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

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Focused on Electrical and Information Technology

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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 *ICMSEM General and Program Chairs*
Philadelphia, Pennsylvania, USA

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Part III Decision Support Systems

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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Chapter 1
Advancements of Engineering Management Based on Electrical and Information Technology for the Seventh ICMSEM

Jiuping Xu

Abstract Computers, networks, information technology, project management, decision support systems, industrial engineering, supply chain management, manufacturing, and ecological engineering are all parts of engineering management based on electrical and information technology (EMEI), which is an interdisciplinary subject that focuses on solving engineering management problems. The goal of the ICMSEM is to foster international research collaboration in EMEI. In this paper, we first give an overview of the former six ICMSEMs. Then, following the technology development trend, we present the central issues of the seventh ICMSEM. Third, by investigating EMEI development, we highlight its important influence on academic research and practical guidance. EMEI's continuous development has brought an upsurge in research and has shown increasing development. The ICMSEM from 2007 to 2013 are closely concerned with the EMEI development trends and reflects the EMEI advancements. After this, Computer-based Research Methodology, a unique research idea,is proposed to interpret the ICMSEM and promote EMEI development. Further, to give prominence to EMEI progress, an evaluation of the seventh conference is conducted. The ICMSEM offers a breakthrough in conference organization as it provides a convenient platform for academic exchange and communication and continues to play a role in promoting EMEI advancements into the future. Finally, we express our thanks to all those concerned and consider prospects for the coming year's conference.

Keywords Computer and networks · Information technology · Project management · Decision support system · Industrial engineering · Supply chain management · Manufacturing · Ecological engineering

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1.1 Overview of the Previous Six ICMSEMs

The International Conference on Management Science and Engineering Management (ICMSEM) is an annual conference organized by the International Society of Management Science and Engineering Management (ISMSEM) to foster international research collaboration and to provide a forum for the presentation of current research at technical sessions, and round table discussions in a relaxed and enjoyable atmosphere. Management Science (MS) and Engineering Management (EM), because of their focus on computer networks and information technology, have a significant influence on engineering project management, decision making, evaluation and forecasting, supply chain management, risk management and ecological engineering management. MSEM and EMEI have experienced significant international development in recent years and have become increasingly popular topics in management and operations research.

Since 2007, ICMSEM has been successfully held six times in Chengdu, Chongqing, Bangkok (Thailand), Taiwan, Macau and Islamabad (Pakistan). Except for the Fifth conference, all the proceedings of the previous ICMSEMs have been archived by ISTP retrieval and the proceedings of the First, the Third and the Sixth ICMSEMs have been archived by EI retrieval. The Seventh conference is scheduled to be held at Drexel University, Philadelphia, USA on November 7-9, 2013. The total number of received and accepted papers for all seven ICMSEMs is shown in Fig. 1.1.

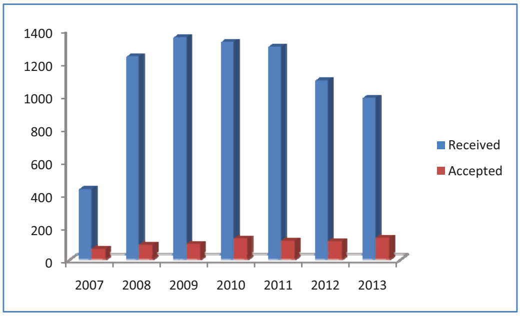

Fig. 1.1 The total number of received and accepted papers for all seven ICMSEMs

The previous six ICMSEMs received more than 6729 papers received from nearly 40 countries and nearly 480 papers were accepted for presentation or poster display at the conference after a thorough referee review [40, 41]. The accepted papers were from more than 20 countries, including Germany, Spain, Portugal, Australia, the UK, the USA, Japan, Korea, Brazil, Turkey, India, Azerbaijan, Pakistan, China and Thailand. Papers in the previous six ICMSEMs focused on various MSEM fields, such as Uncertainty Decision-Making, Logistics and Supply Chain Management, Operations Management, Engineering Project Management, Industry Engineering, Industrial Value Chains, Financial Management, Enterprise Management, Environment Resources Management, Knowledge Management, Risk and Emergency Management, and Service Management. Fig. 1.2 shows a group picture of the sixth ICMSEM.

Fig. 1.2 A group picture of the sixth ICMSEM

1.2 Key Issues of the Seventh ICMSEM

The Seventh ICMSEM is scheduled to be held from November 7 to 9, 2013 in Philadelphia, USA and is accepted to be a further development of the previous six year. This year, 1420 papers from 35 countries have been received and 130 papers from 12 countries have been accepted for presentation or poster display at the conference. The papers accepted are from many countries including USA, UK, Japan, Germany, Spain, Portugal, Turkey, China, Azerbaijan, Pakistan, Saudi Arabia and Australia. They have been classified into 8 sections in the proceedings: Computers and Networks, Information Technology, Decision Support Systems, Manufacturing, Supply Chain Management, Project Management, and Ecological Engineering and Industrial Engineering. The key issues of the seventh ICMSEM cover various areas of EMEI, such as Decision Support Systems, 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, Heuristic Algorithms, Risk Control, and Carbon Credits. 85 of these papers have been sponsored by national funds, 55 by provincial funds and 13 by school funds. All papers in the proceedings have been published by Springer and delivered to ISTP and EI Compendex for retrieval. In order to further encourage state-of-the-art research in Management Science and Engineering Management, the ISMSEM Advancement Prize for EMEI will be awarded at the conference. Papers sponsored by funding have increased year by year. Figs. 1.1 and 1.3 show the total number of papers and funding support for the ICMSEM over the first seven years, respectively, which shows an upsurge in the ICMSEM in not only the total number of received and accepted papers, but also the funding support on all levels of the ICMSEM over the first seven years.

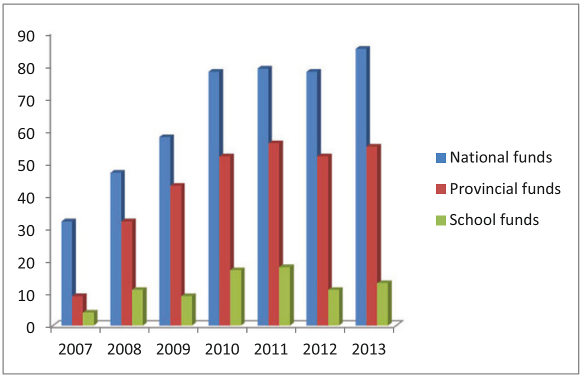

Fig. 1.3 The total number of funding supports on all levels of the ICMSEM over the first seven years

In accordance with the proceedings of the sixth ICMSEM, the proceedings of the seventh ICMSEM focus on solving management problems associated with engineering problems and computer-based research methodology. In this study, the NODEXL was used to determine the research focus of the ICMSEM seventh proceedings. Fig. 1.4 shows that the papers accepted by the seventh ICMSEM are divided into 8 sections covering the most popular issues of the day. It should be noted that the section classifications depend on the key words in all the accepted papers and small revisions were made to express the same meanings. For example, "fuzzy environments" and "uncertain environments" were adjusted to "decision environments" when integrated into NODEXL.

1.2.1 The Focus Area of the Seventh ICMSEM

To begin with, computers and networks are the basic EMEI tools as they provide a foundation for the discussion of practical management problems. In this part, Mehmet Kurt et al presents an optimization of Bandpass lengths in a Multi-Bandpass problem and smoothly implement it. Jae et al explores the determinants of knowledge sharing in a social network. Building on social cognitive theory, social capital theory, and technology acceptance theory, this research-in-progress pa-

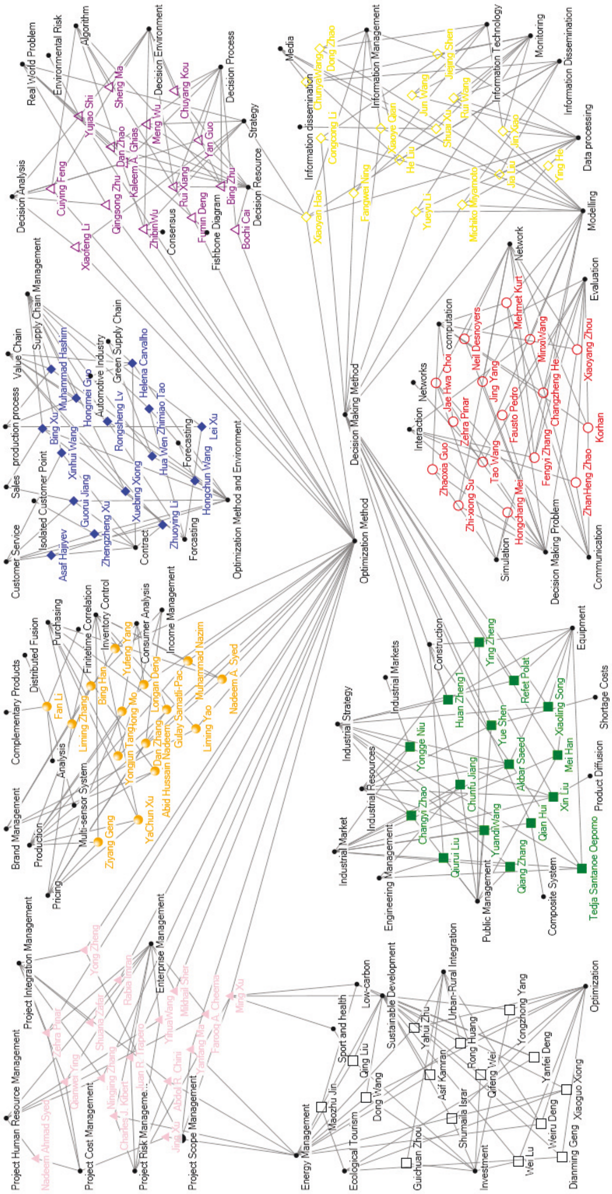

Fig. 1.4 The distribution of the articles in the seventh ICMSEM

per aims to explore how personal cognition, social capital, and technology acceptance attitudes affect knowledge sharing in social networking. Fengyi Zhang and Zhigao Liao forecast prices based on PCA and RBF neural networks by employing a hybrid fuzzy clustering algorithm. Mikhail and Avijit propose a procedure for modeling and solving large scale unit commitment problems using a parallel computing approach. The research in this section shows an excellent combination of computer-based techniques and practical guidance.

Information technology (IT), the second section, is an appropriate technical platform for solving practical management problems, and is defined as "the study, design, development, implementation, support or management of computer-based information systems, particularly software applications and computer hardware", according to the Information Technology Association of America. IT is playing an increasingly dominant part in modern society. Using the MIT90s framework on Japanese enterprises, Miyamoto et al investigates a fit between strategy, organizational structure, management process, individual roles and skills, and IT, to gain competitive advantage. Korhan et al examines how to handle the extraction of learning concepts using support vector machines as a supervised learning algorithm.

The third part is focused on decision support systems. Decision support systems area class of computer-based information systems that support knowledge management, decision making, and management reporting and assist managers in making decisions in highly uncertain and complex environments. In this part, Asaf et al introduces a control function to reduce average customer waiting time. Li and Liu establish a Rough-ANN model for the dynamic risk measurement of technological enterprise innovation based on Rough set theory and the ANN method. Asif et al looks into empirical studies and theoretical frameworks to identify the explanatory variables that can have a considerable effect on the gold price, and explores these factors as determinants of the Pakistani gold prices.

Manufacturing is the use of machines, tools and labor to produce goods that meet a customer's expectations or specifications. In this part, Abid et al explores the important factors which affect the sustainable production of cotton in Pakistan. Gulay and Shen investigate pricing and customer return policies with loss-averse customers. The research highlights that the presence of a return policy and a consumer's loss-averse behavior directly affects the expected utility of the product. Zhang discusses indicator selection in a joint purchasing mode for small and medium-size enterprises. SMEs are shown to have a greater bargaining capacity in acquiring a lower price than when working independently.

The fifth part focuses on supply chain management (SCM). Helena et al identifies and provides a deeper understanding on the trade-offs that exist among Lean, Agile, Resilient and Green (LARG) SCM paradigms. Kurt and Avijit present guidance to determine an appropriate minimum commitment cost for a common situation, where the probability of obsolescence of the contracted part is known, or can be estimated prior to the joint optimization of the relevant policy variables. Juan et al explores a two-staged serially linked supply chain, where weekly data at the SKU level was collected from a manufacturer specialized in household products and a major UK grocery retailer.

Project management is the discipline of planning, organizing, securing and managing resources to bring about the successful completion of specific project goals and objectives. Scholars in this section tend to focus on the accomplishment of desired goals and objectives by using restricted resources efficiently and effectively. Zehra et al explores exact solutions to a tsunami generation analytical model by investigating sub-marine landslides. Fausto et al puts forward a fault tree analysis (FTA) approach for decision making in maintenance management. Fault Tree Analysis (FTA) is proposed as a graphical representation of the logical relationships between the elements that comprise the decision making process in maintenance management. Jiang presents a strict definition for an efficient portfolio subset, and derives some equivalent conditions for determining this subset using a generalized inverse matrix.

Ecological engineering is the intent to integrate ecology and engineering sectors to focus on the design, monitoring and construction of ecosystems. Ecological engineering research is increasing in breadth and depth as more opportunities for the design and use of ecosystems as interfaces between technology and the environment are explored. Abdol and Sandeep establish a framework to explore energy saving measures during construction phases. This framework may also be used for collecting energy consumption data during construction to allow for a continuous update of the database and to increase accuracy in estimating future projects'energy consumption. Xiong and Tang develop a strategy for the BGEZ's marine industry in a low carbon economy. Zhu and Cai apply a stirpat model to a case study in Chinato, Chongqing city to identify the driving factors behind urban residential building energy consumption. This urbanization acceleration is useful as it allows governments to design and implement effective policy measure to promote building energy efficiency if the key factors influencing urban residential building energy consumption can be identified and the impact determined quantitatively.

The last part is Industrial engineering. Industrial engineering is the branch of engineering which deals with the optimization of complex processes or systems. In this part, Tedja puts forward a step by step method on how graph theory and topology can be utilized to construct a Z-loop matrix for the study of faulted 3 phase power systems. Nadeem et al develops a forecasting model to estimate the minimum electricity generating capacity required in Pakistan over the next 20 years. Wang and Shen discuss a joint purchasing alliance decision-making problem which looks at joint procurement in an allowable stock-out condition.

Of course, not all papers are mentioned here. Readers are strongly encouraged to peruse the proceedings for more information about current research on EMEI.

1.2.2 The Focus Area, Management Methodologies and Engineering Practice in the First Seven ICMSEMs

Based on the first seven proceedings, the main research areas have focused on operations management, evaluation and forecasting, information technology, industry management, risk management, knowledge management and hydropower engineering. All these research areas are significant and common in EMEI. In effect, the EMEI development trend has broadened over time. Fig. 1.5 shows the proceedings distribution according to the focus areas for EMEI in ICMSEM, all of which have been covered by the ICMSEM. Specifically, the area attracting the most attention has been operations management, followed by supply chain management, information technology, industrial engineering and project management.

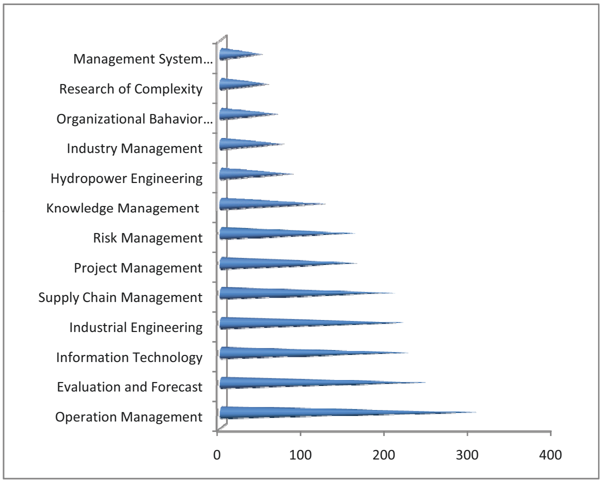

Fig. 1.5 The proceedings distribution according to the focusing area for EMEI in ICMSEM

EMEI has become more and more necessary in engineering practice. Therefore, it is crucial to understand which research methodologies have been most used. In fact, many methodologies have been used in electrical and information technology-based engineering management, which is reflected in the range of articles in the ICMSEM proceedings. The following methods are the most used: evaluation and simulation, optimization, mathematical modeling, decision making, data mining, exact algorithms, game theory, probability and statistics, Markov analysis, network analysis, queuing theory, heuristic methods, computer-aided technology, uncertainty theory, system dynamics, systems analysis, systems thinking, multi-methodology, interactive planning, strategic choice approaches and total system intervention. The top nine methods used in the ICMSEMs are depicted in Fig. 1.7. Among these, the most popular methods have been the optimization method and the mathematical model method. Evaluation and simulation,which are an imitation of real-world applications, states of affairs, or processes, has been used in many contexts, including the modeling of natural and human systems to gain insight into their function. Optimization, which is often used for problems in economics, design, and management,has been applied to choose the best elements from a set of available alternatives. A mathematical model is a representation of the essential aspects of an existing system (or a system to be constructed) in a form that is useful for possible analysis. Game theory is a sort of umbrella or unified field theory for the rational side of social science, where the social aspect is interpreted broadly to include human and non-human players. Network theory,a part of graph theory, is an area in computer science network design, which has been applied to many disciplines including particle physics, computer science, biology, economics, operations research, and sociology. Heuristics refers to experience-based techniques that assist in problem solving, learning and discovery. It can be shown from the ICMSEM proceedings that less exact algorithms have been used in recent years, and more intelligent and computer-aided technologies have been applied to solve practical engineering problems. Systems analysis is the study of the interacting entities of system sets, including computer systems. This field is closely related to operations research. In this research, an increasing number of articles have concentrated on solving practical engineering practices with computer-based technologies.

In the previous part, we described the main management methodologies used in engineering practice. In this part, the engineering fields which have received special management attention by are the core research focus. 20 engineering fields have been widely researched in the last seven ICMSEMs. The detailed distribution of these articles from EMEI engineering practice is shown in Fig. 1.6 It can be seen that more than 20 papers in the ICMSEM have been published in 9 distinct fields: construction engineering, logistics engineering, computer engineering, transportation engineering, systems engineering and industrial engineering.

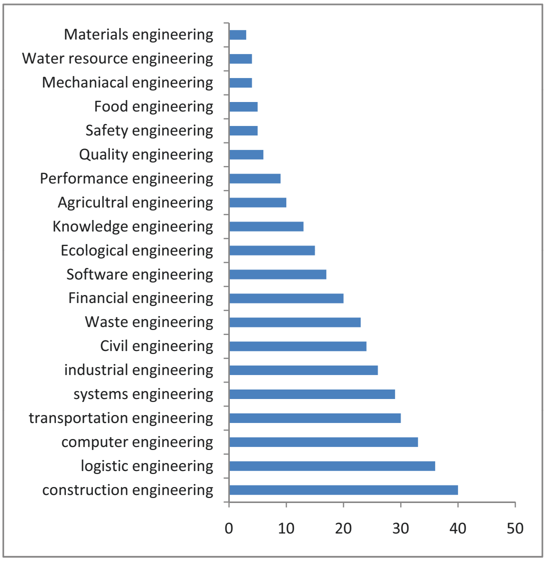

Fig. 1.6 The distribution of these articles in the last seven ICMSEMs based on the engineering practice in EMEI

In the following part, a computer-based research methodology is proposed and the development trends for computer-based RM in the EMEI are summarized, respectively.

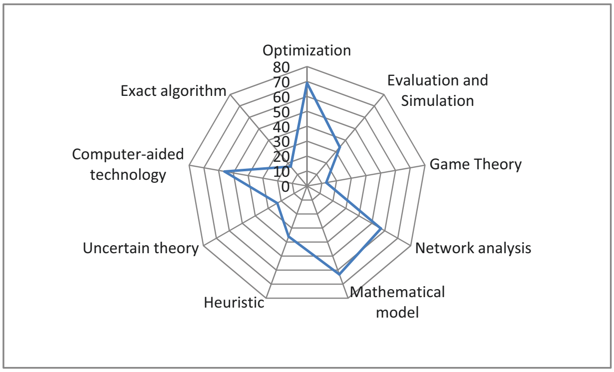

Fig. 1.7 The distribution of the articles in the first seven ICMSEMs based on the management methodologies for EMEI

1.3 Computer-based Research Methodology

EMEI is a multidisciplinary field with a wide range of research areas focusing on the solution of practical engineering background management problems using computer-based techniques to obtain feasible solutions. However, these techniques are often complex. How do we know a problem is significant and meaningful? How can we describe this problem using scientific language? How can an efficient algorithm be designed to solve a practical problem? And, finally, how can this integrated method be applied to engineering fields? For instance, one common phenomenon often found in recent conference proceedings is that some authors presented research which was of great practical significance, but failed to provide a model with a solution algorithm, which meant that the model was unable to solve problems using practical data. Some authors choose problems that are not connected to an urgent issue, and develop an effective and rapid algorithm. In other words, these authors have done a great research job, but some parts of their work could be improved. In excellent papers, all these questions, from determining the practical problems to solving them,are answered.

Future EMEI research must be closely related to practical engineering management problems using computer technology, such as simulations and programming. From the ICMSEM findings, construction engineering, ecological engineering, logistics engineering, financial engineering, and computer engineering have been appearing more regularly in the EMEI research fields, and computer-based methods for determining feasible solutions are becoming increasingly common. Xu [40] has presented a clear discussion about computer-based research methodology.

EMEI is a combination of EM and EI, and emphasizes practical management, effective theories and methods, and significant engineering practice. An excellent EMEI paper should integrate the background of the problem, a mathematical model, and an effective solution method with a significant application. This new methodology enables researchers to draw scientific conclusions, and plays a significant guiding role in the conduct of further scientific research. An excellent paper is guided by Computer-based research methodology (C-based RM), which uses computer technology to express the essential relationships between the research, the model and the problem. C-based RM can also be used in EMEI research, such as in the use of computer-based methods to solve practical engineering management problems. In C-based RM, the specific 6MRP relationship presents a logic for solving practical engineering problems with computer-based methods. Here, R stands for research, which includes research specifics, research background, research base, research reality, research framework, and applied research; M refers to models, which includes concept models, physical models, physical mathematical models, mathematical physical models, algorithm designed models and specific description models, and P represents problems, which includes a particular problem, a class of problems, abstract problems, problem restoration, problem solution, and problem settlement. The specific relationship between Research, Model, and Problem and the detailed C-based RM process is shown in Fig. 1.8. The main steps for the C-based RM used in the seventh ICMSEM can be obtained from Xu [40].

Generally, C-based RM is understood to follow a certain structural process. Although the step orders may depend on the practical subject matter and researchers, the following key steps are usually applied during EMEI research:

- Select research topic: the subject to be addressed in your article should be worthy of investigation.
- Describe key problems: the problem to be investigated should be of significance.
- Present conceptual model: the information presented should be new.
- Establish physical model: this model should be a new and original contribution.
- Build a physical mathematical model: the mathematical model should be correct and helpful in practice.
- Verify the mathematical physical model: the proofs should be correct.
- Improve and innovate a computer-based algorithm: this part should make a valuable contribution to the field of knowledge or practice.

The first thing required is the observation and formation of the topic, which consists of focusing on the subject area of interest and conducting related research. The subject area specification requires the reading of a vast amount of literature on the topic to determine are search focus which has not yet been studied comprehensively. The research needs to be justified by combining its importance with existing knowledge on the topic. The specific requirements include: (1) finding new problems (significance of problem: academic and rational thinking); (2) establishing new model; (3) putting forward new algorithms; (4) solving the problem successfully; (5) indicating the new research direction or field. Secondly, a key problem statement and conceptual model definition should be provided: a description of a conceptual model related to practical concepts; and details regarding the definition of the variables and how they are to be measured/assessed in the study. Specific requirements include: (1) a proposal highlighting the significance of the conceptual model to the problem that must be solved; (2) a description of the significant contributions of the solution to the problem; (3) a review of previous research work and an appreciation of these

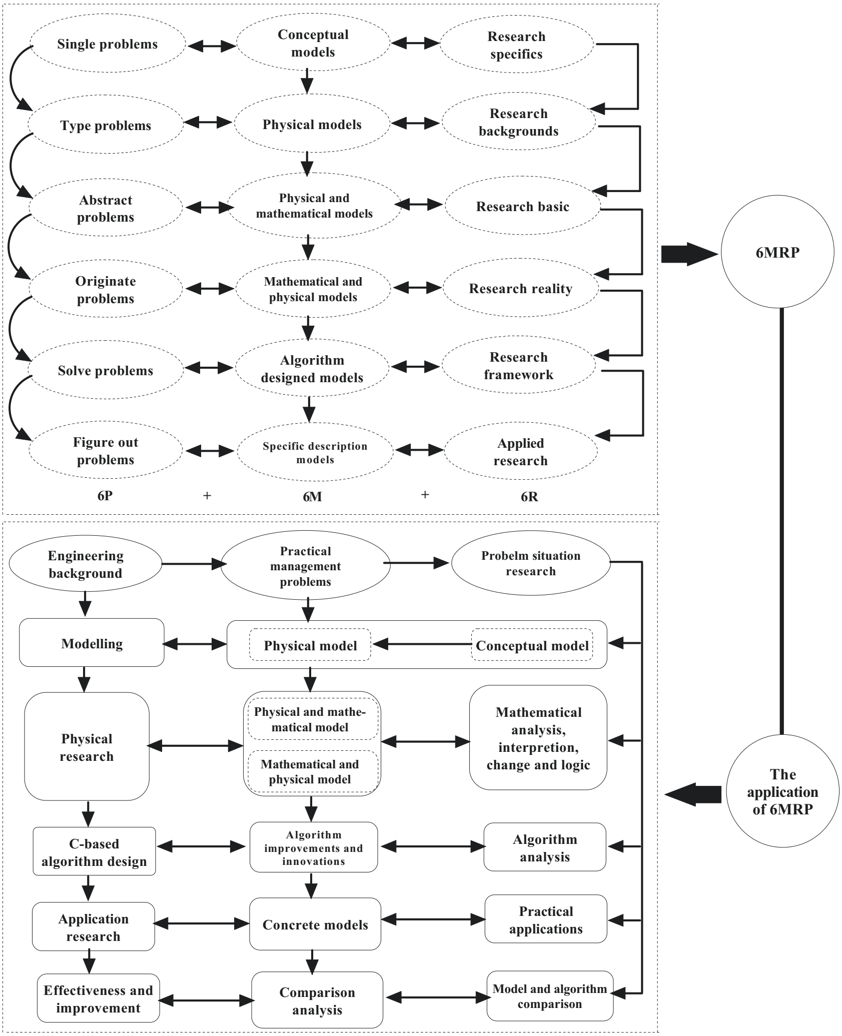

Fig. 1.8 Specific relationship of 6MRP and the detailed C-based RM process

contributions to the body of knowledge, and then an introduction of the new work and it's significant new point of departure; (4) a description of the motivation for solving this problem; (5) a description of the important contents in this work in a logical structure for the reader.

