common to the k^{th} and i^{th} the loops — both loops have the same or opposite orientation or no common part of both loops (see Fig. 130.6).



(1) The i^{th} and the k^{th} loops have two tree branches/edges in common. Since loop orientation runs along these two edges/branches in the opposite direction, therefore the sign for $m_{i,k} = -1$.
(2) The i^{th} and the k^{th} loops have no tree branches/edges in common; therefore $m_{i,k} = 0$.

Fig. 130.6 Generating a loop impedance matrix

The element of the loop-loop incidence matrix M, located in the i^{th} row and k^{th} column, can also be determined by calculation from the equation:

$$m_{i,k} = m_{k,j} = \operatorname{sign}\left(\sum_{r=1}^{b} C_{r,i} C_{r,k}\right). \tag{130.4}$$

If $m_i(Z_{bb})$ is the set of all impedance Z_{bb} contained in the i^{th} loop, the intersection $m_i(Z_{bb})\Omega m_k(Z_{bb})$ is the set of all impedance contained simultaneously.

The rule for determination of $Z_{i,k}$ in accordance with Equation (130.2) can be replaced, set theoretically, by the following rule using the matrix M:

$$Z_{\text{loop}} = m_{i,k} \sum_{r=1}^{b} (m_i(Z_{bb})\Omega m_k(Z_{bb})). \tag{130.5}$$

(2) With mutual coupling

Let us now consider the following configuration. In the first step, we will consider only the impact of mutual coupling. Suppose we have two loops, the i^{th} loop and the k^{th} loop, of a network or circuit. These two loops arrangement are depicted in Table 130.6 below.

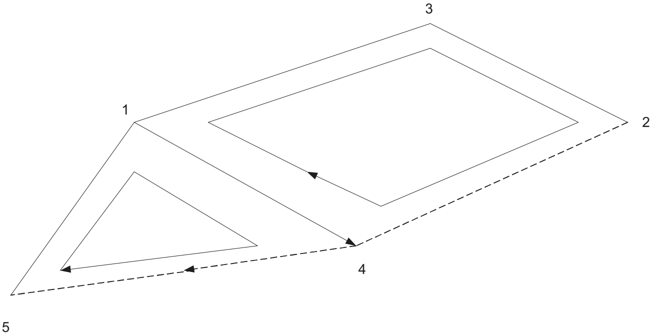
Table 130.6 Sample loop table

First node	Second node	Line number
Loop i:		
4	5	0
5	1	0
1	4	1
Loop k:		
2	4	0
4	1	0
1	3	0
3	2	1

The element of the matrix ZM_{loop} in the k^{th} column or row and i^{th} row or column due to mutual coupling between a tree branch/edge 1 4 and tree branch/edge 2 3 can be determined as follows. We know that i^{th} loop has a tree branch/edge 1 4 and the k^{th} loop has a tree branch/edge 2 3 (see Fig. 130.7).

$$ZM_{\text{loop}}(i,k) = \Sigma(+Zm_{i,k}),$$

where the sign of this coupling group equal to +1 because the i^{th} loop current in branch/edge 1 4 runs in the same orientation to the k^{th} loop current in the tree branch/edge 2 3. However,



The i^{th} loop has a tree branch/edge 1 4 and the k^{th} loop has a tree branch/edge 2 3. The mutual coupling between the k^{th} loop and the l^{th} loop is equal to $Zm_{i,k}$

Fig. 130.7 Generating a loop impedance matrix when mutual coupling exists

$$ZM_{\text{loop}}(i,i) = \Sigma(-Zm_{i,i}),$$

where the sign of this coupling group equal to -1 because the i^{th} loop current in branch/edge 1 4 does not run in the same orientation to the i^{th} loop current in the tree branch/edge 2 3. The rules for determination of the element $ZM_{\text{loop}}(i,k)$ would be:

(a) On the off the main diagonal, the element $ZM_{\text{loop}}(i,k)$ is equal to $ZM_{\text{loop}}(k,i)$, and is equal to the algebraic sum of all mutual impedance of all branches/edges, which belong to the i^{th} loop and have mutual couplings with branches/edges which belong to the k^{th} loop; the sign of the particular coupling group is positive or negative depending on whether the i^{th} loop current in the branches/edges concerned has the same or opposite orientation to the k^{th} loop current in the same branches/edges concerned.

(b) On the main diagonal, the element $ZM_{\text{loop}}(i,i)$ is equal to the algebraic sum of all mutual impedance of all branches/edges, which belong to the i^{th} loop. They have mutual couplings with branches/edges, which also belong to the i^{th} loop. The sign of the particular coupling group is positive or negative depending on whether the i^{th} loop current in the branches/edges concerned has the same or opposite orientation to the i^{th} loop current in the same branches/edges concerned.

$$ZM_{\text{loop}}(i,k) = mm_{i,k} \sum_{r=1}^{bb} (m_i(ZM_{bb})\Omega m_k(ZM_{bb})), \tag{130.6}$$

where $mm_{i,k}$ is the sign and bb is the number of mutual couplings, so if we know also consider the effect of mutual coupling, Equation (130.5) can be re-written as:

$$ZM_{\text{loop}}^{(i,k)} = m_{i,k} \sum_{r=1}^{bb} (m_i(Z_{bb})\Omega m_k(Z_{bb}))_r + ZM_{\text{loop}}(i,k). \tag{130.7}$$

130.3 Existence & Uniqueness of Power System's Solution

To obtain the solution to a power system network analysis problem the bus voltage and each branch current forming the power system network has to be determined, given a knowledge of the structure of the linear, time-invariant power network, the interdependence between currents and bus voltages of the coupled and uncoupled passive two terminal elements modeling the branches, and the characteristics of Thevenin and Norton equivalent-power circuits of generators.

The number of branch-currents and branch-voltages to be determined is.The above characteristics of the two-terminal elements yield equations for the currents and voltages of the two-terminal elements forming the power network. The number of the linearly independent cut-set equations is, and of loop equations is, i.e. further equations are obtained from Kicrhoff's laws. Thus on the whole, equations may be written for the determination of unknowns, and so the problem is solvable unless the equations are inconsistent or redundant. Redundancy or inconsistency may appear in Kirchoff's equations if two-terminal elements with fixed bus voltages form a loop or if two-poles with fixed currents form a cut-set.

130.4 Power System Faulted Studies

Power systems faulted studies can be categorized as short circuits and line interruptions. Table 130.7 shows the various kinds of power system faulted studies.

Table 130.7 Types of power system faults

Short circuits faults	Line interruptions
Single line-to-ground fault (SLG)	Single line open (1LO)
Double line-to-ground fault (2LG)	Double line open (2LO)
Three-phase-to-ground faults	Three line open (3LO)

Power system short circuits can be calculated either on a three-phase basis, by method of phase coordinates/phase frame reference, or by the method of symmetrical components. A symmetrical component approach was selected for the work reported here for two reasons: 1st, present calculations are done this way in similar usage, and 2nd, a larger network can be solved by components with a PC of given memory size. Since power system generated voltages are positive sequence even a component analysis can present a very complicated circuit when there are numerous voltage sources in a system, each of which is represented by its internal generated emf in series with its internal impedance. The a-c network calculator permits the presentation of each generated voltage magnitude and phase angle where it appears in the network, but the circuit is usually solved more conveniently by the application of Thevenin's theorem.

This theorem is useful in analyzing a network or part of a network when its reactions at a particular pair of terminals are of prime importance, as is this case in the calculation of short circuit current at a point of fault. The theorem can be stated as follows: with respect to any single external circuit connected to any given pair of terminals of a network, the network can be replaced by a single branch having an impedance Z equal to the impedance measured at these terminals looking into the network (when all the network emf's are made zero) and containing a single emf Ef equal to the open circuit voltage of the network across the given pair of terminals.

The application of Thevenin's theorem can be illustrated by consideration of the simple three-phase fault. The terminals of the equivalent circuits for the theorem are the point of fault and the zero potential bus of the network. The power system behind these terminals is replaced by an equivalent emf Ef in series with the positive sequence impedance Z_1, then the system short circuit is applied by short-circuiting the terminals of the equivalent circuit.