Based on the conceptual model presented above, the modeling of a physical model can then be implemented. The specific requirements include: (1) stating the reasoning behind the conceptual model in the first part; (2) describing the physical modeling; (3) using insight to determine the key element/s of the problem, for

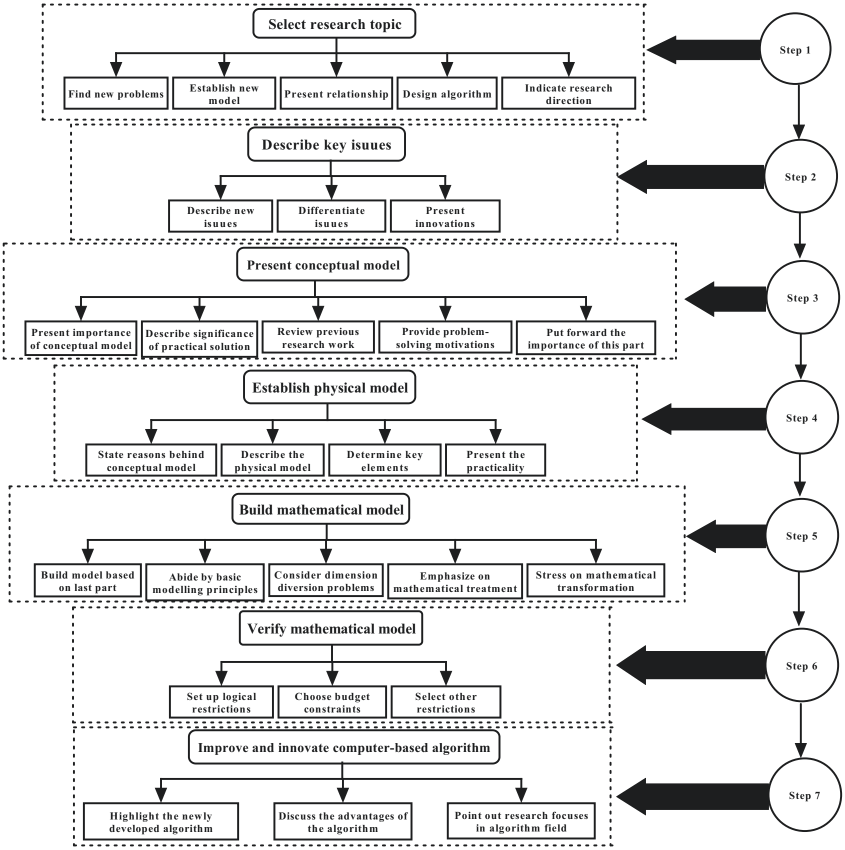

Fig. 1.9 The process of C-based RM

example, uncertainty, indetermination, unreliability, and at the same time ensuring specialization; (4) being easily understood.

After the physical modeling, a physical mathematical model is built and its physical significance explained. Specific requirements include: (1) in the second part modeling must be based on the physical model; (2) the modeling process must abide by basic physics principles, chemical principles, and behavior rules under a sense of probability; (3) dimension conservation must be considered in the mathematical equation; (4) the mathematical treatment must have mathematical sense; (5) the mathematical transformation must have a physical or chemical significance, otherwise, the mathematical reasoning process should be in appendix. Compared to physical mathematical models, mathematical physical models need to point to the physical significance under a mathematical form, in which the conversion of the mathematical equations can be recovered to the physical model.

Finally, an improved and innovative computer-based algorithm is developed to solve the model. Specific requirements include: (1) highlighting the newly developed innovative parts of the algorithm instead of elaborating an existing algorithm with old ideas; (2) clearly discussing the solution, the error estimation and the convergence speed.

Fig. 1.9 presents the details of the C-based RM, which is an effective methodology that can be widely used in various scientific research fields and can contribute to research in all areas in a standardized and efficient manner [40]. In EMEI scope, especially in management problems with engineering backgrounds, C-based RM is particularly useful because of its rigorous logical and effective applicability, and can play an outstanding role in guiding the practical side of research.

1.4 Development Trends for C-based RM in EMEI According to the First Seven ICMSEMs

In the above section, the C-based RM has been discussed. In this section, an overall review of EMEI, especially C-based RM in EMEI, is presented as a summary of past research with an attempt to understand the effect on research and practice. We are seeking to answer three research questions: (1) What are the EMEI C-based RM development trends showcased in the first seven ICMSEMs? (2) Does ICMSEM research coincide with the trends in the international EMEI journals? and (3) What is the future of C-based RM in EMEI?

For a systematic review, in this study, the research method used herein is similar to the one presented by Kitchenham [1], Kitchenham et al [2], with demands placed on research questions, identification of research, selection process, appraisal, synthesis, and inference.

1.4.1 Identification Procedure

The fundamental factor in distinguishing a systematic review from a traditional review of the literature is its comprehensive and unbiased search. In order to answer the three questions, this study reviews two sets of papers: all papers included in the proceedings of ICMSEM and the relevant research papers in EMEI journals.

In order to identify EMEI research, some related search terms and keywords have to be identified. This study starts with a systematic search to identify keywords and search terms. There are two basic keywords in EMEI: engineering management and electrical and information technology. On the basis of these keywords, for engineering management based on electrical and information technology, this study respectively chose 24 terms which are significant and common EMEI concerns as the main search terms. These terms are shown in Table 1.2, which are different to the EMEI keyword trends. It should be noted that a secondary search was executed based on articles found in our primary studies. Moreover, these search terms were also subdivided for more accurate focus. For example, in order to find research on heuristic algorithms, this study used almost all existing heuristics algorithms, such as genetic algorithms, ant colony optimization, particle swarm optimization, simulated annealing, the bee algorithm and meta-heuristics algorithms. Finally, additional searches were also performed directly on key journals and authors to avoid overlooking any important research.

When obtaining related research, this study considered three electronic bases (Shown in Table 1.1). Since the research was performed in May 2013, papers published from 2007 to May 2013 were selected. The identification process yielded 372159 articles, which laid the foundation for the next selection process.

Then, papers were selected according to a "Relativity-Duplicate" exclusion criteria as follows:

- Relativity. We found many papers with one term, but only a minority were relevant to our aim. Through this process, the number of articles was reduced to 136684.
- Duplicate articles. There were some duplicate publications which belong to more than one database. The duplicate publications were eliminated and the number of articles was reduced to 99461.

Table 1.1 Sources of systematic reviews

Source	Address
Web of Science	http://isiknowledge.com
EI Compendex	http://www.engineeringvillage.org
Science Direct	http://www.sciencedirect.com

Table 1.2 The main search terms used in the literature selection process

Terms for		Terms for
○Information Technology		• Electrical Engineering
○ Software Engineering		• Computer Engineering
○ Building Information Modelling (BIM)		• Logistics Engineering
○ Control Systems		• Engineering Management
○ Aerospace & Electronics		• Automatic Control
○ Industrial Informatics	and	• Intelligent Transportation
○ Heuristics Algorithms		• Computer and Networks
○ Risk Management		• Supply Chain Management
○ Management Information		• Performance Evaluation
○ Signal Processing		• Evolutionary Computation
○ Project Management		• Computer Neural Network
○ Ecological Engineering		• Decision Support System

These 99461 papers provided the initial research document database. Following this, more documents were eliminated based on the following criteria since there were still too many articles:

- This study aimed to solve engineering problems. Thus, the keyword "Management" was entered 35064 documents obtained and papers from a pure technical perspective were eliminated.
- This study identified papers with engineering backgrounds. The keywords relevant to engineering management such as "engineering", "engineering management", "civil engineering" and "construction" to 35064 documents were entered, and duplications deleted. The articles reduced to 4673.
- This study added computer technology, such as information technology etc., and the number of papers was reduced to 2257.
- This study eliminated descriptions of books and journals and articles were reduced to 2489.
- This study scrutinized abstracts in an order from the most to the least citations. Research with ambiguous content was reviewed in full. Some research was also eliminated after a careful review since they had only an indirect relationship to C-based RM in EMEI. Thus, the number of articles was reduced to 1357.

Based on the seven criteria above, 1357 papers were eventually selected for review. The final reviewed papers are 1357 in international EMEI related journals which included 680 papers from the ICMSEM.

1.4.2 Survey of the First Seven ICMSEM papers

Computer-based techniques are useful in obtaining feasible solutions for practical engineering background problems. In this section, we survey the potential C-based RM development trends in EMEI in the first six ICMSEM papers. Thus, it is important to review articles that have been published in all proceedings of ICMSEM. Up till now, seven ICMSEM proceedings have been published, with each containing62 papers, 87 papers, 94 papers, 125 papers, 112 papers, 110 papers and 130 papers respectively. From this quick overview, it can be concluded that there is an ascending development in EMEI research based on the rise in total papers published in the ICMSEM proceedings. In practice, EMEI research has been rapidly developing in the past decade, especially in the areas of theoretical and methodological EMEI research, and many practical applications have been developed. Nowadays, with the rapid development of computer and information science, there is a great deal of research on MS under an EM background using information technology, computers and networks. Thus, following this trend, the articles published in all seven proceedings are divided into two groups: research using these technologies and research not using these technologies.

Fig. 1.10 shows that increasingly more papers concentrate on using information technology or computers and networks to solve practical engineering management

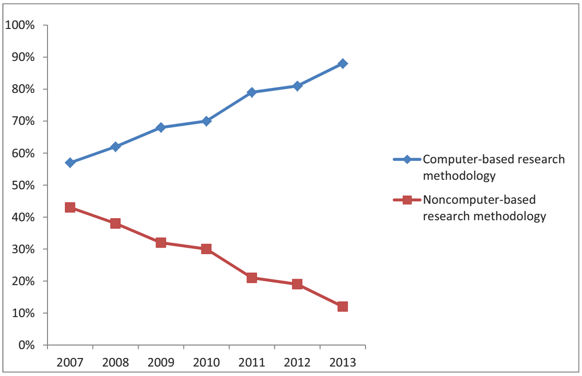

Fig. 1.10 The development trend for researches on computer-based methodology in EMEI

problems in the ICMSEM. It can be seen from Fig. 1.10 that an increasing number of scholars are doing research in an EMEI framework which emphasizes actual management background, effective theories and computer technique-based methods, as well as significant engineering practice. In addition, Table 1.3 shows some outstanding articles related to C-based RM in the proceedings of ICMSEM and Table 1.4 presents articles covering 28 engineering fields according to the EMEI engineering backgrounds. We can see that there is an upward trend in research in the ICMSEM and the number of research areas is expanding. For example, in the first conference, we received few papers on sustainable construction engineering, but in the seventh, three papers on this field were published.

Table 1.3 The article based on C-based RM in the 2008-2012 ICMSEMs

Years	2008	2009	2010	2011	2012
Articles	Xu [3]	Arakawa [8]	Liao [13]	Zhang [18]	Marquez [23]
	Jiang [4]	Cheng [9]	Li [14]	Li [19]	Akhtar [24]
	Jiang [5]	Zhang [10]	Huang [15]	Luo [20]	Oepomo [25]
	Yang [6]	Hong [11]	Patil [16]	Shao [21]	Pinar [26]
	Xu [7]	He [12]	Deng [17]	Zhang [22]	Hajiyev [27]

Xu proposed 12 main engineering fields covering construction, ecology, logistics, finance, computers, software, performance, supply chain, transportation, project management, E-commerce and decision support systems. From Table 1.4, we find that all 11 fields have been paid attention to in the seventh conference proceedings. In this study, the branches are still the same as those in the sixth ICMSEM proceedings. However, some new fields such as building information modelling (BIM) and sustainable construction engineering also have been paid attention to. These were conducted to strengthen the EMEI computer-based methodologies. These methodologies mainly involve computer simulation, mathematical modelling and computer-based optimization methods, network analysis, interactive planning, and data mining, which enable scholars and readers to obtain scientific results and conclusions with the aid of computer technology. Thus, more research in this field has been published for the seventh ICMSEM proceedings.

Table 1.4 The distribution of the articles published in the proceedings of ICMSEM according to the engineering fields

Engineering fields	2007	2008	2009	2010	2011	2012	2013
Aerospace	1		1	2	2	3	
Intelligent	3	5	7	8	4	3	2
Software	3	4	5	7	5	6	5
Computer		2	7	8	9	6	10
Information	2	3	4	7	6	7	6
Communications	2	2	3	7	5	4	3
Data		3	5	6	4	9	3
Network	2	3	5	8	6	7	4
Ecology	2	3	4	5	5	4	1
Construction	2	3	5	6	5	3	6
Transportation	1	2	2	4	3	2	4
Systems		2	2	4	3	4	3
Manufacturing	2		4	3	3	5	5
Safety	1	3		3	6	4	3
Finance	2	1	2	3	2	1	5
Agriculture	1		3	3	1	2	
Power	1	2	3	1	1	2	1
Energy	1	1	2	2	1	1	4
Vehicular			2	1	2	3	1
Signal				3	3	1	
Materials	1		1		1	2	
Hydropower		1			1	2	1
Aviation				1	6	2	
Logistics						2	7
Performance evaluation							5
System analysis					1	3	4
Building construction						1	2
Optimization					2	4	5

We can finally draw a conclusion that there are three trends in the articles on EMEI computer-based methodologies in the first seven ICMSEM: (1) More scholars are doing research in an EMEI framework which emphasizes actual management background, effective theories and methods, and significant engineering practice. (2) There is an ascending trend in the handling of practical engineering problems based on the computer techniques. (3) An increasing range of engineering fields are involved.

1.4.3 Evaluation of the First Seven ICMSEMs

In this section, we evaluate the first seven ICMSEMs and decide whether the trends above are coincident in the trends in EMEI journals. Compared to the documents in the EMEI journals, we found that there was an increasing trend between the ICMSEM and EMEI journals, which is shown in Fig. 1.11. In the ICMSEM and EMEI journals, most papers belonged to research based on computer technology, and those that used information technology or computers and networks in their papers to solve practical problems. Therefore, with the development in computer technology, there is an obvious increasing momentum in MS research which uses information technology or computers and networks (i.e., appropriate management science methodology) under an EM background (i.e., practical engineering problem), indicating than there is an excellent research momentum developing for EMEI computer-based methodologies.

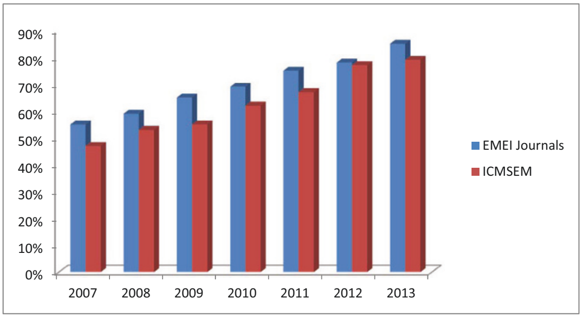

Fig. 1.11 Comparison between ICMSEM and EMEI journals according to C-based RM

More papers stress the solution to practical problems with the aid of computer techniques in the ICMSEM than the EMEI journals, since our conference mainly emphasizes the combination of EM and EI. Compared to other subjects, EMEI has particular research objectives with basic problems to solve, and analytical methods and technological tools to apply. In essence, EMEI equally stresses theory and practice. EMEI articles include new theories and new methods, as well as the successful application of these theories and methods. In EMEI research, it is significant to combine theory and practice to better illustrate the methodology. Practical research focusses on the framework of the problem and stresses the full use of existing knowledge, theories, methods and techniques to analyze the framework of the problem, and apply the techniques of a model group to establish integrated models. Theoretical research focusses on nonrepresentational EMEI problems such as concrete management problems. It is necessary and reasonable to establish theoretical systems by making use of existing knowledge and theories to establish conceptual models, physical models and mathematical models with concluding theories and principles.

By adopting computer-based methodologies, scholars have found new and important practical EMEI research problems, thus, more engineering fields are being considered in the solving of practical engineering problems. The facility layout problem (FLP) is taken as an example here, which belongs to manufacturing or construction engineering. In recent years, FLP has attracted wider attention and been studied in both scientific and practical fields with an attempt to reduce costs or maximize effectiveness. According to Drira et al [28], the most encountered formulations are related to static layout problems (in opposition to dynamic layout problems). Koopmans and Beckmann [29] were among the first to discuss the SFLP, in which they defined the facility layout problem as a common industrial problem. Meller, Narayanan, and Vance [30] then considered that the FLP consists of finding a non-overlapping arrangement of *n* rectangular facilities within a given rectangular plan site so as to minimize the distance based measure. In 2000, Azadivar and Wang [31] defined FLP as the determination of the relative locations of given number of facilities. Besides these papers, Lee and Lee [32] reported that the facility layout problem consisted of arranging *n* unequal-area facilities of different sizes within a given total space, which can be bounded to the length or width of the site area in such a way as to minimize the total material handling cost and slack area cost. It can be reflected that as time goes on, FLP research has become more mature. In the beginning, simulation studies were often used to measure the benefits and performance of given layouts [33]. However, layout problems are known to be complex and are generally NP-Hard, so that a great deal of research has been carried out in this area over the last decades [34]. Based on the different problem descriptions, numerous computer-based methodologies have also been applied to achieve satisfactory solutions, including graph-theoretic heuristics [36, 37], genetic algorithms, ant colony algorithms [38], and simulated annealing algorithms [39]. Therefore, the overall procedure for solving the FLP can be summarized as shown in Fig. 1.12.

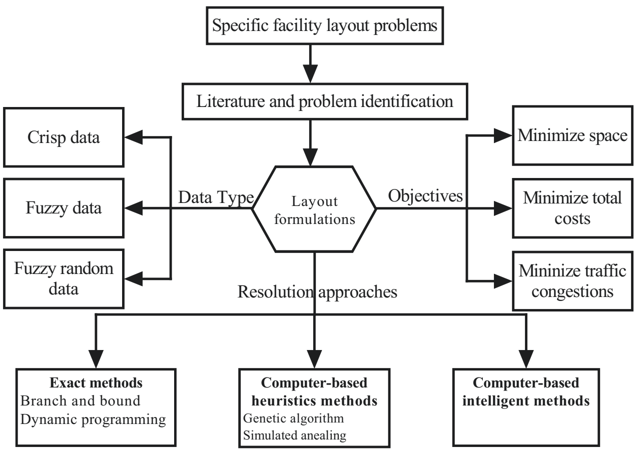

Fig. 1.12 Flowchart for solving FLP with computer-based approaches

In the last section, we found 12 main engineering fields and one rising engineering field in the ICMSEM according to the first seven conference proceedings. We investigated those articles in the EMEI journals from July, 2012 and out of the total 1357 documents, 680 papers were found. Fig. 1.13 shows that the 8 main fields which received more attention in the ICMSEM have close relationships with those in the EMEI journals.

In conclusion, it can be seen that the ICMSEM research coincides with the EMEI development trends. In the future, more EMEI research will concentrate on solving practical engineering problems using computer-based methodologies. Thus, scholars should be focusing on research which provides solutions to meaningful practical problems and should adjust their computer techniques to ensure better solutions.

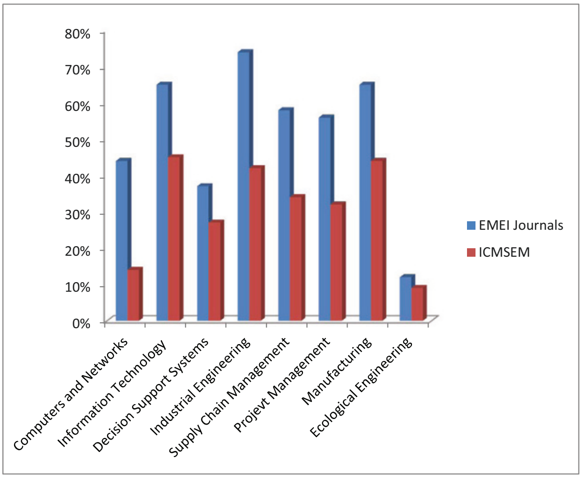

Fig. 1.13 Comparison between ICMSEM and EMEI journals according to 8 main engineering fields

1.5 Appreciation for the Sixth ICMSEM and Prospects for the Seventh ICMSEM

Apart from the help and support from the institutions, many individuals have contributed greatly to this conference. On behalf of the International Society of Management Science and Engineering Management, we want to take this opportunity to thank the National Natural Science Foundation of China (NSFC) for their support, Drexel University for the help in conference organization and Springer-Verlag Press for the publication of the proceedings. We also wish to give appreciation to Prof. John A. Fry as one of the General Chairs, Prof. Benjamin Lev as the Organizing

Committee Chair, Prof. Hajiyev Asaf and Prof. Baldev Raj as Program Committee Chairs, all participants in the conference and all those people who have worked hard to make this conference a success. Finally we want to give appreciation to all authors for their excellent papers at this conference. Due to these excellent papers, the ISMSEM Advancement Prize for EMEI will be awarded again at the conference for the papers which describe a practical application of management science and engineering management though the Grand Prize is not decided according to the strict requirements of the Award Committee.

EMEI covers various fields and EMEI research is in continuous development across the world. There needs to be further developments and new development trends for EMEI to further extend its reach and influence. Our work needs to be constantly updated to focus on the EMEI development trends more intimately and to provide a broader platform for EMEI development. In the coming year, we will continue to try our best to hold another novel and successful ICMSEM related closely to an EMEI based on solving management problems using engineering and computer-based techniques. We will seek to further improve the quality of papers in the proceedings and award more excellent papers the ISMSEM Advancement Prize. In order to make the ICMSEM more attractive, the next conference venue will be a tourist-friendly city in Asia or Europe.

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Part I
Computer and Networks

Chapter 2
A New Ranking Method Approach for Decision Making in Maintenance Management

Fausto Pedro García Márquez, Alberto Pliego, José Lorente and Juan R. Trapero

Abstract Decision making process in maintenance management produces a final choice. Fault Tree Analysis (FTA) is proposed as a graphical representation of logical relationships between the elements that comprise the decision making process in maintenance management. A Fault Tree (FT) is compound by different events and logic gates. Complex systems analysis may produce thousands of combinations of events (cut-sets) that can cause the system failure. The determination of these cut-sets can be a large and time-consuming process even on modern computers. Binary Decision Diagrams (BDD) provides a new alternative to the traditional cut-set based approach for FTA that leads to the determination of the function output value through the examination of the input values. BDD is a directed acyclic graph that represents the Boolean functions. The cut sets generated by BDD will depend on the events ordering. The "Level", "Top-Down-Left-Right", "AND", "Depth-First Search" and "Breadth-First Search" methods have been considered for listing the events, and a comparative analysis of them has been done. A new ranking approach is proposed in this paper, where its efficiency has been validated.

Keywords Decision making · Maintenance management · Fault Tree Analysis · Binary decision diagrams

2.1 Introduction

The study of methods and procedures, by which concerns about multiple conflicting criteria, are taken into account by the International Society on Multiple Criteria Decision Making in order to be formally incorporated into the management planning process. Fault Tree (FT) is used in this paper for supporting decision-making activities in maintenance management.

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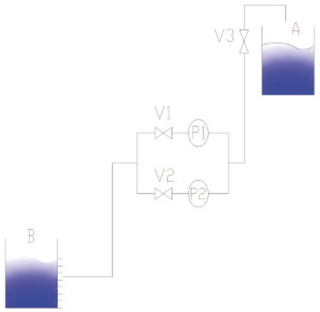
A FT model is a graphical representation of logical relations between events (usually failure/fault events). Complex systems analysis may produce thousands of combinations of events (cut-sets) that can cause the system failure, i.e. the top event occurrence. The determination of these cut-sets can be a large and time-consuming process even on modern computers. The determination of the exact top event probability also requires lengthy calculations if the FT has a great number of cut-sets.



Nomenclature:

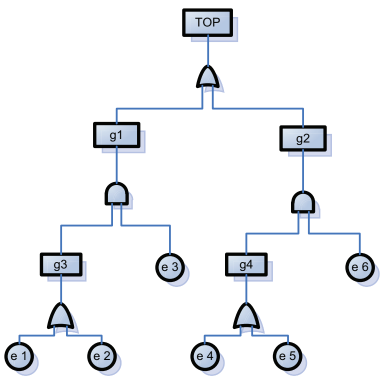
- V: Valve
- P: Pump
-Top: Reservoir A does not receive water.
-g1: V3 does not receive water
-g2: V1 and P1 do not receive water
-g3: V2 and P2 do not receive water
-e1: Level in B is not enough
-e2: Fault in V3. Closed
-e3: Fault in P1
-e4: Fault in V1. Closed
-e5: Fault in P2
-e6: Fault in V2. Closed

Fig. 2.1 Pumping station

Approximation techniques have been introduced with a loss of accuracy in order to reduce the computational cost of the FT analysis (FTA). BDD provides a new alternative to the traditional cut-set based approach for FTA. This technique leads to the determination of the function output value through the examination of the input values. Fig. 2.1 shows a simple example in order to describe the FTA and the use of BDD. The problem consists of flowing water from the tank B to the tank A through the pipes that connect both tanks.

The FT associated to the system shown in Fig. 2.1 is showed in Fig. 2.2.

Fig. 2.2 FT associated to the system shown in Fig. 2.1



2.2 Binary Decision Diagram

Binary Decision Diagrams (BDDs), as a data structure that represents the Boolean functions, were introduced by Lee [3], and further popularized by Akers [13], Moret [1], and Bryant [12].

A BDD is a directed acyclic graph (V,N), with vertex set V and index set N. Vertex set contains two types of vertices. On the one hand, a terminal vertex has as attribute a value: value$(v) \in \{0,1\}$, where "1" state corresponds to the system failure, or "0" state that corresponds to the system success. All the paths that have 1 state provide the cut-sets of the fault tree. On the other hand, a non terminal vertex v has as attributes an argument index$(v) \in N\{0,1,\cdots,n\}$, and two descendants, low(v) and high$(v) \in V$, that are connected by a branch. Each vertex has a vertex 0 branch that represents a non occurrence basic event, or 1 branch that represents an occurrence basic event. For any non-terminal vertex v, if low(v) is also non-terminal, then index$(v) <$ index(low(v)), and if high(v) is non-terminal, then index$(v) <$ index(high(v)).

A BDD has a root vertex v that leads to denote a function f_v defined recursively as: Firstly, if v is a terminal vertex and value$(v) = 1$, then $f_v = 1$. In other case, when value$(v) = 0$ then $f_v = 0$; Secondly, if v is a non terminal vertex with index$(v) = 1$, then f_v will be:

$$f_v(x_1,\cdots,x_n) = x_{i\cdot}\text{flow}_{(v)}(x_1,\cdots,x_n) + x_{i\cdot}\text{high}_{(v)}(x_1,\cdots,x_n).$$

2.3 Conversion from FTA to BDD

The following template conversion method is used for obtaining the BDD from the FTA. Then the level of unreliability can be easily determined from the BDD.