According to the theorem, E^f is the open circuit voltage across the given pair of terminals. There open circuits means without the fault applied. Thus E^f is the voltage to neutral at the point of fault without the fault and is usually a known system operating voltage. It is the reference phase or for the calculation. The equivalent impedance is the positive sequence impedance looking into the terminals at the point of fault with all internal generated emfs short-circuited. The short circuit current per phase is then $\frac{E^f}{Z_1}$. Thus the internal generated voltages need not be determined to calculate the current flowing due to fault.

130.5 Effect of Load Currents

An important point to remember is that Thevinin's theorem gives a valid circuit describing conditions at the terminals of the equivalent network. It accurately gives the total symmetrical current flowing in the fault. This current can be divided among the branches of the sequence network by the number of distribution factors; but when this division is obtained the resulting current is not the total symmetrical branch current. It is only the current flowing in the branch due to the fault. Normal current should be added properly to obtain the total actual branch current. After, load is neglected in short circuit calculations because it is small and out of phase with the fault current, but in some problems it can be significant and should be included by simple addition. Load current is more likely to be significant in system of relatively low short circuit capacity and low $\frac{X}{R}$ ratio. Of course, normal load current is not a component of current in the fault but it is a part of the total current flowing in the network branches feeding the fault [14–17].

130.6 Calculation of Bus Faults

The network of Fig. 130.8 illustrates procedure to solve a faulted power system network. A pint of significance is that no real differences exist in the problems encountered in three phase and single phase line to ground fault calculations, other than that inductive mutual coupling is normally negligible in the positive sequence network but not in the zero sequence network. To simplify the explanation, a single simple network embodying the features required to illustrate all the points has been proposed.

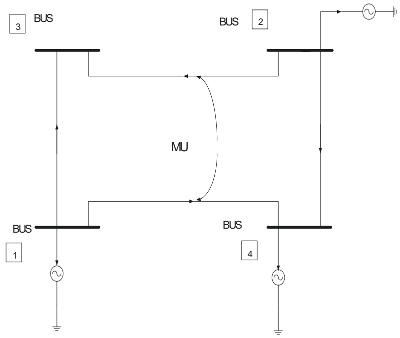


Fig. 130.8 Four bus 3 machine system with mutual reactance and assumed directions of positive current flow

In Fig. 130.8, an arrow shows the positive reference for current (and voltage) in each of the branches of the network. The positive reference is from the low numbered node to the high numbered node in each branch. The network tree is, of course, not unique, but for the particular node numbering scheme shown, Fig. 130.9 shows the network tree that would be selected by the computer software [16, 17].

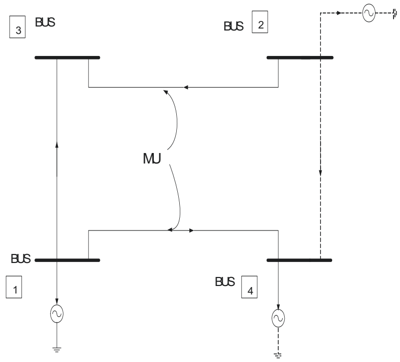


Fig. 130.9 System of Fig. 130.8 showing tree branches as solid lines and links as dashed lines

At this point the assumption is made that the network voltages and currents are required for successive faults on each of the nodes. Note now that the network tree is such that all nodes except the mutual are connected to other nodes by tree branches, which are entirely in the transmission network. The neutral is connected to other nodes through the tree branches represented by generator impedance (node 5 is a reference node). All other shunt branches are thus link branches. The network is shown in Fig. 130.10 with the addition of four fault branches from each of the nodes 1, 2, 3, and 4 to neutral node: 5.