Let A be a vertex set as $A = A(A_1,\cdots,A_n)$. If $A_1,\cdots,A_m$ are the A descendant vertices, then:

$$\text{index}(A(A_1,\cdots,A_n)) = \min(\text{index}(G_i)),\ 1 \le i \le n.$$

Let $x_1,\cdots,x_m$ be Boolean variables, then the following expressions can be obtained:

- If $R(x_1,\cdots,x_m) = S(x_1,\cdots,x_m) \bigcup T(x_1,\cdots,x_m)$, using "binary OR template", then BDD of $R(x_1,\cdots,x_m)$ is denoted as: $R = \text{ite}(S,1,\text{ite}(T,1,0)) = \text{ite}(S,1,T)$, where "ite" means If-Then-Else.
- If $R(x_1,\cdots,x_m) = S(x_1,\cdots,x_m) \bigcap T(x_1,\cdots,x_m)$, employing "binary AND template", then BDD of $R(x_1,\cdots,x_m)$ is obtained as: $R = \text{ite}(S,1,\text{ite}(S,1,0)) = \text{ite}(S,1,T)$.

Let $G_1, G_2, \cdots, G_n$ be a BDD. According to the previous equations it is possible to get the next rules:

• Get-rid-of formula

$\mathrm{ite}(1, G_1, G_2) = 1 \cdot G_1 + 1 \cdot G_2 = 1 \cdot G_1 + 0 \cdot G_2 = G_1,$
$\mathrm{ite}(0, G_1, G_2) = 0 \cdot G_1 + 0 \cdot G_2 = 0 \cdot G_1 + 1 \cdot G_2 = G_2,$
$\mathrm{ite}(G_1, G_1, 0) = G_1 \cdot G_1 + G_1 \cdot 0 = G_1 \cdot G_1 = G_1,$
$\mathrm{ite}(G_1, 1, 0) = G_1 \cdot 1 + G_1 \cdot 0 = G_1,$
$\mathrm{ite}(G_1, G_2, G_2) = G_1 \cdot G_2 + G_1 \cdot G_2 = (G_1 + G_1) \cdot G_2 = G_2.$

• Expansion formula

$\mathrm{ite}(\mathrm{ite}(G_1, G_2, G_3), G_4, G_5) = \mathrm{ite}(G_1, \mathrm{ite}(G_2, G_4, G_5), \mathrm{ite}(G_3, G_4, G_5)).$

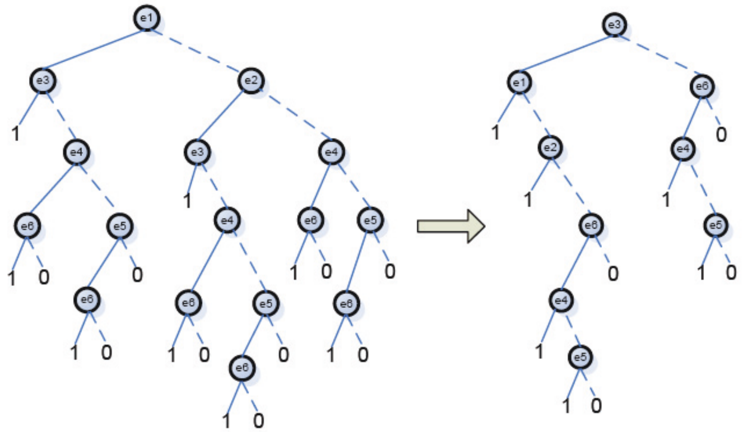
• Absorption formula

$\mathrm{ite}(G_1, \mathrm{ite}(G_1, G_2, G_3), G_4) = \mathrm{ite}(G_1, G_2, G_4),$
$\mathrm{ite}(G_1, G_2, \mathrm{ite}(G_1, G_3, G_4)) = \mathrm{ite}(G_1, G_2, G_4).$

• Changed-order formula

If $\mathrm{index}(G_2) < \mathrm{index}(G_1) \leq \mathrm{index}(G_3)$, then
$\mathrm{ite}(G_1, G_2, G_3) = \mathrm{ite}(G_2, \mathrm{ite}(G_1, 1, G_3), \mathrm{ite}(G_1, 0, G_3)).$
If $\mathrm{index}(G_3) < \mathrm{index}(G_1) \leq \mathrm{index}(G_2)$, then
$\mathrm{ite}(G_1, G_2, G_3) = \mathrm{ite}(G_3, \mathrm{ite}(G_1, G_2, 1), \mathrm{ite}(G_1, G_2, 0)).$
If $\mathrm{index}(G2) \leq \mathrm{index}(G3) < \mathrm{index}(G1)$, then
$\mathrm{ite}(G1, G2, G3) = \mathrm{ite}(G2, \mathrm{ite}(G3, 1, G1), \mathrm{ite}(G3, \mathrm{ite}(G1, 0, 1), 0)).$
If $\mathrm{index}(G3) < \mathrm{index}(G2) < \mathrm{index}(G1)$, then
$\mathrm{ite}(G1, G2, G3) = \mathrm{ite}(G3, \mathrm{ite}(G2, 1, \mathrm{ite}(G1, 0, 1)), \mathrm{ite}(G2, G1, 0)).$

The BDD method does not analyse the FTA directly, but it converts the tree to the Boolean equations that will provide the fault probability of the top event. This conversion presents several problems, where the variable ordering scheme chosen for the construction of the BDD has a great effect on its resulting size (see Fig. 2.3).



(a) $e_3 < e_1 < e_2 < e_6 < e_4 < e_5$ (b) $e_1 < e_2 < e_3 < e_4 < e_5 < e_6$

Fig. 2.3 BDDs associated to FT given in Fig. 2.2

It has been demonstrated that the BDD associated to the FT given in Fig. 2.2 (Fig. 2.3a) can be reduced with a better ordering of the events (Fig. 2.3b). The probability of the top event will be the same employing any of the BDDs associated to the FT (Fig. 2.2), i.e. the computational cost will depend on the ranking of the events where the probability of the top event will always be the same.

2.4 Ranking Criteria

The level in any event is understood as the number of gates that has higher up the tree until the top event. The "level" method creates the ranking of the events regarding to the level of them. In case that there are two or more events at the same level, the event will have highest priority if it appear early in the tree. Employing the Level method to the FT given in Fig. 2.2, the ranking is showed in Table 2.1.

Table 2.1 Ranking of the events (Fig. 2.2) by the Level method: $e_3 < e_2 < e_1 < e_2 < e_5 < e_4$

Basic event	e_1	e_2	e_3	e_4	e_5	e_6	g_1	g_2	g_3	g_4
Number of levels	3	3	2	3	3	2	1	1	2	2

Top-down-left-right (TDLM) method generates a ranking of the events by ordering them from the original fault tree structure in a top-down and then left-right manner [2, 3]. In other words, the listing of the events is initialized at each level from a left to right path, where the basic events that are found are added to the ordering list (see Fig. 2.4). In case that any event is encountered, located higher up the tree and already incorporated in the list, then it is not taken into account.

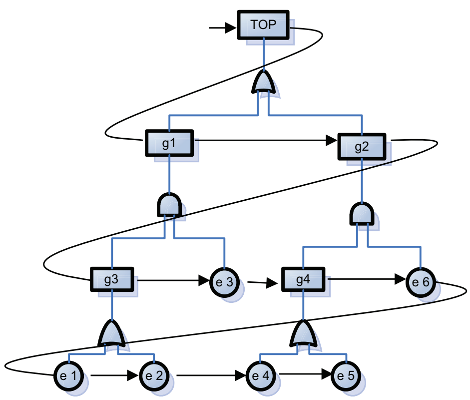


Fig. 2.4 TDLR method for FT from Fig. 2.2: $e_3 < e_6 < e_1 < e_2 < e_4 < e_5$

Xie et al [29] suggest by the AND criterion that the importance of the basic event is based on the "and" gates that there are between the k event and the top event, because in FTA the "and" gates imply that there are redundancies in the system. Consequently, basic events under an "and" gate can be viewed as less important because it is independent to other basic events occurring for the intermediate events [12].

The depth first search (DFS) method goes from top to down of the tree, and each sub-tree from left to right. It is a non-recursive implementation and all freshly expanded nodes are added as last-input last-output process [5]. Fig. 2.5 shows the DFS method applied to the FT from Fig. 2.2.

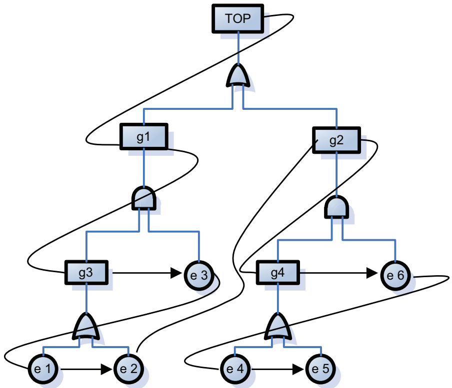


Fig. 2.5 DFS approach for the FT shown in Fig. 2.2: $e_3 < e_1 < e_2 < e_6 < e_4 < e_5$

The breadth-first search (BFS) algorithm begins ordering all the descendants events obtained expanding from the standpoint by the first-input first-output (FIFO) procedure (Fig. 2.6). The events not considered are added in a queue list named "open". It is recalled "closed" list when all the events are considered [6, 11].

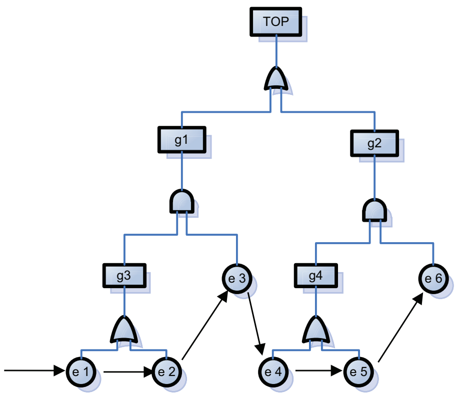


Fig. 2.6 BFS method applied to the FT given in Fig. 2.2: $e_1 < e_2 < e_3 < e_4 < e_5 < e_6$

2.5 New Ranking Method Approach

A new ranking criterion has been defined in order to reduce the size of the BDD. The following considerations have been taken into account:

Each logic gate from the FT needs an appropriate weighting.

The importance of each event is given by the multiplication of the weighting of the gates crossed from the event considered to the top event.

The basic events are sorted in decreasing values of importance.

The weighting of the logic gate will depend on the type of logic-gate (OR or AND gates), and the number of events under the logic-gate.

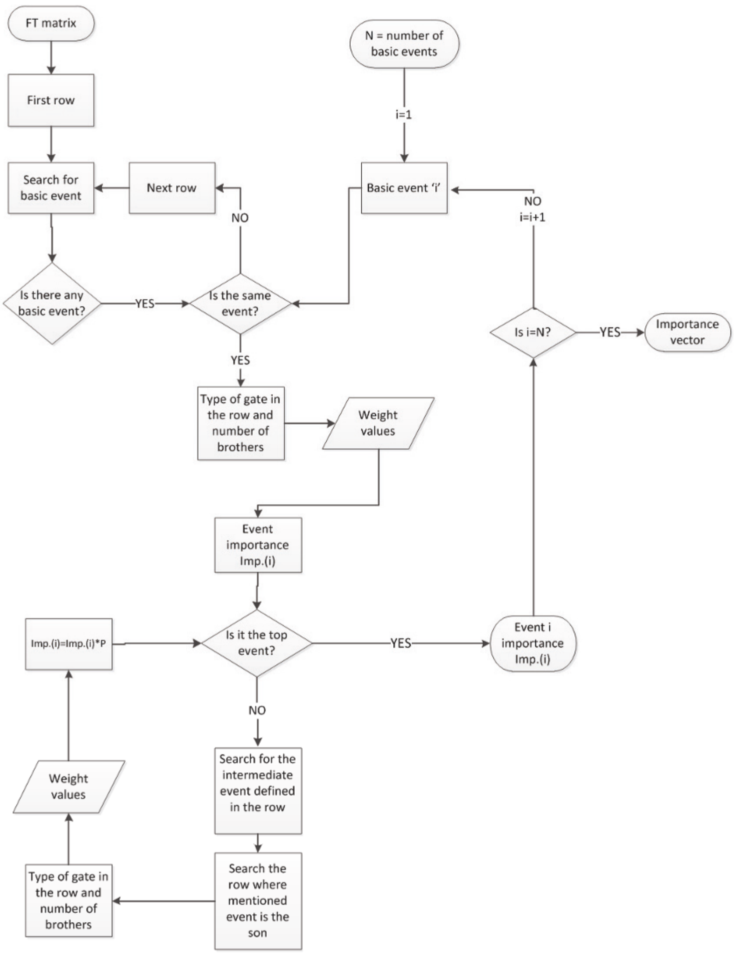


Fig. 2.7 Scheme of the new approach for ranking events

If there is "n" events through an AND logic gate, the failure could only be extended through the gate if all the "n" events are given, i.e. only 1 state of the 2^n. possible states will be done. The case where the "n" events are given is assigned by 1, therefore the weighting of the logic gate will be:

$$P_{\text{and}}(n) = \frac{1}{2^n}.$$

The failure will be extended under any event of the OR gate in all cases where any of the event is not cero, i.e. only one of the 2^n. states will not be extended. The mentioned state is the one in which all the events are 0. Therefore, the OR logic gate weighting is:

$$P_{\text{or}}(n) = \frac{2^n - 1}{2^n}.$$

The new approach for ranking the events is summarised in the scheme given in Fig. 2.7.

In Fig. 2.8 is presented a FT as an example for ranking the event employing the new approach (Fig. 2.7).

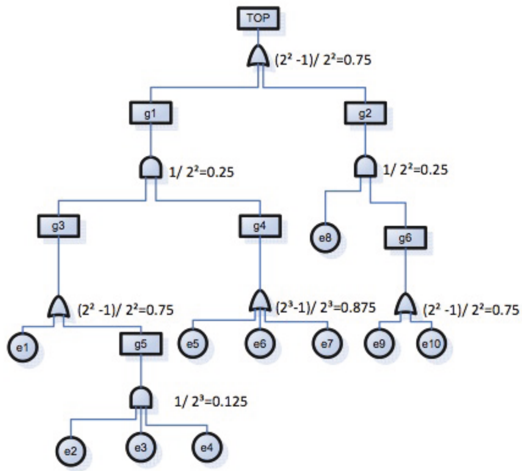


Fig. 2.8 Weighting of the logic gates by the new ranking method

For each basic event, there is a single path to the top event. The importance for event e_1 will be given by all the weights assigned to the gates that are needed to pass through in order to finish to the top event. For example, the importance for the events 1 and 2 (Fig. 2.8) will be:

$$I_{e_1} = 0.75 * 0.25 * 0.75 = 0.140625,$$
$$I_{e_2} = 0.125 * 0.75 * 0.25 * 0.75 = 0.01757813.$$

The importance measurements of the basic events employing the new approach are given in Table 2.2, being the ranking: $e_8 < e_5 < e_6 < e_7 < e_1 < e_9 < e_10 < e_2 < e_3 < e_4$, obtaining 20 cut-sets, where 22 cut-sets are obtained by employing the AND criterion with the ranking $e_8 < e_1 < e_5 < e_6 < e_7 < e_9 < e_10 < e_2 < e_3 < e_4$. The main reason that the new approach provides better results than the AND criterion is because the importance of e_1 is the same to e_5, e_6 and e_7 according to the AND criterion. That means e_1 is more important due to its location in the FT.

Table 2.2 Importance of basic events

Basic event	e_1	e_2	e_3	e_4	e_5	e_6	e_7	e_8	e_9	e_{10}
Importance	0.1406	0.0176	0.0176	0.0176	0.1641	0.1641	0.1641	0.1875	0.1406	0.1406

The new method approach considers that $e_5,\ e_6$ and e_7 are connected by an OR logic gate, which means that the failure is more probable to happen through it, i.e. $e_5,\ e_6$ and e_7 are given more importance than e_1.

2.6 Results

A set of FTs has been considered for evaluating the ranking events. The number of basic events, intermediate or middle events (the events between the top event and the event considered), OR and AND gates and levels have been taken into account in each FT, and presented in Table 2.3.

Table 2.3 FTs characteristics

	Number of basic events	Number of middle events	Number of OR gates	Number of AND gates	Number of levels
FT 1	5	5	3	3	3
FT 2	15	13	10	4	8
FT 3	11	9	5	5	6
FT 4	25	21	16	6	12
FT 5	20	15	10	6	5
FT 7	10	7	7	1	5
FT 8	20	17	12	6	11
FT 9	31	25	16	10	11

The methods described above have been employed for ranking the events of the FTs showed in Table 2.3. The numbers of cut-sets given by the methods are given in Table 2.4.

BFS provides poor results in most of the cases, especially when the fault tree has a large number of events, levels and “or” and “and” gates. The Level and AND

Table 2.4 Cut-sets obtained by the ranking events

	TDLR	DFS	BFS	Level	AND	Approach
FT 1	2	2	2	2	2	2
FT 2	30	30	155	30	30	30
FT 3	12	24	36	12	12	12
FT 4	64	142	176	64	22	28
FT 5	99	207	257	99	55	55
FT 6	9	7	7	9	9	12
FT 7	9	12	21	9	9	9
FT 8	44	76	192	44	44	44
FT 9	1012	1292	3456	1012	1012	924

methods generate the ranking of the events with a minimal cut-sets. The conclusions regarding to Level, DFS and TDLR methods should be studied for each fault tree.

The new approach proposed in this paper provides the minimal cut-sets in most of the cases, i.e. for FT 1-3, 5, 7-9, being the number of cut-sets close to the minimal cut-sets found for FT 4 and 6. The new approach could improve the minimal cut-sets for FT 9, the most complex FT taken into account.

2.7 Conclusions

Decision making in maintenance management requires methods and procedures in order to solve the multiple conflicting criteria. This paper presents the Fault Tree Analysis (FTA) for supporting decision-making criteria in maintenance management.

Fault Tree (FT) is the logical relation between the events by a graph that leads the qualitatively analysis. In order to study the FT quantitatively is needed to determine all the cut-sets, or combinations of the events, that may cause the system failure.

Binary Decision Diagrams (BDD) are used in this research work to minimise the computational cost for the quantitatively FTA, where the the Boolean functions are represented by the BDD as a directed acyclic graph. The ranking of the events employed in the BDD will determinate the size of the cut-sets. The “Level”, “Top-Down-Left-Right”, “AND”, “Depth-First Search” and “Breadth-First Search” methods have been considered for listing the events. A new ranking approach is proposed in this paper and a comparative analysis of the methods has been done.

The Level and AND methods create the listing of the events that provide a reduced number of cut sets. The Level, Depth-First Search and Top-down-Left-Right methods should be studied for each FT. Finally the Breadth-First Search is the ordering method that provides a higher cut sets number.

The minimal cut-sets in most of the cases are found by the new approach proposed in this paper. The new approach could improve the minimal cut-sets found in the most complex FT considered.

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Chapter 3
Exploring Determinants of Knowledge Sharing in a Social Network of Practice

Jae Hwa Choi, Benjamin Lev and Hak-Lae Kim

Abstract Network of practice (NoP) operating on social media have been rapidly grown in recent years since the social media allows users not only to create contents, but also to interact with each other. A new type of NoP using social networking services (SNS) is defined as a social network of practice (sNoP). SNoP involves a collection of individuals who communicate, collaborate, and exchange knowledge openly with others sharing a common practice. Relatively little has been published focusing on the factors that influence the participation in knowledge sharing within the sNoP. This study focuses on the determinants of knowledge sharing in sNoP whose inquiry requires not only social theories, but also socio-technical views. Building on the social cognitive theory, the social capital theory, and the technology acceptance theory, this research-in-progress paper aims to explore how personal cognition, social capital, and technology acceptance attitude affect knowledge sharing in sNoP.

Keywords Social network · Network of practice · Social network services · Knowledge sharing

3.1 Introduction

In the knowledge economy, social networks play a critical role since knowledge work is often getting done through knowledge sharing. Recently with the explosion

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of social media, social networks enter a new level. Social media empower individuals to form social networks not only of personal relationships, but also of the shared interest or practice. In particular, using SNS like Facebook and Twitter, practitioners engage in social interaction, exchange information, and share their knowledge through a wide variety of devices.

As more people communicate, interact, and socialize through social media, both businesses and academics are keenly interested in understanding the factors affecting the participation in sNoP. This is because the sustainability and success of sNoP are dependent upon the participation in knowledge sharing. Understanding the factors of the participation in sNoP is of concern to organizations, which want to create value from the use of social media. Academics have been interested in theorizing factors that influence knowledge sharing in communities and networks [8, 18, 33, 35].

This study focuses on the determinants of knowledge sharing in sNoP whose inquiry requires not only social theories, but also socio-technical views. Drawing on the social cognitive theory, the social capital theory, and the technology acceptance theory, this paper proposes a model and tests it with a sNoP of IT professionals in Korea to explore determinants of knowledge sharing through social networks. This study contributes to the literature by exploring determinants of individuals' participation in sNoP through a holistic view by considering the context not only of social but also of technical factors.

The paper is organized as follows: after an overview of the new issues of knowledge sharing in sNoP, literature review is summarized in Sect. 3.2. Sect. 3.3 provides a research model with hypotheses to explore determinants of member participation in sNoP. Sect. 3.4 discusses the plan of an empirical study for the research model developed. Conclusions and expected contributions are discussed in Sect. 3.5.

3.2 Backgrounds and Literature Review

3.2.1 Knowledge Sharing through Social Media

The importance of using social connections and social relations in achieving goals is well understood. It is through these informal networks-not just through traditional organizational hierarchies-that information or knowledge is acquired and work gets done [38]. Individuals are no longer restricted by the formally commanded relationships in organizations or the organizational boundary.

When individuals have a common interest or are engaged in a similar practice, they create network of practice (NoP) to engage in knowledge sharing. Knowledge management discipline distinguishes two kinds of communities: community of practice (CoP) and NoP. In NoP, relations among network members are significantly looser than those within a CoP. In NoP, relations among members are loose and most of the people within such a network may never know or come across one another. In NoPs, participation is open and voluntary, and no control over the operation of the network is exercised, individuals are willing to mutually engage with others to help solve problems.

With the advance in information and communication technologies, NoP is able to extend its reach. Wasko and Faraj [33] coined a term electronic NoP (eNoP) and consider it as a special case of the broader concept of NoP. eNoP typically coordinates through technologies such as blogs, listservs or bulletin boards [33, 36]. Recently, it has been pointed out and demonstrated that social media carries great promise for knowledge management [13, 27]. In particular, SNS offers a platform for online users to interact with one another and to maintain interpersonal relations [6, 13]. Practitioners began to capitalize the potential of SNS such as Facebook and Twitter [20]. A new type of NoP using social networking services (SNS) is defined as a social network of practice (sNoP). The emerging sNoP can be distinguished from eNoP as it is based on the SNS technology.

People in NoP spend their valuable time and effort to share knowledge with others even when there is no direct benefit for helping other members. In sNoP, the knowledge contributed by members is visible and accessible to all other members. Wasko et al [32] points out that the collective knowledge generated by network members exhibits aspects of a public good, which has two important characteristics: nonexcludability and nonrivalry. In sNoP, members might lurk and free-ride in knowledge sharing [37]. Thus, it is important to understand why individuals forgo their apparent inclination to behave out of self-interest and volunteer to participate in knowledge sharing through communities or networks. That is critical because the success and sustainability of NoP are solely dependent on the willingness to share knowledge with other members. Both practioners and acedemics are interested in a more in-depth understanding of the factors that predict members' participation in knowledge sharing through communities or networks. Knowledge management field has investigated this important research question of factors affecting individuals' participation in knowledge sharing.

This study focuses on this new kind of NoP based on SNS, i.e., sNoP. The 'social' part of the term 'sNoP' indicates the use of SNS, such as Facebook or Twitter. The participation in sNoP takes place through the activities of posting or viewing of information and knowledge. In sNoP, different context of NoP and its SNS platform might involve different perceptions and behaviors among the participants. It is noted that the motivation for participation in communities or networks like sNoP is mainly context dependent [4, 16]. A few researchers have recognized the new opportunity of sNoP for knowledge sharing [15, 27]. Thus, the research question for this study is why individuals volunteer to participate in knowledge sharing in sNoP. A thorough literature review will show us concepts and theories that are applicable to this specific context for this study.

3.2.2 Social Cognitive, Social Capital, and Technical Acceptance Theory

Extant studies highlighted various factors affecting an individual's motivation to share knowledge. These studies covered individual and social factors, and the role of information technology. Factors that are examined range from recognition to anonymity, from identification to network ties, and from monetary incentive to altruism, among others. Recognition, in the form of elevated social status or reputation, is identified as a determinant to participate in the community or network [17]. Self-efficacy and expertise, which will improve one's visibility, are known to motivate participation [8, 33]. The choice of anonymity is also suggested to encourage participation in communities and networks [2]. Identification, in the sense of community identity, and commitment enhance the likelihood of members' participation and contribution [8]. Network ties and trust, which will increase as social interactions continue over time, are also found to determine participation in knowledge sharing [33]. Hsu and Lin [14] found that altruism has positive effect on blogger's attitude.

In examining factors affecting knowledge sharing in communities or networks, information systems researches have applied a variety of relevant theories from a number of related disciplines. Most previous studies have applied theories dealing with personal, contextual, and social factors. Among other theories, the social cognitive theory and the social capital theory are widely applied to investigate social factors of participating in knowledge sharing in community or network [8, 33].

The social cognitive theory addresses personal cognition and contextual factors which influence an individual's behavior in a social setting. In information systems researches, the concept of self-efficacy and personal outcome expectations are considered to be most relevant to the social cognitive theory [8, 25]. Chen and Hung [7] consider norm of reciprocity and interpersonal trust factors in applying the social cognitive theory. Chiu et al [8] points out the limit of the social cognitive theory. That is, the social cognitive theory does not deal with what resources are embedded within a social network and how they affect an individual's behavior.

The social network theory is applied to consider the nature of social interactions and the set of resources embedded within the social network. Wasko and Faraj [33] apply the social capital theory from an individual's perspective. They view that individual relations are important sources of social capital and determine how individual members behave in relation to others. Chiu et al [8] integrates the social cognitive theory and the social capital theory. In both studies the social capital theory is adapted to examine individual motivations for participating in knowledge sharing in communities or networks.

The technology acceptance theory has been integrated with other theories in order to identify factors determining members' participation in knowledge sharing through the blog community [14, 25]. The approach in these studies takes the socio-technical perspective, which views an online community as a socio-technical system [14, 25, 26]. This view considers both technical and social components of a community or network, and highlights perceived usability and sociability as corresponding antecedents of participation for the community or network [26].

The literature on the determinants of participating in knowledge sharing in communities or networks has provided a better understanding of the factors underpinning knowledge sharing from both social and technological perspective. While past studies generated valuable findings, it is not clear whether the studies can be extended to the new context of sNoP, where social network and SNS characteristics are distinct. Thus, the extant literature for the participation of knowledge sharing in the community or network is far more limited in addressing the impact of social and technical factors on sNoP. This study presumes that the behavior of an individual to participate in knowledge sharing in sNoP is affected by personal cognition and social capital as well as the technology in use. The model in this study attempts to address issues related to the technology use behavior as well as both personal cognition and social network.

3.3 Research Model and Hypotheses

3.3.1 Research Model

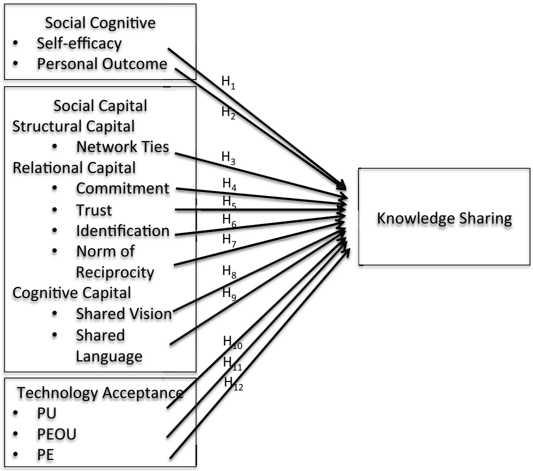
The goal of the current study is to investigate factors determining individuals' participation in knowledge sharing through sNoP. In sNoP, people interact not only to share information and knowledge, but also to engage in social interactions. It is necessary that issues related to both personal cognition and social network should be addressed. To this end, this study applies two social theories: the social cognitive theory and the social capital theory. In addition to these two theories, the technology acceptance theory is also included. A technology (in this study, Facebook) allows knowledge sharing to take place since sNoP is basically a practitioner's social network through SNS. Fig. 3.1 shows the proposed research model.

3.3.2 Hypotheses

(1) Social cognitive theory

The social cognitive theory argues that a person's behavior is partially shaped and controlled by the influence of community or network and the person's cognition. In the social cognitive theory, self-efficacy is a prominent concept and outcome expectation is another major cognitive factor in influencing individuals' behavior. Self-efficacy is an individual's belief in his (or her) ability to succeed and achieve the desired outcome under certain circumstances [3]. Personal outcome expectations are concerned with individual's esteem and sense of accomplishment.

Fig. 3.1 Research model for knowledge sharing in sNoP



Individuals' behavior can often be better predicted by their beliefs they hold about their capabilities than by their capability of accomplishing something. Pajares [24] notes that self-efficacy beliefs provide the foundation for an individual's motivation and personal accomplishment. Chen and Hung [7] view the knowledge sharing self-efficacy as an individual's confidence in an ability to provide knowledge that is valuable to others. Self-efficacy has been used in information technology adoption researches [9].

Studies have shown that higher member's self-efficacy boosts his (or her) intrinsic motivation and therefore makes him (or her) more likely to stay in a community or network. Wang and Fesenmaier [34] confirm that self-efficacy is the major factor in affecting active contribution online. Self-efficacy is found to influence positively the intention to share knowledge [19, 25]. This leads to the following hypothesis:

Hypothesis 1. Self-efficacy is positively related to the knowledge sharing.

Bandura [3] argues that people anticipate the likely consequences of their prospective actions. Wasko and Faraj [33] note that people contribute knowledge in NoP as they expect some new value to be created. Chiu et al [8] views personal outcome expectation as the knowledge contributor's judgment of likely consequences that his (or her) knowledge sharing behavior will produce to himself (or herself).

Butler et al [5] points out that, besides altruistic motivation, individuals would participate in communities since they expect to get benefits such as information, social relationship, and visibility. Hu and Kettinger [15] assert that the primary perceived value of SNS is manifested in the course of construction and enhancement of the relational value among social network members. Compeau et al [9] views that personal outcome expectation is related to expectations of change in image or status or to expectations of rewards, such as promotions, raises, reputation, or praise.

Papadopoulos et al [25] refers personal outcome expectation to image and reward following actions of individuals. They claim that people share knowledge in return for benefits, such as reputation and expected relationship. It has been found that personal outcome expectation positively influences attitude towards knowledge sharing among bloggers [14, 25]. Wang and Fesenmaier [34] discovered that satisfying other members' needs and being helpful to others are the major reasons to contribute to the community or network. This leads to the following hypothesis:

Hypothesis 2. Personal outcome expectation is positively related to the knowledge sharing.

(2) Social capital theory

The social capital theory proposes that social relationships constitute a valuable resource for the conduct of social affairs and provide their members with the community-owned capital [22]. Nahapiet and Ghoshal [22] define social capital as the sum of the actual and potential resources embedded within, and derived from the social relationships possessed by an individual. Social capital, the network and resources which may be mobilized through it, is critical to individuals in achieving objectives.

Nahapiet and Ghoshal [22] suggest to examine the social capital from three distinct dimensions: structural, relational, and cognitive. The structural dimension of social capital is concerned with the structure of social relations and manifested as social interaction ties or network ties. The relational dimension of social capital is concerned with the content of social relations and manifested as commitment, trust, norm of reciprocity, and identification. The cognitive dimension of social capital is concerned with the shared system of meaning within a group and manifested as shared vision and shared language.

(a) Structural Capital

Network tie or social relation provides access to resources, i.e., knowledge in sNoP. The more interconnected a member in a network is to another member, the more the member is able to share knowledge. The overall configuration of these ties constitutes an important facet of social capital [22]. They refer the relational strength of ties in a network as the nature and the quality of relations between the network members. Centrality is related to how deeply an individual is embedded. If an individual is central in his (or her) community or network, he (or she) is the most popular individual in the community or network and gets the most access.

Much of the social interaction on the Internet occurs among those with preexisting social ties [5]. The relational strength of ties influences cooperative behaviors and collective action among the network members [33]. Tsai and Ghoshal [30] found that centrality strongly affects on knowledge exchange. This leads to the following hypothesis:

Hypothesis 3. Network tie is positively related to the knowledge sharing.

(b) Relational Capital

While the structural dimension of social capital covers social interaction, the relational dimension of social capital refers to assets that are rooted in these relationships [22]. Relational capital is related to the affective nature of social relationships within a community or network [33, 37]. Relational dimensions of social capital include obligation, trust, identification, and norm of reciprocity as the predictor of knowledge sharing [22]. This study replace obligation with commitment, as it is more appropriate for the context [8, 33].

Allen and Meyer [1] introduce two types of organizational commitment: normative commitment and affective commitment. The normative commitment to the community or network represents a perceived duty or obligation to engage in future action to meet organizational goals and interests. A committed community or network member feels a sense of responsibility towards the community or network and therefore helps other members through knowledge sharing. The affective commitment, sense of belonging, predicts that the more affinity a member feels with a community or network, the more he (or she) contributes to that community or network.

Commitment builds over repeated interactions with other members [22, 33]. These frequent interactions will likely strengthen his (or her) feelings of obligation to provide help to other members by contributing his (or her) knowledge. Chiu et al [8] views that community-related outcome expectations are related to commitment. They view that the success, growth, and continuance of the virtual community are outcomes which come from members' commitment to the community.

When commitment to the community or network increases, members feel a sense of responsibility to help others in the community or network by sharing their valuable knowledge [33]. It is this commitment that motivates members to contribute content [33, 37]. This leads us to propose the following:

Hypothesis 4. Commitment is positively related to the knowledge sharing.

Trust is viewed as the confidence a person has in his (or her) favorable expectations of what another person will do, based on previous interactions [12]. Mayer et al [21] refers ability, benevolence, and integrity as factors of perceived trustworthiness. Nahapiet and Ghoshal [22] suggest that when trust exists between the parties, they are more willing to engage in cooperative interaction. In a community or network, trust facilitates the ease of cooperation without worrying that a member will be taken advantaged of by another member.

Trust has been identified as an important antecedent of intellectual capital exchange [22], resource exchange and combination [30], and e-commerce [12, 29]. Trust is an essential component of social relationships and a necessity in knowledge sharing in a community or network on the Internet [7, 8, 30]. This leads to the following hypothesis:

Hypothesis 5. Trust is positively related to the knowledge sharing.

Nahapiet and Ghoshal [22] define identification as the process whereby individuals see themselves as one with another person or group of people. Identification reflects individual identification with a community or network, such as senses of belongingness and attachment. Both commitment and identification deal with the similar phenomenon of sense of attachment to a community or network, and the dynamics that influence a member's behavior within the community or network. Identification requires individual members to maintain an active relationship with other members [39]. Chiu et al [8] interprets identification as an individual's sense of belonging and positive feeling toward a virtual community.

Nahapiet and Ghosal [22] found that emotional identification fosters loyalty and citizenship behaviors in the group setting. Shen et al [28] and Zhou [39] found that an individual's intention of participation in online community is affected by

identification. This leads to the following hypothesis:
Hypothesis 6. Identification is positively related to the knowledge sharing.

The social exchange theory distinguishes social exchange and economic exchange since social exchange entails unspecified obligations. Although an exchange intrinsically entails reciprocation, a social exchange involves favors with a general expectation of a future return. The social norm of reciprocity is a sense of mutual indebtedness so that individuals reciprocate by returning equivalent benefits they receive from others. In a community or network, when a member perceives that a norm of reciprocity governs the knowledge sharing within the community or network, they trust that their valuable knowledge sharing will be reciprocated in the future.

The norm of reciprocity can serve as a motivating mechanism for the cooperative behavior required for community or network members. Previous researches indicated that knowledge sharing was facilitated by a strong sense of reciprocity [7]. Wang and Fesenmaier [34] found that the reciprocity norm motivates knowledge sharing in online communities. Wasko and Faraj [33] suggested that individuals who share knowledge in NoP believe in reciprocity. This leads to the following hypothesis:
Hypothesis 7. Norm of reciprocity is positively related to the knowledge sharing.
(c) Cognitive Capital

The cognitive dimension of social capital refers to those resources providing shared interpretations and systems of meaning among members [22]. This dimension of social capital captures the essence of the public good aspect of social capital [30]. Cognitive social capital is created through communicative language, narratives, and codes. They influence perceptions of meaning and reality in relationships. Nahapiet and Ghoshal [22] maintain that meaningful communication requires some sharing of context between the parties. They identify two ways of sharing: shared language and sharing of collective narratives (i.e., shared vision).

Nahapiet and Ghoshal [22] maintain that shared language has a direct and important function in social relations. To the extent that people share a common language, this facilitates their ability to gain access to people and their knowledge. Shared language is essential to learning in virtual communities [8]. It provides an avenue in which participants understand each other and build common vocabularies in their domains. Accordingly, shared language will help motivate the participants to actively involve in knowledge sharing. This leads to the following hypothesis:
Hypothesis 8. Shared language is positively related to the knowledge sharing.

A shared vision or shared code facilitates a common understanding of common goals and proper ways of acting in a social system [30]. The shared vision through the collective goals helps members to see the potential value of their resource exchange. Tsai and Ghoshal [30] found that shared vision has a significant effect on knowledge exchange. The shared vision will help members to actively participate in knowledge exchange. This leads to the following hypothesis:
Hypothesis 9. Shared vision is positively related to the knowledge sharing.
(3) Technology acceptance theory

The technology acceptance theory addresses the issues of how users come to acceptance and use of a technology and is used to predict an individual's intention to use and acceptance of an information system or information technology. The technology acceptance theory suggests two determinants that positively impact the acceptance of a technology: perceived usefulness and perceived ease of use [10, 11]. Perceived enjoyment is added later as another important construct related to beliefs of the user [11]. The technology acceptance theory has been integrated with other theories in search of identifying factors determining participation for knowledge sharing through blog community [14, 25].

Individuals adopt technology because they derive some benefits from its use. A plausible reason is that individuals will use technologies only if they perceive that such usage would help them to achieve the desired task performance. Perceived usefulness is the perception of individuals on their performance when they use a technology. Perceived usefulness is attributed to extrinsic motivation, which refers to an individual's involvement in an activity as something that is perceived to be instrumental in achieving valued outcomes [11].

Previous research has found that perceived usefulness has a strong and consistent relationship with the use of a technology [10, 11]. Perceived usefulness is positively related to Internet use [31]. This leads to the following hypothesis:

Hypothesis 10. Perceived usefulness is positively related to the knowledge sharing using Facebook.

Perceived ease of use is defined as the degree to which an individual believes that using a technology is free of effort. In general, if a technology is easy to use, it requires less effort on the part of users, thereby increasing the likelihood of its adoption and usage. Perceived ease of use is attributed to intrinsic motivation, which refers to doing something because it is inherently enjoyable or interesting [11].

Perceived ease of use has been found to influence computer technology usage directly [10, 11]. It is confirmed that perceived ease of use is positively related to Internet use [31]. Hsu and Lin [14] found that perceived ease of use is important for blog usage. This leads to the following hypothesis:

Hypothesis 11. Perceived ease of use is positively related to the knowledge sharing using Facebook.

Individuals may engage in a particular activity if it yields fun and enjoyment. This implies that individuals may adopt a technology because its use is enjoyable. Perceived enjoyment is defined as the extent to which the activity of using a technology is perceived to be enjoyable in its own right, apart from any associated performance consequences [11].

Perceived enjoyment is supported in Internet use [23, 31] found that fun is the most motivating factor for active participants of Wikipedia. Perceived enjoyment is found to have a significant effect on the use of blog [14, 17, 25]. Chen [6] confirms that the positive influence of perceived enjoyment on the use of SNS. SNS allows individuals to interact with others, exchange knowledge, and participate in groups and events. Thus, the use of SNS is hedonic as users experience fun and entertainment. This leads to the following hypothesis:

Hypothesis 12. Perceived enjoyment is positively related to the knowledge sharing using Facebook.

3.4 Research Methodology

Our continuing research will empirically test the model. All the measurement items in the study will be adapted from prior researches with minor refinements to fit the research context. In this study the terms knowledge and information are used interchangeably, as there is not much practical utility in distinguishing them [35]. Data for the empirical test will be gathered through a web-based survey from an sNoP in Korea. The results will be analyzed and discussed in a scientific manner.

The survey will be conducted to the members of the ‘I Love Semantics (ILS)’. ILS is an sNoP whose members primarily are in the field of IT related business and academics in Korea. ILS uses Facebook to establish more as a platform of an sNoP rather than as a general social network. In sum, ILS is a social network whose members are primarily interested in the technology of Semantic Web.

3.5 Conclusion

In this research-in-progress paper, a research model was proposed in order to investigate factors affecting the participation of professionals in knowledge sharing through an sNoP. This paper is expected to contribute from both theoretical and practical perspectives. This study is likely to be the first empirical study on an sNoP. Secondly, this study adopts a holistic theoretical perspective with which to examine the determinants of the success and sustainability of sNoP. This study will also allow organizations to better understand which factors are important and require attention when managing employees who participate in sNoP.

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Chapter 4
Research on the Function of Chinese NGOs in the Internet Mobilization

Jing Yang and Mengting Yang

Abstract With the changes in the government management system and market-oriented reforms in the field of China's economic, the separation between the State and the Society comes into being. During the fast development of kinds of NGOs, the state power begins to transfer to other poles that may promote social mobilization in China. Due to the administrative control and the legal constraint, the actual mobilization action transfers to mobilization on Internet, which need less political cost, spread faster but have more difficult governance problems. The NGOs are regarded as the important organizations in the citizen society, this paper would analyze the functions of NGOs in the occurrence and spread of social mobilization in cyberspace. According to analyzing the Chinese NGOs' Internet application ability and the relationship between Internet and citizen in contemporary China, this paper will put forward the function of NGOs in Internet mobilization; moreover, give some suggestions on how to react to the Internet mobilization for government.

Keywords Chinese NGO · Internet mobilization · Functions

4.1 Introduction

In January 2013, the data of 31th the state of Chinese Internet Network Development Statistic report which is released by China Internet network information center (CNNIC) [1], showed that The scale of the Internet users has gone up to 564 million in our country, the Internet penetration is further improved, reaching 42.1% at the end of December 2012. The popularity of the Internet not only expands the traditional social concept, but also results in an expansion of the public domain space.

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"The network society" became a public space, which is independent of real society outside and closely linked with the social reality.

This paper will analyze the functions of NGOs in Internet mobilization, which are regarded as the important organizations in the citizen society. On the base of the analysis about the relationship between Internet and the citizen society in contemporary China and the Internet application ability of Chinese NGOs, this paper will put forward a discussion on the function of NGOs in Internet mobilization, moreover, give some suggestions on how to react to the Internet mobilization for government.

4.2 Internet and Social Mobilization in Contemporary China

Along with the economic and political system reform, both theory study and social practice appeal to build "Civil Society" as soon as possible. In this context, our country's NGOs, as the important part of civil society, develop rapidly. Accompanied by the various kinds of society organizations appear and develop, to some extent, the state power begins to change; it tends to transfer from a single bureaucratic governance of administration to democratic governance. This phenomenon contributes a basic condition to bottom-up social mobilization.

At recently decades, Western scholars have achieved rich results in the field of social mobilization. They generally believe that "social mobilization" is a sustained, organized activity for interest demand, the public express their views against target regime by a particular form of collective behavior [2]. This kind of social mobilization, which originates from civil society by bottom-up form with specific interest, is different from the top-down and administrative leading national political mobilization. In 1980s, western scholars put forward "Political Process Promotion Model", which is a far-reaching theory [3]. When a country comes into a period of economic development and social transformation, it is believed that the increasing possibility of a citizen's political opportunity is the root cause of frequent occurrences of bottom-up social mobilization. According to this theory, China has entered a critical period of social transformation, as further accelerate the process of change in the country's political and social system, the growth of citizens' awareness of democratic participation, our country will enter a relatively long period of frequent social mobilization [4]. Besides, owing to international financial crisis in 2009, economic situation is bad all over the world. Our country long-term economy development depends on the demographic and natural resources bonus. However, both of them are reducing now. Numerous economic and society structural contradictions, which were ever covered or delayed by high growth of economy in domestic society, are emerging. Moreover, natural disasters and public crisis are expected to occur frequently. Based on the above analysis, the bottom-up, cluster, with a clear interest demands social mobilization is predicted to occur frequently in Chinese society in the future.

Because of the administrative control and legal constraints, collective mobilization behavior will be faced with lager political and legal risk in the real society of

China. As a result, Internet became the breakthrough under the pressure of social mobilization. Internet space mobilization will be an important form of Chinese social mobilization for its low-cost, quickly spreading and difficult supervision [5]. Currently, China's Internet penetration rate has exceeded the world average. A huge number of Internet users and network transmission technology goes together, promoting the occurrence and the expansion of new forms social mobilization. In recent years, Chinese Internet mobilization happened frequently and had a huge impact on society. Chinese citizens have shown strong mobilization power which captured the world's attention in a series of events. These events include the Beijing Olympic torch overseas relay the activity of boycotting Carrefour earthquake relief work in Wenchuan, the "PX" event in Xiamen, "Fishing" law enforcement in Shanghai. From the above events, we can see NGO-organized Internet mobilizations behavior plays an important role. Therefore, NGOs' function in the Internet mobilization will be an important issue to study China's Internet social mobilization [6]. Owing to the complexity of Internet information diffusion mechanism, mutual interaction of online and offline mobilization behavior and the diversification main body of Internet mobilization, these factors raise the research difficulty in Internet mobilization research. In this case, we should analyze the network social mobilization participants, especially organization participates who have more influence than individual participates. By this way, it will be helpful to get a further identification about the development of China's network social mobilization.

4.3 Internet Application Ability of Chinese NGOs

Since the beginning of 20 century, some Non-profit organizations with modern characteristics have emerged in China. Our country's NGOs developed very quickly; its number has achieved 3million since the reform and opening up. According to the data provided by the civil affairs department, there were 386,900 registering social organizations by the end of 2007. If NGOs want to play important role in network mobilization at the age of Internet, they must depend on their capability of Internet application.

According to the survey, in terms of the popularity of Internet, 85.93% Chinese NGOs own their special computers and the majority of them use Internet at a percentage of 96.33%. Among those NGO who use Internet, 79.68% organizations access to the Internet by using ADSL broadband, 13.02% organizations by using LAN access to the Internet. There are 67.62% organizations own their official websites with own domain names, but the percentage of full-time computer management staff is only 31.11% [7].

In terms of the usage of Internet service projects, the rate of Chinese NGOs E-mail utilization is 90.79%, the rate of communication ratio through instant messaging tools is 87.30%, the ratio of imaging-making, video-making by software tools or digital camera is 85.71%, the rate of using network audio or video materials is 73.02%. They all have quite high using ratio. And more than half organizations have their own BBS, communities or forums among those NGOs of using Internet. However, the utilization rates of blog, network-organization meeting and wiki are relatively low in 45.71%, 51%, and 14.29% respectively. When evaluate their own Internet application abilities, 41% of NGOs think they are very good at it, 51% says they are favorable facing it and the rest 8% believe they still need improvement. And then, 38% NGOs thinks providing training about comprehensive using of computers is the most important demand for themselves, 34% of NGOs regards the supply of web development service as a thing which they need most. By analyzing the data above, NGOs shows well application abilities in Internet hardware support and common function application. However, there still are some problems. NGO is poor at using new Internet technology and function. Even more, one third of NGOs don't have their own domain name website, nearly 70% of organizations do not have professional computer and Internet management staffs. It reflects the NGOs' sensitivity towards Internet technology is still relatively low in some degree. As a result, it limits our NGOs ability to spread ideas and advocated behavior by using Internet and new media [8]. But it doesn't mean our NGOs aren't playing their roles in Internet space. After all, they showed up and played a special role in several influential Internet mobilizations.

4.4 Chinese NGOs' Functions in Internet Mobilization

With the development of Internet information technology, NGOs in China gradually, frequently and thoroughly make use of the Internet as an important platform to promote the social interaction and social integration. In western scholars' opinions, mobilizing citizens to participate in political action, advocating interests' demands, as well as build social capital are the three most important function of NGO in civil society [9]. In the early stage of the construction of civil society in China, although the NGOs do not completely and effectively play a perfect role in making the three functions, they do play the special role in the frequent network social mobilizations in China at present. Summarized as follows:

(1) NGOs can make use of the internet to affect government policies

First of all, a government policy agenda can be established by NGOs' influence. NGOs release information, advocate interest demands, mobilize widely public discussions and expand the influence of the information through Internet. In this way, they guide the public opinion towards social problems. Then public opinions can catch government attention. At last, their interest demands can be added into policy agenda. Second, NGOs can affect the process of government choosing and deciding policies. NGOs reflect and represent the particular groups' demands, so that one of important functions of it is providing public policy decision, reference and consultation for the government. For example, in the earthquake relief effort of Wenchuan earthquake, many NGOs released reliable and real disaster information in time through Internet. In addition, by collecting information, guiding the public opinion, they attracted public attention to the disaster areas where had not been well known yet. These measures are really very helpful for government making correct and effective decisions. Moreover, NGOs can offer powerful supervision in government policy execution by mobilization [10]. For example, after the Wenchuan earthquake, numerous non-governmental organizations, which were in the front line of disaster relief, released the government relief information via Internet platform, traced the disaster relief materials and money. They also advocated the citizens to supervise government behavior, which had eliminated the government corruption and illegal behavior to a large extent.

(2) NGOs can promote information interaction with public by internet

In order to promote the public to participate in mobilization, NGOs share information and interact with the public in cyberspace. In this way, they can guide the public opinion. As an important and quick-developing media, the Internet plays an important role in the formation of the public opinion. The reason why say so was that before the media formed, the public didn't know anything until the media told some related information to them, then the public could reflect on certain issues [11]. When NGOs promote public to participate in mobilizing action, they always release information through the Internet and even make use of blog, BBS, professional web's service function. By these means they can promote social public information interaction and strive to get public's support and concern about certain common interest demand. At last they can strengthen the public opinion and promote public participation in mobilizing action.

For example, in mobilization of Wenchuan earthquake relief effort, Chinese NGOs made full use of online payment service and other technologies to manage and carry donations. China Foundation for Poverty Alleviation cooperated with China Siyuan Foundation for Poverty Alleviation on a platform named "we and you together - Donations" [12]. Thanks to their effective and convenient platform, the majority of Internet users could participate in disaster relief mobilization actions. In the recruitment of online volunteers, NGOs, such as the Red Cross society of China, opened up a volunteer recruitment column through the portal. Chinese volunteers net even integrated the volunteers' demands information in earthquake disaster area and establish volunteer database for Internet users. These NGOs provide a key information platform for volunteers participating in the disaster relief mobilization.

(3) NGOs can communicate and cooperate with other organizations in social mobilization

NGOs can communicate and cooperate with other organizations in social mobilization through Internet. "Any organization operating activities is connected with surrounding environment, and its survival and performance usually rely on relationship with other organizations" [13]. Among well-known social mobilization actions, a NGO mobilization's influence effect is limited. However, if NGOs can cooperate with other entities organization, their influence will no doubt become huge. By this way, they can expand the influence of the mobilization action, and improve the efficiency of the mobilization action. In the Internet space, NGOs can be more convenient to use Internet platform to form alliance with other NGOs or the government, enterprises and organizations which share the common interest demands. Other organizations' support is very helpful for the NGOs [14]. Take Internet mobilization of Wenchuan earthquake relief effort for example, “5.12 folk rescue center” is a website which is ran by government and non-governmental organizations. It plays an important role in collecting every organization’s resources, integrating disaster relief supplies and organizing volunteers.

The Internet no doubt provides a more convenient platform for NGOs participate in social mobilization. It also provides a more convenient information transmission channels. At the same time, by influencing government policies, interacting with public, constructing the coalition, NGOs play a very important roles in the Internet mobilization. They can’t be replaced.

4.5 How to Evaluate and Deal with NGOs’ Role in Internet Mobilization

On the one hand, Network social mobilization speeds up the civil society construction in China. On the other hand, malignant network mobilization may greatly threat social stability. Therefore, we should have a correct understanding and reasonable measures towards Chinese NGOs’ effect in Internet mobilization.

(1) We should objectively evaluate the role of Chinese NGOs in the internet mobilization

As the above analysis, Internet mobilization has became an important way of expanding influence, achieving organization goals, or even influencing government decision-making. Although NGO has so many advantages, its function of social mobilization cannot be exaggerated in practice. There are many reasons. On the one hand, the government carries on strict supervision with administrative power towards NGOs. On the other hand, NGOs themselves have weakness in the management [15].

At present, if you use Baidu search engine to search the web pages containing NGO, there will be more than millions terms associated with it. It illustrates that Internet users are very concerned about it in China. There are about 168,000 Internet users pay close attention in NGOs’ role in society by their blogs. This data reveals that these bloggers can be mobilized by NGO. However, from the perspective of the NGO in China, most of them ignore this potential power [16]. Chinese NGOs few release information through the Internet platform to mobilize citizen fight for their political right. They even less concerned about whether these Internet users’ political demands relate to their organization mission. For example, it is hard to find the first-hand material about Chinese environment on the Internet, which is provided by Environmental Protection Organization. At the same time, in order to obtain organizational development resources, compared with striving Internet users’ support, they prefer to communicate with the mass media or government [17]. In a word, compared with open cyberspace, the NGO in China is more willing to close the administrative system in their development. Therefore, we should have the correct and reasonable evaluation about NGOs’ role in network social mobilization.