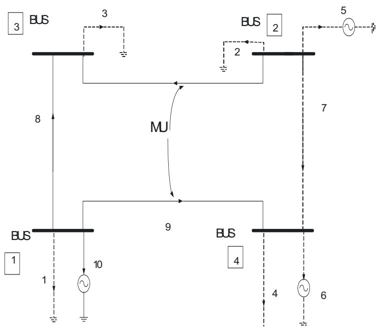


Fig. 130.10 System of Fig. 130.9 with addition of fault links on each bus

130.7 Technical Discussions

(1) Boundary condition issue

Maximum boundary condition is related to current; while minimum boundary condition would be related to electric potential and stability during short-circuit design and studies. However, in power system fault calculation the voltage at the faulted bus is used to calculate how many Amperes will be the fault current. Short circuits have both voltage and current effects. Each is of concern for different reasons. Short circuit current determines the size of wires and especially the size of the circuit breakers necessary to interrupt the faults, and the settings of these breakers. Low voltages from short circuits ("voltage sag") can cause problems for equipment connected to the power system at some distance (several buses) from the location of the fault. Mechanical, electrical and thermal short circuit design is current based. However, there is also a problem due to transient over-voltages after switching operation especially in highly inductive grids; both current and voltages should be considered for correct design of insulation. The limits on short circuit design are mainly the dielectric stress (voltage issue), and mechanical stress (current issue). Classical studies on short-circuits are performed mainly to rate circuit breakers and tune protections. However, power quality issues, such as voltage dips due to short-circuits, is definitely an important issue to consider especially in industries with control systems that rely in PLC's for automation.

(2) Mutual inductance issue

The mutual inductance between two distant transmission lines is important and necessary in power system analysis to perform interference analysis, i.e. inductive interference, during single phase faults. It can be concluded that the use of mutual inductance is in the calculation of zero sequence impedance. Also, the mutual inductance is important for the synchronous and inductive machines when they are modeled for fault calculations. Mutual inductance is important only when the lines are on the same tower. In addition it is also important if the lines are in the same corridor, adjacent to each other, but on different towers. So mutual inductances between phases have to be considered as long as single-phased, shielded cables are not in use. Mutual inductances between systems on parallel lines on different power lines may be neglected. Otherwise, when the line current is unbalanced, then mutual inductances between adjacent parallel lines are required to be considered. The best way is to simulate and compare between the two cases, with and without mutual inductance. Mutual inductance between conductors in parallel is important in unbalance system calculations, especially in fault analysis.

(3) Reference point issue

If a large power system contains transformers, generators, and transmission lines with different voltage levels, then reference point is needed, all values will be then calculated in per unit and then can be found in Ampere and voltage. However, if ground is not included in the development of matrix a bus known as slack or swing bus is using as reference bus and all the variables measured with respect to this reference bus. There is an implicit reference point of ground in all power system network analysis. It is in the form of a bus with a reference angle (the swing, or slack bus), which is needed in power analysis. Many approximate methods for short circuit analysis do not bother finding voltage angles, since current and voltage magnitudes are the primary concern and most impedance can be treated as reactance without losing much accuracy. In these cases no slack bus is needed. So a slack node is not absolutely necessary, only if a detailed short circuit analysis is carried out including a power flow calculation. If a short circuit analysis based on standards, IEC 909, is used then a load flow calculation is not required; therefore, a slack node is not needed. It can be concluded that for short-circuit studies the reference is ground; it is assumed that the generators are grounded, and a second reference, such as a slack bus for load flow studies, is not required during short-circuit studies. A standardized short-circuit calculation is treated the system as a linear system so that standard circuit technique can be used. In general, short-circuit analysis has an embedded reference point, usually is the ground connection [15].