(2) Chinese NGOs should strengthen self-construction for further development

Under the guidance of "civil society", Chinese NGOs should strengthen self-construction for playing more important role in Internet mobilization. In order to get and share information, hardware is the most basic technical equipment for NGO. But compared with foreign countries, our country's NGOs haven't full used of Internet, so they should broaden the financing channels, keep pace with the time, and build the Internet hardware facilities to broaden their network influence. In addition, Chinese NGOs should also request their full-time staff and volunteer with higher quality. Their staff should have professional Internet application ability, including setting up and maintaining web. They also should be sensitive with information so that they can mobilize the public well. In addition, the public lack of trust in NGOs. This factor will restrict NGO's development. So NGOs in China should devote to getting public's trust. There are many measures can be taken, including making information public actively, or establishing a good organization image.

(3) Government should explore new governance mode towards NGO

The government should explore the management strategies about how to govern NGO under the guidance of "common governance mode". Based on the consideration of keeping society stability, the government faces many difficulties. For example, the governance policy is either "too strict" or "too passive". In view of the complexity of social mobilization and double-sided influence, the government should fully analyze NGOs' role and function in network mobilization. In addition, government also should devote to achieve "multi-subject governance mode". The policies' target should be "using", "guiding", not only "controlling". Policy tools shouldn't be just control information transmission, they also should analyze all kinds of organizations' characteristics, behavior process, behavior effectiveness, and even their motivation in social mobilization. Policy tools' target should be Multi-objective, multi-dimensional in the future. Take these factors into consideration, NGOs can develop better.

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Chapter 5
Dealing with Learning Concepts via Support Vector Machines

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Abstract Extracting learning concepts is one of the major problems of artificial intelligence on education. Essentially, the determination of learning concepts within an educational content has some differences as compared with keyword or technical term extraction process. However, the problem can still taught as a classification problem, notwithstanding. In this paper, we examine how to handle the extraction of learning concepts using support vector machines as a supervised learning algorithm, and we evaluate the performance of the proposed approach using f-measure.

Keywords Text mining · Support Vector Machines · Classification · Machine learning · Intelligent tutoring systems

5.1 Introduction

Lots of educational tools and software try to teach learning concepts to the students within a domain. However, not all of them provide a solution or a component to obtain the learning concepts related with an educational content. In other words, although many existing tutoring systems are called as intelligent or adaptive system, they do not know what to teach to students. The educational support systems should

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automatically detect what to teach to students. Because they should act as a real teacher in class; they must teach the learning concepts in an educational content according the students' learning speed and learning style. With this manner, the existing literature is not fully complete; there is a serious gap between educational technology and learning concepts.

Extracting keywords or terms from a given document is not a new research area at all, and several techniques and methods have been developed [1–7]. Daille [8] uses a combination of linguistic filters and statistical methods to extract concepts from corpora. Frantzi et al [9] developed a method, which uses C-value/NC-value to extract multiword terms automatically. Cimiano and Völker [10] developed a tool that uses Probabilistic Ontology Model to extract terms for ontology development on a particular domain. Zouaq and Nkambou [11] present a semiautomatic methodology for knowledge acquisition from text to produce domain concept maps in e-learning. Villalon and Calvo [12] present a new approach for automatic concept extraction from students' essays, using grammatical parsers and Latent Semantic Analysis. Qasim et al [13] use Affinity Propagation Algorithm for automatic acquisition of domain concepts.

Simply, the learning concept extraction can be considered as a keyword extraction process. Although both of them are very similar, they have completely different in semantic manner. While a keyword are the word sequences that capture the essence of the topic of a document, the learning concepts are the word sequences that are used for acquiring new, or modifying existing, knowledge and skills on a topic. This research issue has begun to use within educational technologies in last decade [12, 14, 15]. Gunel and Asliyan [14] propose an approach that uses the statistical language models together with content vectors to extract the minimal set of learning concepts within an educational content. Obviously, extracting learning concepts within a specific learning domain is a difficult, controversial, time consuming and highly non-trivial process, even for an expert in this field.

In this paper, we consider the problem of extracting learning concepts as a classification problem, and we examine whether the support vector machines are capable of extracting learning concepts from an educational material or not. The utopian aim is to develop a machine learning system that knows what students should learn, and to highlight the importance of the component in the intelligent tutoring systems, which is able to detect the learning concepts.

The paper is organized as follows: Sect. 5.2 presents the method of extracting candidate concepts with a related feature vector from a document. In Sect. 5.2, also, the support vector machines are introduced to solve a classification problem, briefly. Sect. 5.3 explains the experimental results over the learning domains. Finally, conclusions are given in Sect. 5.4.

5.2 Methods and Materials

5.2.1 Feature Extraction

In this paper, the problem of detecting learning concepts is considered as a classification task, and it involves separating data into training and testing sets. Each instance in the training set contains one class label and several features. The class labels in our study are $+1$ and -1 which denote the learning concepts and others as word sequences within an educational text respectively. The educational texts can be considered as word sequences $w_1, w_2, \cdots, w_n$, and each word sequences can be considered a candidate for learning concepts in this study. To detect the candidates the educational content is preprocessed, firstly. In the preprocessing stage, all the mathematical formulations, symbols, variables and numbers in contents have been removed from the text. The sentences and paragraphs are parsed from the document. In addition, the punctuation marks and special characters such as #, @, %, &, !, *, +, $ have been cleared. The characters of the content have been changed as lowercase and the whitespace characters have been excluded from the text. After preprocessing step, only one blank space character between two words has been allowed.

In next stage, for $1 \leq n \leq 5$, the n-gram frequencies of the words have been specified in the given content to extract the learning concepts. An n-gram consists of n consecutive words from a given text. After that some features are obtained for n-grams. First feature is the number of words of the candidate. The second one is the term frequency-inverse document frequency value, $tf \times idf$ which is one of the mostly used features in information retrieval, and it presents the importance of a word within a document belongs to a document collection. Assume w is a word in the document d, and the document d belongs to the document collection D, then $tf \times idf$ value of the word w is calculated with the Equation (5.1):

$$tf(w,d) \times idf(w,d,D) = tf(w,d) \times \log \frac{|D|}{|\{d' \in D | w \in d'\}|}, \tag{5.1}$$

where tf is the number of times that word w occurs in the document d Another feature for a word is determined with the entropy given in the Equation (5.2). Entropy quantifies the expected value of the information for a word.

$$\text{entropy}(w) = -\sum_{d \in D} P(w,d) \log(P(w,d)), \tag{5.2}$$

where $P(w,d)$ is the occurrences probability of the word, w in the document, d which belongs to the collection of the documents, D.

The two other features are inverse sentence frequency (isf) and the term frequency-inverse sentence frequency ($tf \times isf$). Inverse sentence frequency value is similar to idf, and it is calculated by the Equation (5.3).

$$tf(w,d) \times isf(w,d) = tf(w,d) \times \log \left(\frac{|s|}{1 + |\{s \in d : w \in s\}|} \right), \tag{5.3}$$

where s represents the sentences of the document d. The domain relevance, DR, is defined as:

$$DR(w, D_k) = \frac{P(w, D_k)}{\max\limits_{1 \le i \le m} \{P(w, D_i)\}}, \tag{5.4}$$

where $P(w, D_k)$ gives the probability of the word, w, in the collection of documents, D_k. If the value of the domain relevance is close to 0, this implies the word cannot be a learning concept. On the other hand, DR is close to 1 implies that the word is possible to be a learning concept. A candidate can be composed of not only a single word, but also a sequence of words. The lexical cohesion (LC) is another feature that calculates the dependency relationship among words based on associative relations in common documents, and it is given by Equation (5.5) for $n > 1$.

$$LC(W, d) = \frac{n \cdot tf(W, d) \cdot \log_{10}(tf(W, d))}{\sum\limits_{w_i \in W} tf(w_i, d)}, \tag{5.5}$$

where W is a word sequence, $w_1, w_2, \cdots, w_n$ belongs to the document, d. To improve accuracy, we construct a dictionary of technical terms, and define a binary function by Equation (5.6). The value of this function is another feature of the candidate.

$$\chi(w, d) = \begin{cases} 1, \text{ if } w \text{ occurs in the lookup dictinoary,} \\ 0, \text{ otherwise.} \end{cases} \tag{5.6}$$

The last $(m-1)$ features are defined the number of occurrences of the word w, which belongs to a learning domain, D_k, within the opposite learning domains, D_i such that $i \neq k$ for $1 \le i \le m$.

Based on above mentioned features, a feature vector is generated for a candidate. This feature vector is used to train the support vector machines to detect whether the candidate is a real learning concept or not. In Sect. 5.2.2, we briefly summarized the support vector machine to make a decision.

5.2.2 Support Vector Machines

Support Vector Machine (SVM) is a useful supervised learning technique used for data classification and regression [16, 17]. SVM aims to find a hyperplane that can separate two classes of given samples in training set with a maximal margin. A margin can be defined as the amount of space between two classes as defined by the hyperplane. The optimal separating hyperplane corresponds to the shortest distance between the closest data points of each class for maximizing the margin of separation. These points are called support vectors.

Let $\mathbf{w}$ and b denote the weight vector and bias respectively, then the hyperplane can be defined in Equation (5.7):

$$\mathbf{w}^T \mathbf{x} + b = 0, \tag{5.7}$$

where $\mathbf{w}$ is a sample in the training set. Given a training set $\{\mathbf{x}_i, y_i | i = 1, 2, \cdots, n \in R\} \in R^m \times \{-1, 1\}$, where y_i are class labels, we have Equation (5.8):

$$\begin{cases} \mathbf{w}^T \mathbf{x}_i + b > 1, & \text{for } y_i = +1, \\ \mathbf{w}^T \mathbf{x}_i + b \leq -1, & \text{for } y_i = -1. \end{cases} \tag{5.8}$$

Then, the distance from the support vector, $\mathbf{x}^*$ to the optimal hyperplane is calculated as in the Equation (5.9):

$$d^* = \frac{g(\mathbf{x}^*)}{\|\mathbf{x}\|} = \begin{cases} \frac{1}{\|\mathbf{w}\|}, & \text{if } y^* = +1, \\ -\frac{1}{\|\mathbf{w}\|}, & \text{if } y^* = -1, \end{cases} \tag{5.9}$$

where $g(\mathbf{x}) = \mathbf{w}^T \mathbf{x} + b$ is the linear discriminant function. As seen in Fig. 5.1, SVM tries to find the weight vectors, $\mathbf{w}$ and the bias value, b given in the discriminant function in order to obtain optimal hyperplane by maximizing the margin of separation, $\max 2d^* = \max \left\{ \frac{2}{\|\mathbf{w}\|} \right\}$ under the constraints $y_i \left(w^T x_i + b \right) \geq 1, \text{ for } i = 1, 2, \cdots, n$. Therefore, the problem can be thought as a constrained optimization problem.

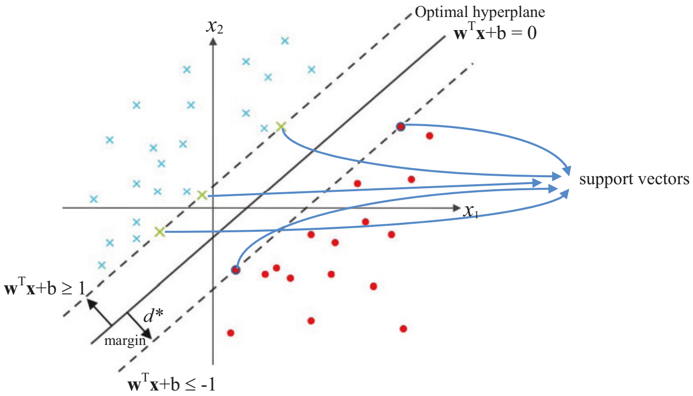

Fig. 5.1 Support vector classifiers for linearly separable problem

However, a nonlinear classifier is preferred in many applications to obtain more accurate results. In nonlinear case, the discriminant function is identified by a kernel as seen in Equation (5.10):

$$g : X \rightarrow F, \; g(\mathbf{x}) = w^T \varphi(\mathbf{x}) + b = \sum_{i=1}^{n} \alpha_i K(\mathbf{x}_i, \mathbf{x}) + b, \tag{5.10}$$

where X is the set of samples, F is the feature space and $K(\mathbf{x}_i, \mathbf{x}) = \phi(\mathbf{x}_i)^T \phi(\mathbf{x})$ as the kernel function. In this paper, we select widely used kernel called Gaussian radial basis kernel defined by Equation (5.11):

$$K(\mathbf{x}_i, \mathbf{x}) = \exp\left(-\frac{\|\mathbf{x}-\mathbf{x}_i\|^2}{2\sigma^2}\right), \tag{5.11}$$

where $\sigma > 0$ is a bandwidth parameter that controls the discriminant boundary.

Table 5.1 The validation of training set for each learning domain consists of two documents, d_1 and d_2

Learning domain	Accuracy	Precision	Recall	f-measure
Group theory	0.89	0.89	0.62	0.73
Limits and continuity	0.84	0.81	0.37	0.51
Derivation	0.79	0.77	0.52	0.62

Table 5.2 The test results for each learning domain consists of four documents, d_3, d_4, d_5 and d_6

Learning Domains	Documents	Accuracy	Precision	Recall	f-measure
Group theory	d_3	0.79	0.45	0.42	0.44
	d_4	0.84	0.50	0.48	0.49
	d_5	0.75	0.30	0.31	0.30
	d_6	0.87	0.63	0.58	0.60
Limits and continuity	d_3	0.78	0.57	0.41	0.48
	d_4	0.79	0.64	0.39	0.49
	d_5	0.79	0.59	0.25	0.35
	d_6	0.82	0.52	0.20	0.29
Derivation	d_3	0.77	0.65	0.45	0.54
	d_4	0.75	0.71	0.49	0.58
	d_5	0.77	0.71	0.40	0.51
	d_6	0.82	0.79	0.40	0.53

5.3 Experimental Results

In this study, the three different learning domains have been constituted for the subjects “Group theory”, “Limits and continuity” and “Derivation” in mathematics. Also an opposite learning domain for the subject, “Multi-Layer Perceptrons and Backpropagation Algorithm” has been constructed. Each learning domain consists of six different educational contents. To obtain the candidate from an educational text, firstly all n-grams are extracted. The first 400 n-grams of the two documents in each learning domain belong to the training set, and others are in the test set. Support vector machine is trained with these elements to detect whether the candidate is a learning concept, or not. The total number of samples is 2400 in the test set, in this study.

Table 5.3 The extracted learning concepts in the learning domain "Limits and continuity"

Documents			
d_3	d_4	d_5	d_6
function	lim	limit	function
limit	function	limits	interval
interval	limit	function	lim
lim	graph	value	limits
continuous	limits	point	closed interval
sequence	continuous	infinity	continuity
point	line	number	number
limits	the limit	graph	cos
real	number	zero	graph
continuity	the graph	line	limit
number	value	the graph	intermediate value
domain	the tangent	denominator	point
set	velocity	tangent	the graph
bounded	slope	sided limits	bounded
the limit	curve	one sided limits	values
sequences	the slope	numerator	
a limit	point	estimate	
a function	average	the numerator	
the domain	the curve	the	
intervals	interval	denominator	
real number	the values	the tangent	
sums	equation	slope	
uniformly continuous	derivatives	factor	
limit point	lines	interval	
converges continuous function	asymptotes		
a continuous	cos		
root	horizontal		
a real	secant		
polynomial	distance		
zero	vertical		
infinitely	asymptote		
image	denominator		
equation	negative		
convergence	the velocity		
odd	infinite		
infinite	the secant		
denominator	velocities		
degree	integer		
graph	graphs		
intermediate value	points		
	infinity		

Table 5.4 The extracted learning concepts in the learning domain “Group Theory”

Documents			
d_3	d_4	d_5	d_6
subgroups	subgroup	isomorphism	group
finite	subgroups	the group	order
set	isomorphic	homomorphism	subgroup
isomorphic	the group	an element	operation
identity	set	cosets	integers
composition	operation	positive	elements
cosets	matrices	isomorphic	identity
finite group	multiplication	integers	inverse
identity element	abelian	numbers	cosets
quotient	homomorphism	the elements	the group
prime	product	normal subgroup	finite
multiplication	isomorphism	cyclic group	multiplication
homomorphism	cosets	subgroups	left cosets
addition	finite	quotient	integer
additive group	function	identity	groups
mapping	normal subgroup	multiple	subgroups
the group	cyclic group	true	abelian
subset	direct product	relatively prime	mod
abelian	subset	multiplication	number
subgroup	number	cycle	addition
inverse	kernel	kernel	finite group
cyclic group	addition	bijective	associativity
the mapping	image		coset
permutation	zn		set
normal subgroup	homomorphisms		union
residue	integer		group operation
right cosets	centralizer		divisor
cyclic group	equivalence		common multiple
maximal invariant	the centralizer		left coset
modulo	normal subgroups		relatively prime
number	cyclic groups		least common
coset			multiple
			permutations
			cyclic
			counting
			disjoint union
			modulo
			index
			matrices
			cyclic subgroups

The recall, precision and f-measure scores have been used for evaluating the system performance. The recall score has been adapted as the ratio of number of concepts that are required to be extracted by the system to the total number of candidate concepts in an educational content. If C represents the number of concepts that are required to be extracted by the system and T is the total number of candi-

Table 5.5 The extracted learning concepts in the learning domain "Derivation"

Documents				
d_3	d_4		d_5	d_6
function	graph	cosh	function	function
differentiable	cos	marginal	derivative	point
derivative	derivative	local maximum	the derivative	interval
interval	equation	lines	point	functions
lim	curve	intervals	sin	derivatives
point	point	differentiation rules	critical points	the graph
graph	the graph	the average	lim	maximum
functions	tangent	chain	cos	cost
mean	maximum	speed	derivatives	differentiable
continuous	line	chain rule	interval	minimum
mean value	minimum	height	absolute	points
mean value theorem	the curve	differentiate	zero	value
points	differentiation	domain	relative	lim
domain	change	increase	maximum	derivative
limit	velocity	value theorem	graph	curve
increasing	the tangent	mean	extrema	real
derivatives	derivatives		increasing	tangent
rate	the derivative		minimum	continuous
line	number		volume	time
real	the rate		decreasing	the tangent
rate of change	tan		critical point	slope
differentiation	estimate		differentiate	decreasing
quotient	tangent line		tan	equation
an interval	differentiable		limit	increasing
critical	constant		the graph	local minimum
equation	the point		the interval	e
l hôpital	graphs		second derivative	local maximum
chain rule	interval		line	number
the chain rule	area		equation	the slope
plane	approximation		tangent	differentiation
second derivative	increasing		continuous	mean
constant	the equation		chain	line
maximum	the velocity		absolute extrema	positive
e	slope		cost	open interval
tangent	rate of change		differentiation	horizontal
the second derivative	formula		negative	mean value
infinitesimal	acceleration		number	mean value theorem
limits	radius		chain rule	information
minimum	the tangent line		numerator	origin
zero	volume		denominator	approximation
critical points	absolute		information	graphs
extreme	average		quotient	intersects
polynomial	horizontal		formula	
continuous function	inflection		exponential	
open interval	limit		mean	
the rate	concave		trig	
continuity	negative		first derivative	
decreasing	angle		the chain	
formula	distance			
integer	the graphs			
number	length			
secant	decreasing			
slope	l hospital			

date concepts in an educational content, then the recall is calculated as C/T. The precision score has been adapted as the ratio of the number of concepts that are required to be extracted by the system to total number of extracted concepts by the system in reality. If R describes the total number of extracted concepts by the system in reality, then the precision is gauged as C/R. The F-measure is a measure of a test's accuracy. The traditional balanced f-measure is to combine recall and precision into single measure of overall performance and is the harmonic mean of precision and recall. In Table 5.1, the validation results of each learning domain are given according to accuracy and f-measure. The test results are shown in Table 5.2. The list of extracted learning concepts related to the learning domains, "Limits and continuity", "Group theory" and "Derivation" are shown in Table 5.3, Table 5.4 and Table 5.5 respectively.

5.4 Conclusions

In this paper, we explore the support vector classifiers to solve the problem of extracting learning concepts from a single educational text. The extracting learning concepts is first step of generating concept maps that can enrich students' understanding of a new concept. However, we observe that the problem is so complex, because the feature space tends to be so noisy. It is not so possible to balance the training set, because the positive and negative examples in the training set are so close. To handle this issue, some dimension reduction techniques as Singular Value Decomposition (SVD), Principal Component Analysis (PCA) and Multi-Dimensional Scaling (MDS) are applied to the feature space, in this study. When we apply a dimension reduction technique is applied, we recognize that the accuracy of the system is decreased. The test results show that while the precision value is acceptable, recall rate is low. The high precision means that the system detects more learning concepts than the other word sequences. The low recall means that the system does not detect most of the learning concepts. Hence, we have reached the conclusion of that SVM is very limited when the dataset is imbalanced.

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Chapter 6
Gold Price Forecasting Based on RBF Neural Network and Hybrid Fuzzy Clustering Algorithm

Fengyi Zhang and Zhigao Liao

Abstract This paper predicts good price based on RBF neural network employing hybrid fuzzy clustering algorithm. PCA technique has been used to integrate the 6 parameter dependent sub-variables of each TI (Technical Indicators, include MA, ROC, BIAS, D, K), which has been originated from the gold price before, and the results act as input. By employing a new hybrid fuzzy clustering algorithm, which is proposed by Antonios and George [10], *K*-Mean clustering algorithm and RBE algorithm, the predictions of price are yielded for each interval-*n* model. *n* refers to the number of predictions achieved by 1 operation. The most important conclusion indicates that the hybrid fuzzy clustering algorithm is superior to the general RBF central vector selecting algorithm mentioned above, in the aspects of MSE, *P*-Accuracy Rate and ROC.

Keywords Gold price forecasting · RBF neural network · PCA · Hybrid fuzzy clustering algorithm

6.1 Introduction

Forecasting gold price is becoming more and more important. For long in history, gold has been traded actively on international markets. Many derivatives of gold trading in international gold markets are also traded, such as gold futures, gold options, gold forward contracts, and so on [1, 2]. Remarkably, since the price of gold varies within a limited range, gold is able to reduce the effect of inflation, control the rise of price and help carry out constrictive monetary policy [3]. Hence, gold becomes an essential tool for risk hedging as well as an investment avenue. There-

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fore, to investors, it has become very significant and important to predict the price of gold.

The use of neural networks in forecasting the gold price has been operated before. McCann and Kalman [4] make an effort to use recursive neural networks to recognize the inflection points in the gold market based on historical data of ten indices, coming up with predictions that are both meaningful and profitable for the period studied. Tsibouris and Zeidenberg [5] and White [6] work with neural networks to forecast stock market indexes and individual assets. More recently, McMillan [7], using recursive and rolling estimation, find evidence of STAR nonlinearity being present within the DJIA. Further, the parameters of interest exhibit some temporal dependence. These results suggest that nonlinearity is a regular feature of the data that should be modeled and used in forecasting, although variations in parameter values may need to be incorporated. Chen and Leung [8] performance an evaluation of neural network architectures applied to the prediction of foreign exchange correlations, comparing the performance of models based on two competing neural network architectures, the multi-layered feed forward neural network (MLFN) and general regression neural network (GRNN). Their empirical evaluation measures the network models' strength on the prediction of currency exchange correlation with respect to a variety of statistical tests. The results of the experiments suggest that the selection of proper architectural design may contribute directly to the success in neural network forecasting. In addition, market-timing tests indicate that both MLFN and GRNN models have economically significant values in predicting the exchange rate correlation. Lai et al [9] propose a hybrid synergy model integrating exponential smoothing and neural network. The proposed model attempts to incorporate the linear characteristics of an exponential smoothing model and nonlinear patterns of neural network to create a "synergetic" model via the linear programming technique.

The rest of this paper is organized as follows. Sect. 6.2 presents the traditional RBF neural network model and hybrid fuzzy clustering algorithm. In Sect. 6.3, the measurements of performance are thrown light on. Sect. 6.4 provides the experimental process and results by comparison. Finally, in Sect. 6.5, conclusions will be drawn.

6.2 Methodology

6.2.1 Traditional RBF Neural Network

The basic topology of the RBF network comprises in sequence a hidden layer and a linear processing unit forming the output layer. It is a kind of topology for a multi-input single-output network, where c represents the number of nodes in the hidden layer. Each hidden node corresponds to a radial basis function, while the output layer computes the weighted sum of the nodes' outputs. A radial basis function represents a local effect, the range of which is determined by its center element and width (variance). Herein, the radial basis function will also be referred to as kernel function or simply kernel. Employing the nomenclature of the topology mentioned above, the set of inputCoutput data pairs is symbolized as $S = \{(x_k, y_k) \in \Re^p \times \Re | f(x_k) = y_k, 1 \le k \le n\}$, n is the number of training samples, $x_k = [x_{k1}, x_{k2}, \cdots, x_{kp}]^T$ is the k-th input vector and y_k is the k-th output sample. We select Gaussian type kernel functions of the form:

$$g_i(x_k) = \exp\left(-\frac{\|x_k - v_i\|^2}{\sigma_i^2}\right), \tag{6.1}$$

where $v_1, v_2, \cdots, v_i, \cdots, v_c$ arise in the form of p-dimensional vectors and are referred to as kernel centers, and $\sigma_1, \sigma_2, \cdots, \sigma_i, \cdots, \sigma_c$ are the respective kernel widths.

Although too much effort has been put on calculating appropriate values for the kernels' centers, there are relatively few methods that address the issue of estimating the widths. Moody and Darken calculated each width using the average distance of the respective cluster center to its τ nearest neighbors,

$$\sigma_i = \frac{1}{\tau}\sqrt{\sum_{j=1}^{\tau} d_{ij}^2}, \tag{6.2}$$

where $d_{ij} = \|v_i - v_j\|$ with $i \neq j$, and typical values of τ are $\tau = 2$ and $\tau = 3$. A special case of Equation (6.2) was introduced by Pal and Bezdek [11] , where the width of each node was calculated by the distance between the center of the kernel and its nearest neighbor, multiplied by a positive factor.

6.2.2 Hybrid Fuzzy Clustering Algorithm

The K-Means algorithm is very sensitive to initialization but it is a fast procedure, while the fuzzy K-Means is able to reduce the dependence on initialization but it remains a slow process [11]. In a recent publication, Antonios and George [10] have developed a fuzzy learning vector quantization algorithm for image compression tasks, which combined the K-means and the fuzzy k-means. The basic idea of this paper is originated on that learning algorithm and utilizes the following objective function:

$$J_H = \theta \sum_{k=1}^{n}\sum_{i=1}^{c} u_{ik}\|x_k - v_i\|^2 + (1-\theta)\sum_{k=1}^{n}\sum_{i=1}^{c} (u_{ik})^2 \|x_k - v_i\|^2, \tag{6.3}$$

where K is the number of clusters, $\theta \in [0,1)$, and $u_{ik} \in [0,1]$ is the membership degree of the k-th training vector to the i-th cluster. Notice that when $\theta = 0$, the objective function is transformed to the fuzzy k-means with $m = 2$, and when $\theta = 1$

it becomes the k-means algorithm. Therefore, the function posses a hybrid structure enabling the switch from fuzzy to crisp conditions depending on the value of θ.

Antonios and George [10] define the set T_k as the aggregate of the cluster centers affected by x_k. Initially, the set T_k includes all cluster centers and its cardinality is: $\aleph(T_k^{(0)}) = c$, where c is the number of radial basis. The proposed hybrid clustering algorithm can be operated as follows: Select values for c, and θ. Randomly initialize $v_1, v_2, \cdots, v_3$. Set $v = 0$, $\forall k : \aleph(T_k^{(0)}) = c$, and $T_k^{(0)} = \{v_1, v_2, \cdots, v_c\}$.
Step 1. Set $v = v + 1$.
Step 2. Update the sets $T_k^{(v)}$ and their cardinalities $\aleph(T_k^{(v)})(1 \leq k \leq n)$.
Step 3. Calculate the membership degrees $u_{ik}(1 \leq k \leq n; 1 \leq i \leq c)$.
Step 4. If $u_{ik} < 0(1 \leq k \leq n; 1 \leq i \leq c)$ then set $u_{ik} = 0$.
Step 5. Calculate the normalized membership degrees.
Step 6. Update the cluster centers.
Step 7. If there are no noticeable changes for the cluster centers then stop, else turn the algorithm to Step 1.

6.3 Measurement of Performance

(1) MSE

MSE is short for Mean Square Error, which measures the overall predicting ability of models. We define $r(s_i)$ as the real value of s_i and $p(s_i)$ the prediction of real value. Besides, $s_i \in S$ and $\mathrm{MSE}(S) = \sum(r(s_i) - p(s_i))^2/(\aleph(S) - 1)$ is the value of MSE over set S. Employing such a measurement, we can measure the degree of the deviation from real price to prediction.

(2) ROC

To measure the prediction performance, the area under the curve (AUC), which is defined as the area under the receiver operating characteristic (ROC) curve, is used. The ROC curve plots true positive rate as a function of false positive rate for differing classification thresholds. The AUC measures the overall quality of the ranking induced by model rather than the quality of a single value of threshold in that ranking. The closer the curve follows the left-hand border and then the top-border of the ROC space, the larger value of AUC the model produces, the more accurate the model is.

(3) P-Accuracy Rate

P-Accuracy Rate is a measurement used to detect how many predictions of value are close to the real value with p percent deviation. In this term, p refers to a variable number such as 0.1, 0.5 and 1. We define $r(s_i)$ as the real value of s_i and $p(s_i)$ the prediction of real value. Else, $A_p(S) = \{s_i \in S| \quad |r(s_i) - p(s_i)|/r(s_i) \leq p\%\}$ and $AR_p(S) = \aleph(A_p(S))/\aleph(S)$ is the value of P-Accuracy Rate over set S. By adjusting the value of P, an accuracy distribution is achieved, which plays an important role in comparison.

6.4 Experiment

There are 6 kinds of models: Interval-10, Interval-20, Interval-30, Interval-3, Interval-2 and Interval-1 in the Experiment. In Interval-n, n refers to the number of prediction of price achieved by 1 operation. This Experiment contains 3 parts, which are called data preprocessing, pretest and principal process, while the first and the second serve the third. In the first parts, 5 TIs (Technical Indicators, include MA, BIAS, ROC, K and D), which has been originated from the price before t, and the real price at the time of t are assembled as sample t. The samples set was separated for the reason that the two sample sets has been identified independent by statistic test. All samples was sorted by ascending time series. In the second part, we have used part of the preprocessed data and each group of parameters to forecast the gold price, and got the MSEs belonging to different groups of parameters. In the third part, rolling operation was employed to yield the result. 270 predictions in the big samples sets and 30 predictions in the small one were achieved. After calculating the MSE (Mean Square Error), CDPA (Correct Direction Predicted Rate), P-Accuracy Rate and ROC by the ways to compare the predicted price with the real price at the same time, to measure the performance of the models was not groundless. We have assessed the superiority of each algorithm by compare the MSE, CDPA, P-Accuracy Rate and ROC of the same Interval-n model.

6.4.1 Data Preprocessing

The data were downloaded from the website of WBG (World Bank Group), ranges from January-1975 to December-2011. The monthly averages of gold price were selected as our material for it could present the price lever of the every month better. There were 444 samples in total before data preprocessing.

The purpose of data preprocessing was to achieve the proper input which could supply enough information to forecast gold price, but also had the least dimensions.

The parameters for each TI were set as $P \in \{3,4,6,8,9,12\}$. Since a single price data was transformed to 5 TIs by the equation proposed in sheet n, and each of which has 6 dependent sub-variables, then the total number of the sub-variables per variable, or simply input dimensionality, became 30 ($=$ 5TIs $\times$ 6 parameter dependent sub-variables). Even though the use of TI facilitates the consideration of the trends and the structure of the data, there was, on the other hand, the drawback that one variable has turned into a set of an increased number of sub-variables. The increased number of input variables means an increase in dimensionality, which degrades the performance of the prediction model. If we extract a single feature per TI, then the 6 parameter dependent sub-variables will be reduced to one dimensional feature. For PCA, this implies that we use only the first principal component from the covariance matrix of the 6 parameter dependent sub-variables. After the processing above, we put the last 420 samples into our samples set, ranged from January-1977 to December-2011.

Subprime Crisis has led to the decrease of confidence for credit currency, but also became an important factor that pushed the gold price soaring [13]. Hence, to divide the previous set into two sets, which refer to the samples range from January-1977 to October-2007 before Subprime Crisis and the samples range from November-2007 to December-2011 after Subprime Crisis, is reasonable. Interval-10, Interval-20 and Interval-30 was used to forecast gold price in the big samples set which has 370 samples, while Interval-1, Interval-2 and Interval-3 are put into forecasting gold price in the small samples set which has 50 samples.

6.4.2 Pretest

The purpose of pretest was to find the seemingly proper group of parameters for each Model employing the hybrid fuzzy clustering algorithm. A consecutive area of data, whose size equals to the size that the Interval-n model requires, were employed to act as the 'historical knowledge' randomly for a certain model. For $n = 30, 20$ and 10, the corresponding size was 100. Likely, we has changed the size to be 20 for $n = 3, 2$ and 1. Then, each group of parameters and the 'historical knowledge' were employed by each model to get the forecasting price. And an n-width area next to the 'historical knowledge' was used to test the forecasting price.

Table 6.1 MSEs over pretest in Interval-10

MSE		$\theta = 0.3$	$\theta = 0.4$	$\theta = 0.5$	$\theta = 0.6$	$\theta = 0.7$
Iteration	4	19.653	2.491	3.593	111.344	140.709
	5	32.859	3.346	2.691	5.795	374.596
	6	9.866	3.819	1.102	48.692	2.0104
	7	6.359	4.062	4.991	27.360	2.887
	8	185.856	6.191	6.993	6.870	2.055
	9	174.705	48.852	51.045	<u>0.501</u>	29.223
	10	4.544	59.362	49.430	4.471	1.109
	11	5.523	31.385	59.319	4.707	1.431
	12	2.253	20.784	6.058	29.892	2.403
	13	1.790	4.086	2.812	16.309	43.483
	14	4.056	26.300	15.894	3.452	11.554
	15	2.699	3.368	3.536	2.176	27.584
	16	2.877	3.764	47.088	1.724	7.802

LMS (Least Mean Square) principle was used to measure the performance of the certain model with different group of parameters. The parameters we used for this experiment were composed of θ (which has a great effect on the function of the forecast model and have belonged to the set $\{0.3, 0.4, 0.5, 0.6, 0.7\}$) and the number of iterations (which refers to the times that the hybrid fuzzy clustering algorithm be operated to choose the proper radial basis. In this Experiment, it only included integers range from 4 to 16). To select the optimal θ-iteration group which related to the least MSE for a certain interval-n was of great importance. Such as, in Table 6.1 ($\theta = 0.6$, iteration $= 9$) was selected as the corresponding parameter group for the interval-10, for no other group has a less MSE. Likely, we have chosen ($\theta = 0.5$, iteration $= 6$), ($\theta = 0.6$, iteration $= 9$), ($\theta = 0.5$, iteration $= 6$), ($\theta = 0.7$, iteration $=$ 9) and ($\theta = 0.7$, iteration $= 6$) as the group of parameters for Interval-20, Interval-30, Interval-3, Interval-2 and Interval respectively.

6.4.3 Principal Process

The purpose of this part was to yield the prediction of gold price in each samples set. In addition, the algorithms of the models have contained hybrid fuzzy clustering algorithm, K-Mean clustering algorithm and the RBE algorithm which can perfectly fitting the multi-dimensions curve by employing m (m equals to the number of input-sample) radial basis.

While applying the models that disposing of the big samples set, we has used the first 100 samples, as ‘historical knowledge’, to yield the predicted price from 101^{th} to $100+n^{th}$. In interval-10, n refers to 10, and the like in other models. Assuming n equals to 10, as the process proceeding in a rolling operation, finally the prediction for the price from 361^{th} to 370^{th} could be yielded by using the samples from 261^{th} to 360^{th} as ‘historical knowledge’. In operating small samples sets, excepted that the number of samples to be ‘historical knowledge’ was initialed by 20 and added to $20+i*n$ (i refers to the iteration that had been finished before) as the forecast process proceeding. Other processes are similar to the big one.

The difference between the two sorts of models lied in the size of samples set. The big one had adequate samples, while the small one has insufficient samples. By trial and err, it was verified that more ‘historical knowledge’ does not lead to more accurate result. On the contrary, it may bring in ‘noise’ which has decreased the prediction precise because of the ‘out-of-date samples’. In the case of big samples set, 100 was a proper size for ‘historical knowledge’. However, in the small one, the system was not stable for the small size of samples. To achieve a balance between high prediction precise and adequate predictions, the size of ‘historical knowledge’ was initialized by 20 and increases as the process proceeding.

The number of radial basis has also played an important role in our prediction process. Small-size radial basis model had poor ability to analyze, extract and restore the key information from the input, while too much radial basis have led to the ‘over-approximating’ situation, in which too much detail of the samples have been reserved however the intrinsic rule has not been recognized. By trial and error, 0.9 was a proper ratio between the number of radial basis and the size of input for hybrid fuzzy clustering algorithm and k-mean clustering algorithm.

6.4.4 Results of the Comparison: Between Algorithms

Abiding by the method mentioned above, 18 groups of prediction price, which refers to 6 kinds of models employing 3 different kinds of algorithm, have been achieved. After calculating the 4 kinds of performance measures, Interval-3 in the small set and Interval-10 in the big set were chosen to illustrate the excellent overall performance of hybrid fuzzy clustering algorithm, comparing with other algorithm, in Fig. 6.1, for they show the best performance in the aspect of *P*-Accuracy Rate, which is considered of great value.

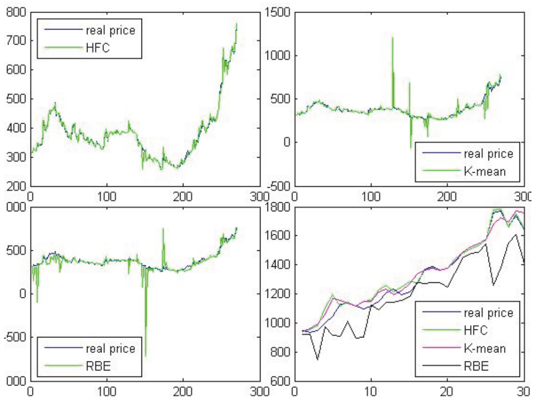

Fig. 6.1 Comparison between predictions and real price in Interval-10 and Interval-3

(1) MSE

As was mentioned above, MSE was a very important measurement for it can measure the degree how the predicted price deviates from the real price properly. In Table 6.2, the MSE-*m* referred to the MSE of the first *m* predictions.

Apparently, the results show that the hybrid fuzzy clustering algorithm always had a least MSE, compared to the *K*-Mean clustering and RBE, in each model. For example, in Interval-10, the MSE of hybrid fuzzy clustering was 34.230, seems to be much smaller than 459.280 and 6922.130, that of the *K*-Mean clustering and RBE. This phenomenon has appeared in each of model over the experiment. It means that the hybrid fuzzy clustering algorithm is superior to the *K*-Mean clustering and RBE in forecasting.

Another interesting thing was that, the MSE-m of hybrid fuzzy clustering and *K*-Mean clustering in each model had a trend of decreasing with respect to the increasing of m. It means that, as the size of 'history knowledge' increasing, the forecast ability of hybrid fuzzy clustering and that of *K*-Mean clustering is strengthening.

(2) ROC

As was mentioned above, ROC is a very important measurement for it can measure the ability to predict the direction of the price. Interval-1 in the small set and Interval-10 in the big set are chosen to illustrate the excellent overall performance of hybrid fuzzy clustering algorithms, comparing with other algorithm in Table 6.3,

Table 6.2 MSEs in each modes

MSE		Algorithm		
		HFC	*K*-Mean	RBE
Interval-1	MSE-5	4439.996	4635.752	7120.005
	MSE-10	2357.829	2397.470	8172.744
	MSE-15	1940.494	2109.092	5895.572
	MSE-20	1741.743	1794.250	5108.762
	MSE-25	1379.549	1423.007	4146.090
	MSE-30	1429.305	1443.070	13016.080
Interval-2	MSE-5	2933.092	5211.516	11619.470
	MSE-10	1495.537	2598.631	14507.470
	MSE-15	1593.897	2256.629	10168.720
	MSE-20	1433.599	1856.365	9770.745
	MSE-25	1135.340	1470.952	7906.600
	MSE-30	1289.372	1547.582	19533.740
Interval-3	MSE-5	8888.387	5289.069	14447.270
	MSE-10	4513.322	2864.558	23127.380
	MSE-15	4066.433	2518.297	16186.820
	MSE-20	3005.126	2109.878	14325.570
	MSE-25	2388.210	1683.368	11830.000
	MSE-30	1999.735	2242.144	26469.620
Interval-10	MSE-270	34.230	459.280	6922.130
Interval-20	MSE-270	256.370	28415.330	28415.330
Interval-30	MSE-270	110.480	9385.840	10643.640

Table 6.3 AUCs in each modes

AUC	HFC	*K*-Mean	RBE
Interval-1	0.956	0.955	0.818
Interval-2	0.935	0.948	0.773
Interval-3	0.948	0.890	0.786
Interval-10	0.984	0.843	0.734
Interval-20	0.951	0.823	0.679
Interval-30	0.970	0.782	0.653

for they show the best performance in the aspect of AUC, which refers to the area under curve and be considered as the principal character of ROC.

Apparently, the results have showed that the hybrid fuzzy clustering algorithm always has a best ROC, compared to the *k*-mean clustering and RBE, in each model. For example, in Interval-10, the AUC of hybrid fuzzy clustering is 0.984 seems to be much better than 0.843 and 0.734, which are the value of the *K*-Mean clustering and RBE. This phenomenon appears in each of model over the experiment. It means that the hybrid fuzzy clustering algorithm is superior to the *K*-Mean clustering and RBE in forecasting.

(3) *P*-Accuracy Rate

As was mentioned above, P-Accuracy Rate was a very important measurement for it can measure the degree how the predicted price deviated from the real price properly. In Table 6.4, there were 3 kinds of value of P, belonged to the set $\{1, 0.5, 0.1\}$.

Table 6.4 P-Accuracy Rates in each modes

P-Accuracy Rate		$P = 1$	$P = 0.5$	$P = 0.1$
Interval-1	HFC	0.433	0.333	0.100
	K-Mean	0.467	0.400	0.133
	RBE	0.300	0.167	0.067
Interval-2	HFC	0.500	0.400	0.167
	K-Mean	0.500	0.400	0.100
	RBE	0.100	0.100	0.067
Interval-3	HFC	0.600	0.300	0.133
	K-Mean	0.367	0.233	0.033
	RBE	0.067	0.000	0.000
Interval-10	HFC	0.870	0.740	0.220
	K-Mean	0.628	0.468	0.063
	RBE	0.3978	0.2602	0.0706
Interval-20	HFC	0.848	0.744	0.249
	K-Mean	0.599	0.450	0.078
	RBE	0.364	0.260	0.082
Interval-30	HFC	0.836	0.673	0.234
	K-Mean	0.595	0.454	0.138
	RBE	0.338	0.223	0.052

Apparently, the results have showed that the hybrid fuzzy clustering algorithm always had a best P-Accuracy Rate, compared to the K-Mean clustering and RBE, in each model. For example, in Interval-10, the P-Accuracy Rate of hybrid fuzzy clustering was 0.870, seems to be much better than 0.628 and 0.398, that of the K-Mean clustering and RBE. This phenomenon has appeared in each of the models over the experiment. It means that the hybrid fuzzy clustering algorithm is superior to the K-Mean clustering and RBE in forecasting.

6.4.5 Results of the Comparison: Between Models

The issue we should focus on is that employing hybrid fuzzy clustering algorithm, the Interval-3 performs better than the Interval-2 colliding with the assumption that the short-interval models should be superior to that of the long-interval models. The reason why assume above condition was that as the interval increasing, the prediction would originate from the more upgraded set, which has more important information for the certain prediction. Considering such an issue, there is a vital difference between the Interval-2 and the Interval-3. With the different group of parameters, the small interval performs better than the big one becomes not sure.

Table 6.5 Comparison of interval-2 and interval-3 employing hybrid fuzzy clustering with the same parameters group ($\theta = 0.5$, iteration = 6)

Value		Interval	
		2	3
MSE	MSE-5	3431.386	8888.387
	MSE-10	2441.681	4513.322
	MSE-15	2432.076	4066.433
	MSE-20	2146.086	3005.126
	MSE-25	1758.642	2388.210
	MSE-30	2863.197	1999.735
P-Accuracy Rate	$P = 1$	0.333	0.600
	$P = 0.5$	0.200	0.300
	$P = 0.1$	0.067	0.133
ROC	AUC	0.916	0.948

So, to set the same group of parameters to the Interval-2 and the Interval-3 is advisable. By recalculating the predicted price, MSE, P-Accuracy Rate, CDPR and ROC, the final results were presented in Table 6.5, and the parameters of Interval-2 and Interval-3 were both ($\theta = 0.5$, iteration = 6). In this way, the assumption was testified to be untrue. For applying the same parameters group, the Interval-2 was still inferior to the Interval-3 in all of the aspects.

6.5 Conclusions

There are 4 conclusions can be drawn from the experiment:

- Hybrid fuzzy clustering algorithm is superior to K-Mean clustering and RBE on the ability to generalize.
- The generalizing ability of hybrid fuzzy algorithm increase with respect to size of ‘historical knowledge’.
- The parameters group for hybrid fuzzy clustering algorithm effects the performance deeply.
- While employing hybrid fuzzy clustering algorithm, the short-interval models may not generate more precise results compared to the long-interval models.

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Chapter 7
A Cloud-based Decision Support System Framework for Order Planning and Tracking

Zhaoxia Guo and Chunxiang Guo

Abstract This paper presents a cloud-based decision support system framework for order planning and tracking in a distributed manufacturing environment. Under this framework, computational intelligent techniques are employed to generate order planning decisions while RFID and cloud computing technologies are utilized to capture real-time production records and make remote production order tracking. On the basis of this framework, a pilot system was developed and implemented in a distributed manufacturing company, which reported distinct reductions in production costs and increases in production efficiency. The system framework is also easy-to-extend to integrate wider operations processes in supply chain.

Keywords Order tracking · Order planning · Intelligent optimization · RFID · Cloud computing

7.1 Introduction

Due to increasing globalization as well as global cooperation and division network, more and more manufacturing companies produce their production tasks in multiple plants located in different locations. The increasingly complicated production network leads to an increasing challenge for such companies to make effective order tracking and decision-making. This paper aims at presenting a cloud-based decision support system framework for order scheduling planning and tracking in a distributed manufacturing environment with multiple production plants.

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7.1.1 Importance of Order Planning and Tracking

Production management at the headquarter of manufacturing company needs to effectively track and monitor the production of their orders in its plants located in different areas, on a real-time basis, so as to improve the company's production transparency and supply chain performance. In addition, making effective order scheduling planning at the headquarter is one of the most important decision-making tasks in the company because it is crucial to downstream production decision-making, such as production scheduling and control in each plant.

7.1.2 Order Tracking and Cloud-based Applications

Effectiveness and accuracy of production order tracking rely heavily on the timeliness and the accuracy of production data collected from production departments. In some real-world production environments, production data of each production order are collected from assembly lines by various types of data capture systems based on different data capture methods, including manual recording, barcode scanning and RFID-based methods. However, the existing data capture systems are usually designed for an independent plant. In real-world labor-intensive manufacturing, due to the absence of remote order tracking system, production management at the headquarter track production progress by emails, phones and summary reports from each plant, which are time-consuming, delayed and often inaccurate.

In recent years, cloud-based systems and applications have emerged as an important trend in information technology, which have obtained successful applications in such organizations as government [1], manufacturing [2], healthcare [3] and education [4]. With intriguing benefits such as cost savings, increased storage capabilities, and guaranteed uptime, more and more companies, especially those looking to speed service delivery and increase management performance, are considering incorporating cloud technology into their operations. However, cloud-based application in order scheduling planning and tracking has not been reported in labor-intensive manufacturing industries so far.

7.1.3 Order Scheduling Planning and Decision-making

Labor-intensive manufacturing is characterized by short production lead-time, tight delivery due dates, small quantities with frequent product change, as well as the multi-plant and multi-production department nature. These phenomena and characteristics increase the complexity of making effective production decisions.

In the area of production decision-making, a great number of papers have been published and there are also comprehensive review papers [5–7], which involve a large number of research areas, including aggregate planning [8], shop scheduling

[9], assembly line balancing [10, 11], etc. However, only a very limited number of research has investigated the production decision-making problems in the manufacturing environment with the consideration of multiple production plants located in different locations [12–14]. Unfortunately, their research has not considered the effects of learning phenomena on production performance.

It is well accepted that learning phenomenon has large effects on production efficiencies. In manufacturing industries, it is usually that additional production orders are placed to produce some popular products. If an original order and its additional orders are placed to the same plant, the efficiency of producing the additional order will be higher than that of producing the original order due to the effects of learning phenomena. That is, higher production efficiency can be obtained to produce these additional orders.

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7.2 Problem Statement

Considering a distributed manufacturing environment, the manufacturing company contains n production plants, including self-owned or cooperative plants, located in different locations. The manufacturing company receives various production orders from different customers. These orders need to be assigned to the company's n production plants for production. These plants involve N production departments numbered as 1 to N, which perform, respectively, N types of different production processes denoted as process type 1 to process type N. That is, production process i can only be produced in production department i ($i = 1, \cdots, N$). These production departments can be classified into two categories: ordinary category and special category. Each category involves multiple production departments. The departments of the ordinary category are fully contained in all plants but it is possible that those of the special category are only partly included (or not included) in some of plants. That is, it is possible that different production processes of an order need to be performed in different plants.

The manufacturer receives a group of production orders, called an order group, from a customer at a time. Each order group consists of multiple production orders. Each order consists of a maximum of N production processes. Each production process of an order is assigned to only one plant for processing. All finished products are delivered to a distribution center for product delivery and distribution. The transportation time between different production departments in a plant is included in the processing time of production processes. Production orders must be processed in turn in each production department; once a production process is started, it cannot be interrupted; there is no shortage of materials and machines in production. In addition, various production uncertainties, such as uncertain production orders and uncertain processing time in production departments, need to be considered.

The production management at the company's headquarters needs to track and monitor the production status and progress of each order in each production department timely. The production scheduler at the headquarter needs to schedule each order to appropriate plant for production so as to optimize three order scheduling objectives, including minimizing the total tardiness and the total throughput time of all orders, and the total idle time of all production departments.

7.3 Cloud-based Decision Support System Framework

The cloud-based decision support system (CDSS) framework is presented to implement real-time production tracking of orders being produced in plants located in different locations, and make effective order scheduling decisions so that each production order can be assigned to an appropriate plant for production. The CDSS framework is shown in Fig. 7.1. The system mainly consists of a distributed production data capture (DPDC) module, a heuristic data analysis and processing (HDAP) module, a remote order tracking and monitoring (ROTM) module, an heuristic efficiency projection module, and an intelligent order scheduling (IOS) module.

The DPDC module is in charge of collecting real-time production records, from each workstation in different plants, for further data analysis and decision-making process. These production records collected are transferred to the real-time data capture server. The real-time data capture server is the bridge between the DPDC module and the real-time production database, which receives data from RFID readers, enters the production data into the real-time production database, and provides access to the data. The server also provides the function of interaction between the front-end applications in each plant and the back-end application system in a browser/server manner. Based on the real-time production data collected, the HDAP module analyzes and preprocesses the raw data, and then extracts necessary summary data and save them into the production decision-making database. The ROTM module is in charge of tracking and monitoring the production progress of each production order in plants. The heuristic efficiency projection module analyzes and estimates the production efficiency of each production department for different production orders. The efficiencies projected are then used as the input of the IOS module. The IOS module finally makes order scheduling decisions by automatically generating optimal order scheduling solutions. These modules are introduced in detail as follows.

7.3.1 Distributed Production Data Capture

The DPDC module consists of *n* real-time production data capture (RPDC) subsystems, each of which is installed in a plant and responsible for collecting real-time production records from workstations of different production departments. Fig. 7.2 shows the flowchart of capturing real-time production records from workstations in a production department. A production plant consists of multiple production departments, and each department includes multiple workstations. In each workstation, an RFID terminal is installed, which reads the RFID tag attached to each workpiece to capture the starting time and end time of each workpiece being processed on this workstation. The RFID terminals in each department are integrated into an intranet by the switch. The switch is a device that channels incoming data from any of the multiple input ports to the specified output port that takes the data toward its intended destination. The data communication between the switch and the real-time data capture server is implemented based on TCP/IP protocol.