(4) Z_{loop} issue

The mathematical model of power system network for the purpose of steady state analysis such as load flow and planning studies or short circuit studies, are a set of network equations. These network equations can be established either in the bus frame of references using, in the loop frame of reference using, or in the branch frame of reference using. In order to solve network equations of a large-scale power system network; it is necessary to choose the proper frame of references with the least matrix's size, i.e. the least number of rows and/or columns. This is done to optimize computer memory and also to reduce computational time in order to save the cost of computations. This is why the size of the matrix and its exploitations are very important in the formulations and analysis of power system under faulted studies. In practical application, is more common than analysis; however, if the size of the matrix is of a great concern in term of a reduction of the required memory to be stored during fault studies, then can gain some benefits. If the original power network has n nodes and b branches, then the number of linearly independent current and voltages law equations is $(b-n+1)$. The size of the matrix is $(b-n+1)$ by $(b-n+1)$; so for the same power network the size of the matrix is $(n-1)$ by $(n-1)$. It can be concluded that if $(n-1)$ is bigger than $(b-n+1)$ then the size of the matrix is bigger than the size of the matrix. It should be apparent that computer using either a loop or a bus matrix technique may solve power system faults. But there are other important considerations which should be mentioned such as computer memory utilization to store the Z matrix. Recently, processing power system studies has mushroomed and computer size shrunk, to the pointy where today, a power system engineer can sit at his desk and optimize the performance of large power system networks in real times. In the nodal reference frame, the network is modeled by voltages at and current injections into each node within the network. In contrast, the loop reference frame is modeled by the voltages and currents around each loop formed within the network and network behavior is characterized by the flows within each assigned loop. In either case, formation of network equations is dependent on the frame of reference adopted. Use of the nodal reference frame is widely accepted. Despite this, the nodal frame of reference can only provide information for a point (node) within the network. It is not able to provide any indication about the distribution of power flow contributed by different sources through the network.

130.8 Conclusions

Algorithms have been derived for forming a Z_{loop} matrix by graph theory. Such a matrix contains the information regarding the number of independent equations, which needed to establish the required number of independent mesh or loop equations. Considering several immediate applications, the author chooses to work with the formation of Z_{loop} matrix for solving power system faulted studies. The main limitation of this approach is the presence of multiple, equally valid, loop combinations for any network. Graph theory concepts such as "breadth first" and "depth first" search strategies were used to limit the number of possible loop combinations. Use of the nodal reference frame is widely accepted. Despite this, the nodal frame of reference can only provide information for a point (node) within the network. It is not able to provide any indication about the distribution of power flow contributed by different sources through the network.

In this paper, a direct approach algorithm for fault studies in power system has been developed. The features of this method are robustness and computer economy. The Z_{loop} matrix, developed based on the topological structure of power systems have been used to solve the fault studies problem. The loop impedance matrix is responsible for the variation between the loop current and branch current, and the branches and links tables are responsible for the variation between the branch current and links current. The proposed solution algorithm is primarily based on these two tables and without any matrix multiplication. Time-consuming procedures, such as Bus impedance and loop impedance matrix are not needed, and the ill-conditioned problem which occurs during the matrix multiplication does not exist in the solution procedure. Therefore, the proposed method is robust and economical. Test results show that the proposed method is suitable for power faulted system calculations in large-scale distribution systems. Other issues involved in distribution system operation, such as multi-phase operation with unbalanced and distributed loads, voltage regulators and capacitors with automatic tap controls, will be discussed in a future paper.

Z_{loop} were found to exhibit a trend to yielding higher estimates for initial symmetrical and peak fault currents.

Computer simulations performed with both methods suggest that adherence to either methods from beginning to end is essential for consistent results. Furthermore, quantities needed by either method are not necessarily computable by the other. Therefore, using results calculated according to either method to estimate quantities needed by other can lead to significant simulation errors.

This Z_{loop} method in this manuscript was constructed without using matrix multiplication; so no new matrix is required to be constructed for different a bus to be faulted as it is presented in the Appendix of this manuscript. Even if new branches, generators, and motors are added, this method will be a lot easier to handle.

If the number of buses is more than the number of independent loops in the power systems, then the size of the Z_{loop} matrix will be less than the size of the Z_{Bus} matrix.

Since the trend is toward the solution of very large networks, the Z_{loop} technique has definite advantages. It can effectively and economically solve networks at least 10 times of Buses as large as the independent loop equations

It should be apparent that either Z_{loop} or Z_{Bus} may solve power system faults. It is also apparent that the Z_{Bus} technique has its problems: the Z_{Bus} method in its difficult and time consuming matrix formation method.

In the Z_{loop} method mutually coupled or not, it is easier to construct than the Z_{Bus} method

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