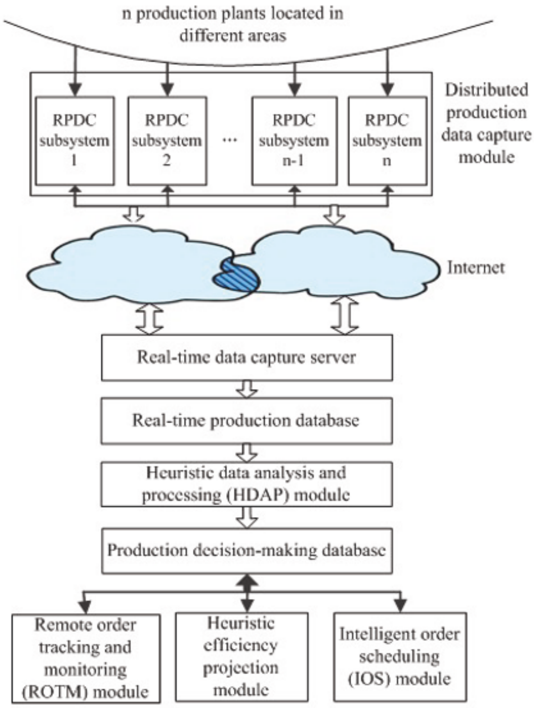

Fig. 7.1 The CDSS framework

The RFID tags used in this module are passive RFID tags with the low frequency of 125 KHZ, which are low cost and technically mature for industrial practice. Only the tag ID is stored in the memory of the tag. All other information related to the

RFID tags is stored in the remote real-time production database. The database can be implemented by using MySQL, MS SQL Server or Oracle database according to the different requirements of data processing. Each tag ID is mapped with the additional information of the tag through the real-time production database. Since the information acquired through the RFID device is brief and simple, the high scanning speed of the RFID reader for a tag can be reached. To help frontline operators save time in identifying different workpieces, RFID tags with different colors are utilized to indicate different types of workpieces.

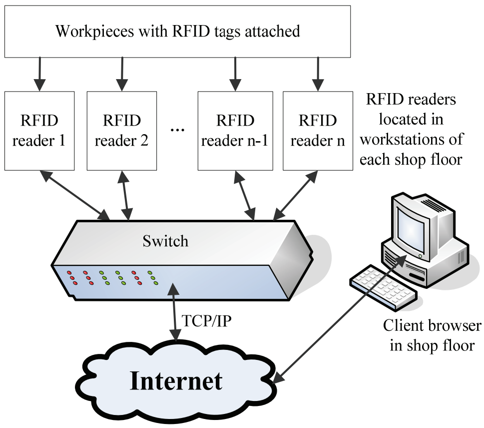

Fig. 7.2 Flowchart of real-time production data capture in a production department

7.3.2 *Heuristic Data Analysis and Processing*

The real-time production data collected by the DPDC module include production records of each operation being processed on each workstation. The amount of the production records collected is huge, which will inevitably lower the speed of database operations. Besides, the top production management at the headquarters does not concern the detailed production information. To implement order tracking and scheduling in a high-efficiency manner, necessary data are extracted from the real-time production database and placed into the production decision-making database, which consists of: (1) operator and machine configuration of each production department, including the numbers of operators and machines and the type of each machine; (2) the information of each production order, including operations involved in this order and each operation's standard allowed time (SAM); (3) working records of each operator on each day, including the number of each operation he/she processed and his/her average operative efficiency for each operation.

In real-world production, production records are collected by frontline operators scanning RFID tags. It is inevitably that some production records collected are inaccurate since it is hard to control each operator's scanning operations. To eliminate the effects of inaccurate RFID data, the average operative efficiency of an operator processing an operation on a day is set to the median of the operator's all operative efficiencies to this operation on the same day.

To make order scheduling decisions, three variables need to be utilized as the inputs of the IOS module, including the workload of each production process in each order, the standard manpower (production capacity) of each production department and the completion time of each production process in processing. These variables can be calculated based on the real-time production data collected by the DPDC module.

7.3.3 Remote Order Tracking and Monitoring

Fig. 7.3 shows the structure of the ROTM module. This module is actually a web-based production monitoring program, which connects with the production decision-making database and provides a user friendly web portal to help production management at the headquarters to track and monitor the production progress of each order in each production department. The web portal gives production management easy access to the most updated production status, such as material delivery status, production progress of each order, production output and workload of each plant. The user can thus browse all this information by web browsers in microcomputers and mobile phones with Internet connections.

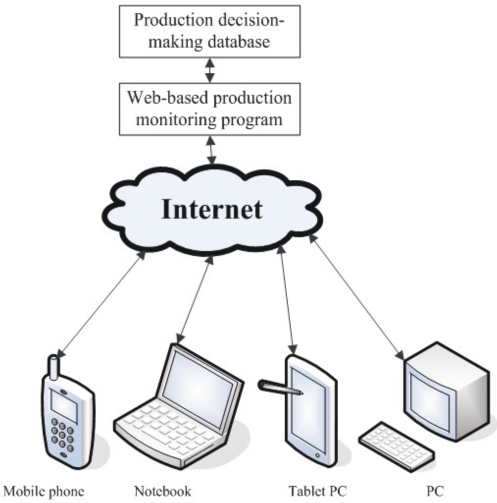

Fig. 7.3 Structure of the ROTM module

7.3.4 Heuristic Efficiency Projection

The accuracy of production efficiency of each production department for corresponding production process is crucial to the performance of each order scheduling solution. If production order O_i has been produced already in production department S_{kj}, its next additional order $O_{i'}$ will be produced with higher production efficiency in this department. Let $E^{i}{}_{kj}$ and $E^{i'}{}_{kj}$ denote the efficiencies of production department S_{kj} for the corresponding process of production orders O_i and $O_{i'}$ respectively, which represent the average production workloads that can be completed within one working day. We have:

$$E^{i}{}_{kj} = \frac{SAM_{ij} \cdot Q_i}{T}$$

and

$$E^{i'}{}_{kj} = E^{i}{}_{kj} \cdot (1 + ir),$$

where T denotes the number of standard workdays used for producing production process P_{ij} in production department S_{kj} and ir denotes the increase rate of production efficiency. ir is a random variable. Because of the small-batch production feature of labor-intensive manufacturing, the value of ir is determined randomly based on the following empirical rules from the senior production management:

- $0.1 < ir < 0.4$, if order $O_{i'}$ is the first (second) additional order;
- $0.05 < ir < 0.1$, if order $O_{i'}$ is the third additional order;
- $0 < ir < 0.5$, if order $O_{i'}$ is the fourth additional order.

7.3.5 Intelligent Order Scheduling

The IOS module is proposed to generate effective order scheduling solutions. In a manufacturing company with multiple plants, the order scheduling problem is a complicated combinatorial optimization problem with a huge solution space. Take a simple order scheduling problem considering 20 production orders and 3 plants as an example. There are 3^{20} candidate solutions for this problem even if each order has only one production process. The real-world problems have a much greater solution space because they need to handle the production of a large number of production orders (often more than 100) with multiple production processes in a longer time period and determine the values of a large number of variables. There does not exist effective methodology for this type of problem nowadays. The order scheduling process in today's labor-intensive manufacturing mainly rests on the experience and subjective assessment of the production planner. In addition, production uncertainties exist widely in real-world production.

The order scheduling problem with the consideration of production uncertainties is a stochastic problem whereas the same order scheduling problem without the consideration of production uncertainties is a corresponding deterministic problem. To generate effective solutions for the stochastic order scheduling problem, the IOS module is developed on the basis of the MOHI model proposed in one of the author's latest work [14]. Fig. 7.4 illustrates the architecture of the IOS module, which is composed of three submodels, including a novel multi-objective memetic optimization (MOMO) submodel, a Monte Carlo simulation (MCS) submodel and a heuristic pruning submodel. The MOMO submodel is adopted firstly to seek the initial Pareto optimal solutions to the deterministic order scheduling problem, which does not consider the production uncertainty and assumes that all uncertain orders need to be produced and the processing time of an order in a production department equals the mean of its processing time in this department. To tackle the stochastic order scheduling problem, the MCS technique is then employed to evaluate performance (fitness) of each initial Pareto optimal solution under various production uncertainties in order scheduling. Based on the fitness of initial solutions for the stochastic problem, the heuristic pruning submodel is finally employed to generate the final optimal solutions for order scheduling practice.

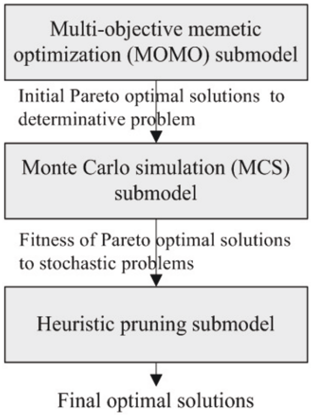

Fig. 7.4 Architecture of the IOS model

7.4 System Implementation

Based on the framework presented in Sect. 7.3, a pilot system was developed and implemented in an apparel manufacturing company headquartered in Hong Kong. The company has four production plants located in four different cities. The company involves five different production departments, including cutting, silk-screen, sewing, finishing and packaging. Table 7.4 shows the production departments included in each plant. Plant 1 includes all 5 production departments while plant 4 only includes the last 3 production departments. In apparel manufacturing, sewing production is the most crucial to the production performance of each plant. An RFID reader is thus installed in each sewing workstation in sewing departments to capture the production records of each sewing operations. In cutting department, RFID readers are installed in each cutting workstation to capture the output of cutting pieces from each cutting bed. In silk-screen department, each bundle of garments is collected while the production record of each piece of garment is collected in finishing department. In packing department, RFID readers collect the records of each carton of garments.

Table 7.1 Production departments included in each plant

	Cutting	Silk-screen	Sewing	Finishing	Packaging
Plant 1	√	√	√	√	√
Plant 2	√	×	√	√	√
Plant 3	√	×	√	√	√
Plant 4	×	×	√	√	√

The pilot system was developed on the basis of Java/J2EE, SQL Server 2005 and web technologies. The production management at headquarters can thus track the production progress of each order in each shop floor by a series of summarized production reports, and also assign each order to an appropriate plant. Some examples of interfaces of the pilot system are shown in Fig. 7.5 and Fig. 7.6.

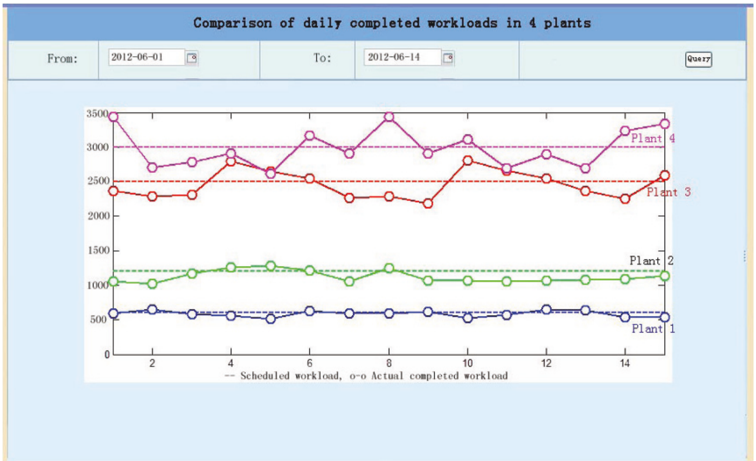

Fig. 7.5 Interface 1 - comparison of daily completed workloads in 4 plants

Fig. 7.5 shows the comparison of daily completed workloads in 4 plants, in which the dashed line '–' represents the scheduled workloads and the line 'o-o' represents the actual completed workloads (unit: standard mandays). By this interface, the management can learn about if the daily production output goes on as scheduled in each plant.

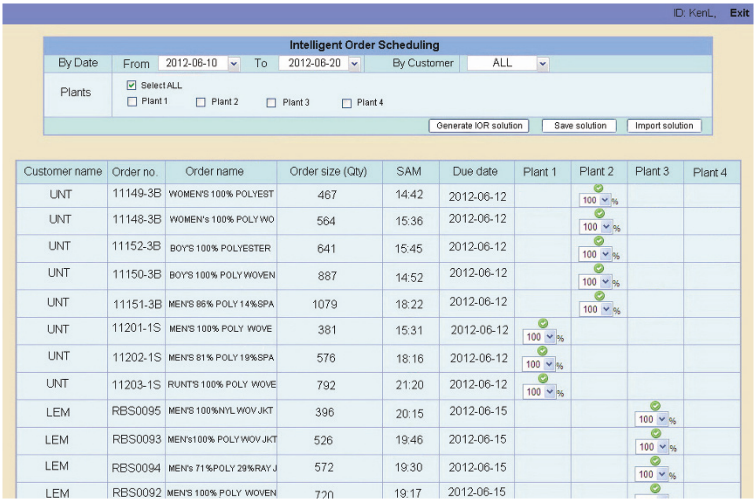

Fig. 7.6 Interface 2 - intelligent order scheduling

Fig. 7.6 shows the interface of generating the intelligent order scheduling solutions. Each production order can only be assigned to one plant for production due to its small-batch feature. In addition, the sequence of orders shown in the table represents their sequence to be produced in the corresponding plant.

7.5 Evaluation

Before the pilot system was implemented in the apparel manufacturing company investigated, the production management at the headquarters cannot track the production progress of each order and make order scheduling decisions effectively. They need to spend a large amount of time in reading and analyzing summary reports from each plant every day. However, the report is not updated and usually unreliable. In addition, to assign each order to appropriate plant, the production scheduler at the headquarters makes order scheduling decisions on the basis of their experience and subjective judgments.

A shop floor in each plant of the manufacturing company was used to install and test the pilot system. After the pilot system was implemented for 4 months, the data from the investigated company showed that the following quantitative business impact and benefits have been achieved:

- 4% reduction in labor and system costs: No computer operator is required to input job tickets records now. The CDSS needs less computer servers, less installation and maintenance costs, less IT-related and IE-related manpower, etc.
- 18% increase in production efficiency: The real-time and accurate production data collected and effective and efficient production decisions generated by the pilot system can definitely improve production efficiencies.

The CDSS has also brought the following qualitative benefits:

- Real-time data can be utilized for real-time diagnosis and decision-making by the production management at the headquarters through user-friendly and in-depth diagnosis so as to make decisions promptly. Better supply chain coordination can be achieved so as to provide its customers as well as its production management with better services.
- Effective and efficient production order scheduling decisions can be made at the headquarters, instead of relying on subjective assessment and ineffective quick-fixed solutions.

7.6 Discussions

7.6.1 Necessities of RFID Technology and Cloud-based System Architecture

In real-world production environment of labor-intensive manufacturing, production data capture technologies mainly includes barcode scanning and RFID-based technologies. Comparing with barcode technology, RFID technology has some distinct advantages which make it necessary and irreplaceable in the investigated application.

- RFID technology can make real-time and accurate data collection while barcode-based data capture is prone to causing incomplete and lagged data.
- RFID tags are reusable but it is impossible to reuse barcode labels.
- RFID technology can work well in environments wherein barcode labels are prone to being wrinkled, dirty or smudged because the electronic components of RFID tags are better protected. However, barcodes cannot work well in these environments because they will result in barcode labels cannot be read.

With the development of global manufacturing and fierce market competition, production data capture system designed for one plant cannot implement the effective integration and sharing of production data collected from different plants, which impedes the implementation of effective and real-time order tracking and decision-making. The proposed CDSS framework, which adopts cloud-based system architecture, can tackle this effectively. The cloud-based system architecture has the following advantages:

- Production data from different plants can be collected and shared in a real-time manner. Real-time tracking and decision-making is helpful to improve response speed as well as decision-making efficiency and effectiveness.
- Each plant does not need to concern the system installation and maintenance, which will be completed by the company headquarters. It will reduce the labor and system costs for production plants.

7.6.2 Necessity of Considering Learning Effects

In real-world production, with the increased involvement in production process, production management and frontline operators became more and more familiar with the production process, which leads to improvement in their production efficiency.

If learning effects are not considered, the subsequent production decision-making process will not be able to reflect the real production, which will inevitably decrease the decision-making performance. For example, an additional production order is assigned to an assembly line for second production. According to the original production efficiency, 10 days are required to complete this order. However, only 7.7 days are required due to the efficiency improvement caused by learning effects. That is, a 2.3-day time deviation will be generated if the decision-making process does not consider learning effects. If more products need to be produced in this order, larger time deviation will be generated, which will make the original decision-making solution infeasible

On the other hand, production decision-making without the consideration of learning effects will make it hard to know the available production capacity. It is thus hard to make accurate decisions in order and acceptance negotiating, which will subsequently decrease the opportunities of producing more orders and making more profits.

7.7 Conclusions

In this paper, we proposed a CDSS framework which contains a DPDC module, a real-time data capture server, a real-time production database, a HDAP module, a production decision-making database, a ROTM module, an heuristic efficiency projection module and an IOS module. The system employed RFID technology to collect real-time production records from each workstation, employed TCP/IP protocol to transfer collected data to remote real-time production database, and employed a ROTM module to implement order tracking and used an IOS module to implement order scheduling.

The CDSS framework is a an effective framework for production management to track and monitor production status of each production order in shop floors, and to make use of the abundant data collected to make production decisions. The system has been installed and run in a manufacturing company with multiple plants. The trial run demonstrated the benefits brought by the system, including 4% reduction in labor and system maintenance costs, 18% increase in production efficiency. By implementing this system, better supply chain coordination and better production decisions can be achieved so as to provide its customers with better services.

Our future work will extend the proposed framework to integrate with more extensive supply chain operations and more decision-making functions. For example, supplying, retailing and logistics operations can be integrated.

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Chapter 8
A Third-party Logistics Network Design Model under Fuzzy Random Environment

Xiaoyang Zhou and Yan Tu

Abstract In the present paper, for the location problem of a third-party logistics company which is under the fuzzy random environment, we proposed an chance constraint model. In order to solve it, we transform it into an equivalent crisp model by some mathematical proofs. Finally, an illustrative examples are given in order to show the application of the proposed models.

Keywords 3PLs · Network design · Fuzzy random variable · Chance-constraint operator

8.1 Introduction

Today's competitive business environment has resulted in increasing cooperation among individual companies as members of a supply chain. In other words, the success of a companies will depend on their ability to achieve effective integration of worldwide organizational relationships within a supply chain [1]. Moreover, consumers now require high levels of customer services for a variety of products with a short life cycle. In such an environment, companies are under pressure with filling their customers' orders, keeping the deliveries of products up to speed, reducing inventory. Consequently, the individual companies of a supply chain are frequently faced with the challenges of restructuring their distribution network with respect to global need and volatile market changes. Faced with such a situation, 3PLs come into being to cooperate the manufacturing companies to improve the logistics efficiency.

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In the recent past, third-party logistics (3PLs), also referred to as logistics outsourcing [2–4], has received considerable attention from logistics scholars, resulting in a plethora of research and writing in this field. The interest of researchers in 3PLs should continue as several recent studies suggest that a steadily increasing number of companies across industry sectors use third-party providers for the management of all or part of their logistics operations [5, 6].

The main advantage of outsourcing services to 3PLs is that these 3PLs allow companies to get into a new business or a new market without interrupting forward flows; in addition, logistics costs can be greatly reduced. These 3PLs have evolved the logistics functions such as transportation management, warehouse management, inventory management etc. 3PLs are playing an increasing role in the management of supply chains.

In general, 3PLs operate clients' transportation and warehouses services. More specifically, through the use of these logistics centers, 3PLs provide inbound and outbound transportation, cross-docking, and distribution as well as holding inventory for their clients. So the design of 3PLs network is very important for a third party logistics enterprise.

Unfortunately, the 3PLs network design problem is subject to many sources of uncertainty besides random uncertainty and fuzzy uncertainty. In a practical decision-making process, we often face a hybrid uncertain environment. To deal with this twofold uncertainty, fuzzy random variable was proposed by Kwakernaak [13, 14] to depict the phenomena in which fuzziness and randomness appear simultaneously [11, 15]. Several research works have been published in recent years [16, 17]. However, in this paper, we consider the amount of demand on the products as normally distributed variable $N(\mu,\sigma^2)$ from the view point of probability theory, and the values of μ as a triangular fuzzy variable (a,b,c) because of scanty data to analyze. Therefore, probability 3PLs network with fuzzy parameters appears. In this case, random fuzzy variable which was presented by Liu [12] can be used to deal with this kind of combined uncertainty of randomness and fuzziness. How to model and solve the problem of 3PLs network design in random fuzzy environment is a new area of research interest. To the best of the author's knowledge, so far, there is little research in this area.

Our purpose in this paper is to make some contribution on 3PLs network design in an uncertain environment of combined fuzziness and randomness and obtain optimal solutions. We apply uncertain programming techniques to the real 3PLs network design problem, and provide optimal alternative solutions to the decision-maker.

The remainder of the paper is organized as follows: In Sect. 8.2, we introduce the third-party logistics problem, the fuzzy random chance constraint model and the details of modelling for 3PLS location problem. A crisp equivalent model is presented in Sect. 8.3. An application is presented in Sect. 8.4. Finally the conclusion has been drawn in Sect. 8.5.

8.2 Model for 3PLs Network Design

In this section, we will built up a model according to the third-party logistics network design problem under fuzzy random environment.

(1) Problem statement

The first important thing for a third-party logistics company is to decide the location of logistics centers, it's the core of a 3PLs company. The function of a third-party logistics company is to manage the products of the client plants, that is, to perform the outsourcing contract signed with client plants, which includes distributing the products to the customers to satisfy their demand, and manage the inventory for the client plants. So the client plants can just concentrate on the production, and let the 3PLS company to deal with the distribution and the inventory.

For a 3PLs company, first all of the products are transported to logistics centers, then according to the demand of customers the products are sent to the destination of the customers. For the superfluous amount, the 3PLs company will keep them as inventory, see Fig. 8.1.

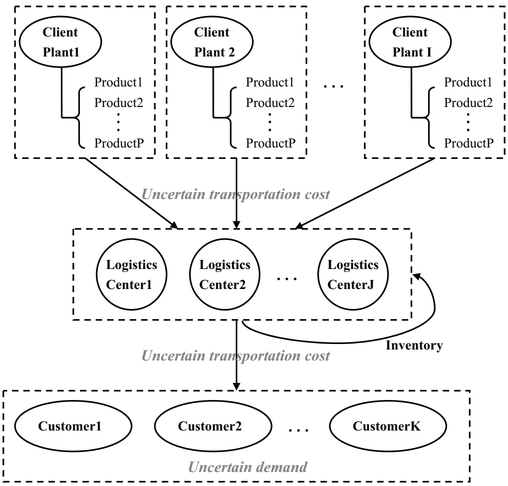

Fig. 8.1 Third-party logistics system

A third-party logistics company want to profit, they should minimize the total cost under the precondition that they should carry out the outsourcing contract.

(2) 3PLs model with fuzzy random coefficients

We try to present a 3PLS model under fuzzy random environment, here we first introduce some basic knowledge about fuzzy random, and then we give the details of establishing fuzzy random chance constraint 3PLS model.

In order to establish a optimization network, we have the following assumptions:

- The 3PLs company sign a outsourcing contract with the client company for very long time, and we consider one period;
- The location and the number of client companies and customers are known;

- The demand of customers and the standard transaction costs are uncertain, we use random fuzzy variables to denote it.

Fuzzy random variable, which was introduced by Kwakemaak [7] in 1978, is a concept to depict the phenomena in which randomness and fuzziness appear simultaneously. Since then, its variants and extensions were presented by other researchers, e.g., Colubi et al. [8], Kruse and Meyer [9], Lόpez-Diaz and Gil [10] , Puri and Ralescu [11] and Liu [12].

In this paper, the definitions about fuzzy random variable are cited from Liu [12].

Definition 8.1. [12] Let $(\Omega, \mathscr{A}, Pr)$ be a probability space, $\mathscr{F}$ be a collection of fuzzy variables defined on the possibility space. A fuzzy random variable is a function $\xi : \Omega \to \mathscr{F}$ such that for any Borel set B of $\Re$, $\xi^*(B) = Pos\{\xi(\omega) \in B\}$ is a measurable function of ω.

Fuzzy random variable ξ is said to be triangular, if for each ω, $\xi(\omega)$ is a triangular fuzzy variable, denoted by $(X_1(\omega), X_2(\omega), X_3(\omega))$, with X_i are random variables defined on the probability space Ω. The randomness of ξ is said to be determined by random variables X_i, $i = 1, 2, 3$.

In this problem, we assume each logistic center has enough storage space for the client plant. The notations for the proposed model are presented as follows:

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p : set of clients' product types, $p = \{1, \cdots, P\}$;
i : set of clients' plant locations, $i = \{1, \cdots, I\}$;
j : set of potential sites of logistics centers, $j = \{1, \cdots, J\}$;
k : set of fixed customers locations, $k = \{1, \cdots, K\}$.

Parameters

$\tilde{\bar{c}}^1_{pij}$: standard unit transportation cost from i to j by product p;
$\tilde{\bar{c}}^2_{pjk}$: standard unit transportation cost from j to k by product p;
f_j : fixed cost of potential logistics center j;
$\tilde{\bar{d}}_{pk}$: demand of customer k for product p;
s_{pi} : supply of product p of client company i;
t_{pj} : the unit storage cost of product p in logistics center j;
y_{pj} : the storage amount of product p in logistics center j.

Decision variables

x^1_{pij} : amount of product p from client plant i to logistics center j;
x^2_{pjk} : amount of product p from logistics center j to customer k;
$$z_j \ : \begin{cases} 1 \text{ if the logistics center } j \text{ is open,} \\ 0 \text{ otherwise.} \end{cases}$$

For a 3Pls company, the objective is minimizing the total cost which is composed of the transaction cost from client plant 1 to the logistics center j and from the logistics center j to customer k, the fixed cost of opening the logistics center j, the variable intermediary cost of logistics center j transfer the products, and the storage cost, ao we get the following objective function:

$$\min\ F = \sum_{p\in P}\sum_{i\in I}\sum_{j\in J} x^1_{pij}\tilde{\bar{c}}^1_{pij} + \sum_{p\in P}\sum_{j\in J}\sum_{k\in K} x^2_{pjk}\tilde{\bar{c}}^2_{pjk} + \sum_{j\in J} z_j f_j + \sum_{p\in P}\sum_{j\in J} t_{pj}y_{pj}. \quad (8.1)$$

The constraints include the following:
The total amount of products from logistics center to the customer should be just satisfied the demand of customer,

$$\sum_{j\in J} x^2_{pjk} \geq \tilde{\bar{d}}_{pk},\ \forall p,k. \quad (8.2)$$

The total amount of products from client plant to logistics center should be no more than the production of client plant,

$$\sum_{j\in J} x^1_{pij} \leq s_{pi},\ \forall p,i. \quad (8.3)$$

The total number of logistics centers that will be open should be not larger than a certain number,

$$\sum_{j\in J} z_j \leq n,\ \forall j. \quad (8.4)$$

For a logistics center and a product, the quantity difference between inbound and output is the products that should be stocked, that is the storage amount,

$$y_{pj} = \sum_{i\in I} x^1_{pij} - \sum_{k\in K} x^2_{pjk},\ \forall p,j. \quad (8.5)$$

The storage amount should be no less than 0,

$$y_{pj} \geq 0,\ \forall p,j. \quad (8.6)$$

In addition, there are some logical constrains,

$$\begin{aligned} &x^1_{pij} = x^1_{pij}\cdot z_j,\ \forall i,j, \quad x^2_{pjk} = x^2_{pjk}\cdot z_j,\ \forall j,k, \\ &x^1_{pij} \geq 0,\ \forall i,j, \quad x^2_{pjk} \geq 0,\ \forall j,k, \quad z_j = \{0,1\},\ \forall j. \end{aligned} \quad (8.7)$$

From the discussions above, we can formulate a fuzzy random mixed-integer non-linear programming model as follows:

$$\min\ F = \sum_{p\in P}\sum_{i\in I}\sum_{j\in J} x^1_{pij}\tilde{\bar{c}}^1_{pij} + \sum_{p\in P}\sum_{j\in J}\sum_{k\in K} x^2_{pjk}\tilde{\bar{c}}^2_{pjk} + \sum_{j\in J} z_j f_j + \sum_{p\in P}\sum_{j\in J} t_{pj}y_{pj},$$

$$\text{s.t.}\begin{cases}\sum_{j\in J} x^2_{pjk} \geq \tilde{\bar{d}}_{pk},\ \forall p,k,\\ \sum_{j\in J} x^1_{pij} \leq s_{pi},\ \forall p,i,\\ y_{pj} = \sum_{i\in I} x^1_{pij} - \sum_{k\in K} x^2_{pjk},\ \forall p,j,\\ y_{pj} \geq 0,\ \forall p,j,\\ x^1_{pij} = x^1_{pij} z_j,\ \forall i,j,\\ x^2_{pjk} = x^2_{pjk} z_j,\ \forall j,k,\\ x^1_{pij} \geq 0,\ \forall i,j,\\ x^2_{pjk} \geq 0,\ \forall j,k,\\ z_j = \{0,1\},\ \forall j.\end{cases} \tag{8.8}$$

Generally, in order to solve the model above, we have to transform these fuzzy random variables into crisp parameters. In this paper we use the chance operator to transform the fuzzy random programming to a chance-constraint programming model.

Before the transformation, we give the following three useful definitions.

Definition 8.2. [17] (Probability measure) Let Ω be a nonempty set, and $\mathscr{A}$ a σ-algebra over Ω, A is an event in $\mathscr{A}$. The set function Pr is called a probability measure if it satisfies the following three axioms.
Axiom 1. $Pr\{\Omega\} = 1$.
Axiom 2. $Pr\{A\} \geq 0$ for any $A \in \mathscr{A}$.
Axiom 3. For every countable sequence of mutually disjoint events $\{A_i\}_{i=1}^{\infty}$, we have:

$$Pr\left\{\bigcup_{i=1}^{\infty} A_i\right\} = \sum_{i=1}^{\infty} Pr\{A_i\}.$$

Definition 8.3. [17](Possibility measure) Given a universe Γ, $\mathscr{P}(\Gamma)$ is the power set of Γ and Pos is a set function defined on $\mathscr{P}(\Gamma)$. Pos is said to be a possibility measure, if Pos satisfies the following conditions:
(1) $Pos\{\Phi\} = 0$;
(2) $Pos(\Gamma) = 1$, and
(3) $Pos\left(\bigcup_{i\in I} A_i\right) = \sup_{i\in I} Pos(A_i)$ for any subclass $\{A_i | i \in I\}$ of $\mathscr{P}(\Gamma)$.

Definition 8.4. [17] (Chance measure) Let ξ be a fuzzy random variable, and B a Borel set of $\Re$. Then the chance of fuzzy random event $\xi \in B$ is a function from $(0,\ 1]$ to $[0,\ 1]$, define as:

$$Ch\{\xi \in B\}(\alpha) = \sup_{Pr\{A\}\geq\alpha}\ \inf_{\omega\in A} Pos\{\xi(\omega) \in B\}.$$

Therefore, $Ch\{f_i(\xi) \leq 0\}(\alpha_i),\ i = 1,2,\cdots,m$ means the possibility of the fuzzy random event $f_i(\xi) \leq 0$ standing under the probability level α_i. $Ch\{f_i(\xi) \leq 0\}(\alpha_i) \geq \beta_i,\ i = 1,2,\cdots,m$ means the possibility of the fuzzy random event $f_i(\xi) \leq 0$ standing under the probability level α_i is no less than β_i.

For the purpose of minimizing the optimistic value F' of the fuzzy random objective, we turn the objective function to Equation (8.9),

$$\min\ F', \tag{8.9}$$

and we add constraint (8.9),

$$Ch\Big\{\sum_{p\in P}\sum_{i\in I}\sum_{j\in J} x_{pij}^1 \tilde{\bar{c}}_{pij}^1 + \sum_{p\in P}\sum_{j\in J}\sum_{k\in K} x_{pjk}^2 \tilde{\bar{c}}_{pjk}^2 + \sum_{j\in J} z_j f_j + \sum_{p\in P}\sum_{j\in J} v_{pj} x_{pij}^1 + \sum_{p\in P}\sum_{j\in J} t_{pj} y_{pj} \le F'\Big\}(\varphi) \ge \delta, \tag{8.10}$$

where $\delta, \varphi \in [0,1]$ are confidence levels, and min F' is the (δ,φ)-optimistic return, $Ch\{\cdot\}$ denotes the chance of the event in $\{\cdot\}$.

According to the definition of chance, constraint (8.10) could be written as Equation (8.11),

$$Pr\Big\{\omega \Big| Pos\Big\{\sum_{p\in P}\sum_{i\in I}\sum_{j\in J} x_{pij}^1 \tilde{\bar{c}}_{pij}^1(\omega) + \sum_{p\in P}\sum_{j\in J}\sum_{k\in K} x_{pjk}^2 \tilde{\bar{c}}_{pjk}^2(\omega)) + \sum_{j\in J} z_j f_j + \sum_{p\in P}\sum_{j\in J} v_{pj} x_{pij}^1 + \sum_{p\in P}\sum_{j\in J} t_{pj} y_{pj} \le F'\Big\} \ge \delta\Big\} \ge \varphi, \tag{8.11}$$

where $Pos\{\cdot\}$ denotes the possibility of the event in $\{\cdot\}$, and $Pr\{\cdot\}$ denotes the probability of the event in $\{\cdot\}$.

Remark 8.1. When the fuzzy random variable $\tilde{\bar{c}}_p$ degenerates to random variable $\bar{c}_p$, the constraint (8.11) is equivalent to Equation (8.12),

$$Pr\Big\{\sum_{p\in P}\sum_{i\in I}\sum_{j\in J} x_{pij}^1 \bar{c}_{pij}(\omega) + \sum_{p\in P}\sum_{j\in J}\sum_{k\in K} x_{pjk}^2 \bar{c}_{pjk}(\omega) + \sum_{j\in J} z_j f_j + \sum_{p\in P}\sum_{j\in J} v_{pj} x_{pij}^1 + \sum_{p\in P}\sum_{j\in J} t_{pj} y_{pj} \le F'\Big\} \ge \varphi. \tag{8.12}$$

And similarly, when the fuzzy random variable $\tilde{\bar{c}}_p$ degenerates to fuzzy variable $\tilde{c}_p$, the constraint (8.11) is equivalent to Equation (8.13),

$$Pos\Big\{\sum_{p\in P}\sum_{i\in I}\sum_{j\in J} x_{pij}^1 \tilde{c}_{pij}(\omega) + \sum_{p\in P}\sum_{j\in J}\sum_{k\in K} x_{pjk}^2 \tilde{c}_{pjk}(\omega) + \sum_{j\in J} z_j f_j + \sum_{p\in P}\sum_{j\in J} v_{pj} x_{pij}^1 + \sum_{p\in P}\sum_{j\in J} t_{pj} y_{pj} \le F'\Big\} \ge \delta. \tag{8.13}$$

For given confidence level $(\alpha_{pk}, \beta_{pk})$, constraint (8.2) can be transformed to Equation (8.14),

$$Ch\left\{\sum_{j\in J} x_{pjk}^2 \geq \tilde{\bar{d}}_{kp}\right\}(\alpha_{pk}) \geq \beta_{pk}, \tag{8.14}$$

and it also can be written as Equation (8.15),

$$Pr\left\{\omega \middle| Pos\left\{\sum_{j\in J} x_{pjk}^2 \geq \tilde{\bar{d}}_{pk}(\omega)\right\} \geq \beta_{pk}\right\} \geq (\alpha_{pk}), \tag{8.15}$$

where α_{pk} and β_{pk} are predetermined confidence levels.

Remark 8.2. When the random fuzzy variable $\tilde{\bar{d}}_{pk}$ degenerates to random variable $\bar{d}_{kp}$, the constraint (8.14) is equivalent to Eqaution (8.16),

$$Pr\left\{\sum_{j\in J} x_{pjk}^2 \geq \bar{d}_{pk}(\omega)\right\} \geq (\alpha_{pk}). \tag{8.16}$$

And similarly, when the fuzzy random variable $\tilde{\bar{d}}_{pk}$ degenerates to fuzzy variable $\tilde{d}_{kp}$, the constraint (8.15) is equivalent to Equation (8.17),

$$Pos\left\{\sum_{j\in J} x_{pjk}^2 \geq \tilde{d}_{pk}(\omega)\right\} \geq \beta_{pk}. \tag{8.17}$$

We propose the chance-constraint programming model under random fuzzy environment as follows,

$$\begin{array}{l}
\min\ F', \\
\text{s.t.} \left\{\begin{array}{l}
Ch\left\{\sum_{p\in P}\sum_{i\in I}\sum_{j\in J} x_{pij}^1 \tilde{\bar{c}}_{pij}^1 + \sum_{p\in P}\sum_{j\in J}\sum_{k\in K} x_{pjk}^2 \tilde{\bar{c}}_{pjk}^2 + \sum_{j\in J} z_j f_j \right. \\
\qquad \left. + \sum_{p\in P}\sum_{j\in J} t_{pj} y_{pj} \leq F' \right\}(\varphi) \geq \delta, \\
Ch\left\{\sum_{j\in J} x_{pjk}^2 \geq \tilde{\bar{d}}_{pk}\right\}(\alpha_{pk}) \geq \beta_{pk},\ \forall p,k, \\
\sum_{j\in J} x_{pij}^1 \leq s_{pi},\ \forall p,i, \\
y_{pj} = \sum_{i\in I} x_{pij}^1 - \sum_{k\in K} x_{pjk}^2,\ \forall p,j, \\
y_{pj} \geq 0,\ \forall p,j, \\
x_{pij}^1 = x_{pij}^1 \cdot z_j,\ \forall i,j, \\
x_{pjk}^2 = x_{pjk}^2 \cdot z_j,\ \forall j,k, \\
x_{pij}^1 \geq 0,\ \forall i,j, \\
x_{pjk}^2 \geq 0,\ \forall j,k, \\
z_j = \{0,1\},\ \forall j.
\end{array}\right.
\end{array} \tag{8.18}$$

8.3 Model Analysis

One way of solving a chance constraint programming model is to convert the constraints of problem (8.18) into their respective crisp equivalents. As we know, this process is usually a hard work and only successful for some special cases. Next, we will consider a special case and present the result in this section.

Lemma 8.1. *Let $\tilde{m}$ and $\tilde{n}$ be two independently fuzzy numbers with continuous membership functions. For given confidence level $\alpha \in [0,1]$,*

$$Pos\{\tilde{m} \geq \tilde{n}\} \geq \alpha = \sup\{\mu_{\tilde{m}}(u) \wedge \mu_{\tilde{n}}(v) | u > v\}.$$

By using the α-level sets of the fuzzy variables, the above Lemma 8.1 can also be rewritten as:

$$Pos\{\tilde{m} \geq \tilde{n}\} \geq \alpha \Leftrightarrow m_\alpha^R \geq n_\alpha^L, \tag{8.19}$$

where m_α^L, m_α^R and n_α^L, n_α^R are the left and right side extreme points of the α-level sets $[m_\alpha^L, m_\alpha^R]$ and $[n_\alpha^L, n_\alpha^R]$ of $\tilde{m}$ and $\tilde{n}$, respectively, and $Pos\{\tilde{m} \geq \tilde{n}\}$ means the degree of possibility that $\tilde{m}$ is greater than or equal to $\tilde{n}$.

Theorem 8.1. *Let $\tilde{\bar{d}}_{pk}$ be a fuzzy random variable which is characterized by the following membership function,*

$$\mu_{\tilde{\bar{d}}_{pk}(\omega)}(t) = \begin{cases} L\left(\frac{d_{pk}(\omega)-t}{a_{pk}^d}\right), & t \leq d_{pk}(\omega),\ a_{pk}^d > 0, \\ R\left(\frac{t-d_{pk}(\omega)}{b_{pk}^d}\right), & t \geq d_{pk}(\omega),\ b_{pk}^d > 0, \end{cases} \quad \omega \in \Omega, \tag{8.20}$$

where random vector $d_{pk}(\omega)$ is normally distributed with mean vector u^d and variance ${\sigma_{pk}^d}^2$, written as $d_{pk}(\omega) \sim \mathcal{N}(u_{pk}^d, {\sigma_{pk}^d}^2)$, a_{pk}^d, b_{pk}^d are positive numbers expressing the left and right spreads of $\tilde{\bar{d}}_{pk}(\omega)$, and reference functions $L, R : [0,1] \to [0,1]$ with $L(1) = R(1) = 0$ and $L(0) = R(0) = 1$ are non-increasing, continuous functions. Then, we have:

$$Pr\left\{\omega \middle| Pos\left\{\sum_{j \in J} x_{pjk}^2 \geq \tilde{\bar{d}}_{pk}(\omega)\right\} \geq \alpha_{pk}\right\} \geq \beta_{pk},$$

if and only if

$$\sum_{j \in J} x_{pjk}^2 \geq u_{pk}^d - L^{-1}(\alpha_{pk}) a_{pk}^d + \Phi^{-1}(\beta_{pk}) \sigma_{pk}^d,$$

where Φ is the standardized normal distribution and $\alpha_{pk}, \beta_{pk} \in (0,1)$ are predetermined confidence levels.

Proof. From assumption we know that $\tilde{\bar{d}}_{pk}$ is a fuzzy number with membership function $\mu_{\tilde{\bar{d}}_{pk}}(t)$ for given $\omega \in \Omega$. For convenience, we denote $\tilde{\bar{d}}_{pk}(\omega) = (d_{pk}(\omega), a_{pk}^d, b_{pk}^d)_{LR}$. By Lemma (8.1), we have that:

$$Pos\left\{\sum_{j\in J} x_{pjk}^2 \geq \tilde{\bar{d}}_{pk}(\omega)\right\} \geq \alpha_{pk} \Leftrightarrow \sum_{j\in J} x_{pjk}^2 \geq d_{pk}(\omega) - L^{-1}(\alpha_{pk})a_{pk}^d.$$

Since $d_{pk}(\omega) \sim \mathscr{N}(u_{pk}^d, {\sigma_{pk}^d}^2)$, for given confidence levels $\alpha_{pk}, \beta_{pk} \in (0,1)$, we have:

$$\begin{aligned}
&Pr\left\{\omega \middle| Pos\left\{\sum_{j\in J} x_{pjk}^2 \geq \tilde{\bar{d}}_{pk}(\omega)\right\} \geq \alpha_{pk}\right\} \geq \beta_{pk} \\
&\Leftrightarrow Pr\left\{\omega \middle| \sum_{j\in J} x_{pjk}^2 \geq d_{pk}(\omega) - L^{-1}(\alpha_{pk})a_{pk}^d\right\} \geq \beta_{pk} \\
&\Leftrightarrow Pr\left\{\omega \middle| \frac{d_{pk}(\omega) - u_{pk}^d}{\sigma_{pk}^d} \leq \frac{\sum_{j\in J} x_{pjk}^2 + L^{-1}(\alpha_{pk})a_{pk}^d - u_{pk}^d}{\sigma_{pk}^d}\right\} \geq \beta_{pk} \\
&\Leftrightarrow \Phi\left(\frac{\sum_{j\in J} x_{pjk}^2 + L^{-1}(\alpha_{pk})a_{pk}^d - u_{pk}^d}{\sigma_{pk}^d}\right) \geq \beta_{pk} \\
&\Leftrightarrow \sum_{j\in J} x_{pjk}^2 \geq u_{pk}^d - L^{-1}(\alpha_{pk})a_{pk}^d + \Phi^{-1}(\beta_{pk})\sigma_{pk}^d.
\end{aligned}$$

This completes the proof. □

Theorem 8.2. *Let $\tilde{\bar{c}}$ be a fuzzy random variable which is characterized by the following membership function,*

$$\mu_{\tilde{\bar{c}}(\omega)}(t) = \begin{cases} L\left(\frac{c(\omega)-t}{a^c}\right), \ t \leq c(\omega), a^c > 0, \\ R\left(\frac{t-c(\omega)}{b^c}\right), \ t \geq c(\omega), b^c > 0, \end{cases} \quad \omega \in \Omega, \tag{8.21}$$

where random vector $(C(\omega))$ is normally distributed with mean vector u^c and positive define covariance matrix V^c, written as $(c(\omega)) \sim \mathscr{N}(u^c, V^c)$, a^c, b^c are positive numbers expressing the left and right spreads of $\tilde{\bar{c}}(\omega)$, and reference functions $L, R : [0,1] \to [0,1]$ with $L(1) = R(1) = 0$ and $L(0) = R(0) = 1$ are non-increasing, continuous functions. Then, we have:

$$Pr\{\omega | Pos\{\tilde{\bar{c}}(\omega)^T x \leq \bar{F}\} \geq \delta\} \geq \varphi,$$

if and only if

$$\bar{F} \geq u^{cT}x - L^{-1}(\delta)a^{cT}x + \Phi^{-1}(\varphi)\sqrt{x^T V^c x},$$

where Φ is the standardized normal distribution and $\delta, \varphi \in [0,1]$ are predetermined confidence levels.

Proof. From assumption we know that $\tilde{\bar{c}}$ is a fuzzy number with membership function $\mu_{\tilde{\bar{c}}}(t)$ for given $\omega \in \Omega$. It follows from extension principle [12] that fuzzy number $\tilde{\bar{c}}^T x$ is characterized by the following membership function

$$\mu_{\tilde{\bar{c}}(\omega)^T x}(r) = \begin{cases} L\left(\frac{c(\omega)^T x - r}{a^{cT} x}\right), & r \leq c(\omega)^T x, \\ R\left(\frac{r - c(\omega)^T x}{b^{cT} x}\right), & r \geq c(\omega)^T x. \end{cases} \tag{8.22}$$

For convenience, we denote $\tilde{\bar{c}}(\omega) = (c(\omega), a^c, b^c)_{LR}$ and $\tilde{\bar{c}}(\omega)^T x = (c(\omega)^T x, a^{cT} x, b^{cT} x)_{LR}$ respectively. By Equation (8.1), we have:

$$Pos\{\tilde{\bar{c}}(\omega)^T \leq \bar{F}\} \leq \delta \Leftrightarrow c(\omega)^T x - L^{-1}(\delta) a^{cT} x \leq \bar{F}.$$

Since $c(\omega) \sim \mathcal{N}(u^c, V^c)$, it follows that $c(\omega)^T x \sim \mathcal{N}(u^{cT} x, x^T V^c x)$. So, for given confidence levels $\delta, \varphi \in (0,1)$, we have:

$$\begin{aligned}
& Pr\{\omega | Pos\{c(\omega)^T x \geq \bar{F}\} \geq \delta\} \geq \varphi \\
& \Leftrightarrow Pr\{\omega | c(\omega)^T x \leq \bar{F} + L^{-1}(\delta) a^{cT} x\} \geq \varphi \\
& \Leftrightarrow Pr\left\{\omega \left| \frac{c(\omega)^T x - u^{cT} x}{\sqrt{x^T V^c C x}} \leq \frac{\bar{F} + L^{-1}(\delta) a^{cT} x - u^{cT} x}{\sqrt{x^T V^c x}} \right.\right\} \geq \varphi \\
& \Leftrightarrow \Phi\left(\frac{\bar{F} + L^{-1}(\delta) a^{cT} x - u^{cT} x}{\sqrt{x^T V^c x}}\right) \geq \varphi \\
& \Leftrightarrow \bar{F} \geq u^{cT} x - L^{-1}(\delta) a^{cT} x + \Phi^{-1}(\varphi) \sqrt{x^T V^c x}.
\end{aligned}$$

This completes the proof. □

8.4 Numerical Example

Suppose there is a 3PLs company, the first important decision for this company is to design the logistics network, which including choose the logistics centers, limited by the capital, only $n = 2$ logistics centers could be established. This 3Pls company will be in charge of the transportation from two client plants to six customers via two logistic centers.

Table 8.1 Parameters about logistics center

Logistics center	Fixed cost(f_j) (RMB)	Unit inventory cost(t_j) (RMB)
1	1800	5
2	2200	6
3	1900	5
4	2000	6

Here we just consider one type of product, that is $P = 1$. So we can apply Model (8.18) to this numerical problem, and obtain the following specific Model (8.23).

$$
\begin{array}{l}
\min F', \\
\text{s.t.} \left\{
\begin{array}{l}
Pr\left\{ \omega | Pos\left\{ \sum_{i=1}^{2} \sum_{j=1}^{4} x_{ij}^{1} \tilde{\bar{c}}_{ij}^{1} + \sum_{j=1}^{4} \sum_{j=1}^{6} x_{jk}^{2} \tilde{\bar{c}}_{jk}^{2} \leq F' - \sum_{j=1}^{4} z_j f_j - \sum_{j=1}^{4} t_j y_j \right\} \geq \delta \right\} \geq \varphi, \\
Pr\left\{ \omega | Pos\left\{ \sum_{j=1}^{4} x_{jk}^{2} \geq \tilde{\bar{d}}_k \right\} \geq \alpha_k \right\} \geq \beta_k,\ k = 1, \cdots, 6, \\
\sum_{j=1}^{4} x_{ij}^{1} \leq s_i,\ i = 1, 2, \\
\sum_{j=1}^{4} z_j \leq 2,\ j = 1, \cdots, 4, \\
y_j = \sum_{i=1}^{2} x_{ij}^{1} - \sum_{k=1}^{6} x_{jk}^{2},\ j = 1, \cdots, 4, \\
y_j \geq 0, j = 1, \cdots, 4, \\
x_{ij}^{1} = x_{ij}^{1} z_j,\ i = 1, 2, j = 1, \cdots, 4, \\
x_{jk}^{2} = x_{jk}^{2} z_j,\ j = 1, \cdots, 4,\ k = 1, \cdots, 6, \\
x_{ij}^{1} \geq 0,\ i = 1, 2,\ j = 1, \cdots, 4, \\
x_{jk}^{2} \geq 0,\ j = 1, \cdots, 4,\ k = 1, \cdots, 6, \\
z_j = \{0, 1\},\ j = 1, \cdots, 4.
\end{array}
\right.
\end{array}
\tag{8.23}
$$

It's known that there are two client plants which produce one kind of product. Client plant 1 will produce 1800 products, and client plant 1 will produce 1500 products. After doing some surveys, there are 4 potential logistics centers. Some important data are in Table 8.1. The standard unit transportation costs of this product from client plants to logistic centers and from the logistic centers to customers are shown in Tables 8.2 and 8.3. Table 8.4 reveals the demand of each customers.

Table 8.2 Transportation cost from client plants to logistic centers

$\tilde{\bar{c}}_{11}^{1} = [c_{11}^{1}, 0.5, 0.5]_{LR}$ with $c_{11}^{1} \sim N(5, 0.5)$	$\tilde{\bar{c}}_{12}^{1} = [c_{12}^{1}, 0.5, 0.5]_{LR}$ with $c_{12}^{1} \sim N(6, 0.5)$
$\tilde{\bar{c}}_{13}^{1} = [c_{13}^{1}, 0.3, 0.3]_{LR}$ with $c_{13}^{1} \sim N(3, 0.2)$	$\tilde{\bar{c}}_{14}^{1} = [c_{14}^{1}, 0.5, 0.4]_{LR}$ with $c_{12}^{1} \sim N(5, 0.5)$
$\tilde{\bar{c}}_{21}^{1} = [c_{21}^{1}, 0.5, 0.5]_{LR}$ with $c_{21}^{1} \sim N(4, 0.4)$	$\tilde{\bar{c}}_{22}^{1} = [c_{22}^{1}, 0.5, 0.5]_{LR}$ with $c_{22}^{1} \sim N(4, 0.5)$
$\tilde{\bar{c}}_{13}^{1} = [c_{23}^{1}, 0.4, 0.4]_{LR}$ with $c_{23}^{1} \sim N(5, 0.2)$	$\tilde{\bar{c}}_{24}^{1} = [c_{24}^{1}, 0.5, 0.5]_{LR}$ with $c_{22}^{1} \sim N(3, 0.3)$

Because the fuzzy random variables in this model are normally distributed, so we can use Theorems 8.1 and 8.2 which in Sect. 8.3 to transform the above model (8.23) to an equivalent crisp model (8.24) as follows, here we suppose $\delta = \varphi = \alpha_k = \beta_k = 0.9$.

$$
\begin{array}{ll}
\min & F', \\
\text{s. t.} & \left\{
\begin{array}{l}
F' - [1800z_1 + 2200z_2 + 1900z_3 + 2000z_4 + 5y_1 + 6y_2 + 5y_3 + 6y_4] \\
\qquad \geq 5x_{11}^1 + \cdots + 3x_{24}^1 + 7x_{11}^2 + \cdots + 12x_{46}^2 - L^{-1}(0.9) \\
\qquad (0.5x_{11}^1 + \cdots + 0.5x_{24}^1 + x_{11}^2 + \cdots + 2x_{46}^2) \\
\qquad + \Phi(0.9)\sqrt{0.5{x_{11}^1}^2 + \cdots + 0.3{x_{24}^1}^2 + 0.5{x_{11}^2}^2 + \cdots + 2{x_{46}^2}^2}, \\
\sum_{j=1}^{4} x_{j1} \geq 800 - 5L^{-1}(0.9) + \sqrt{16}\Phi^{-1}(0.9), \\
\vdots \\
\sum_{j=1}^{4} x_{j6} \geq 400 - 10L^{-1}(0.9) + \sqrt{9}\Phi^{-1}(0.9), \\
x_{11}^1 + x_{12}^1 + x_{13}^1 + x_{14}^1 + x_{15}^1 + x_{16}^1 \leq 1800, \\
x_{21}^1 + x_{22}^1 + x_{23}^1 + x_{24}^1 + x_{25}^1 + x_{26}^1 \leq 1500, \\
\sum_{j=1}^{4} z_j \leq 2, \\
y_1 = x_{11}^1 + x_{21}^1 - (x_{11}^2 + x_{12}^2 + x_{13}^2 + x_{14}^2 + x_{15}^2 + x_{16}^2), \\
\vdots \\
y_4 = x_{14}^1 + x_{24}^1 - (x_{41}^2 + x_{42}^2 + x_{43}^2 + x_{44}^2 + x_{45}^2 + x_{46}^2), \\
x_{ij}^1 = x_{ij}^1 \cdot z_j \ i = 1,2; j = 1,\cdots,4, \\
x_{jk}^2 = x_{jk}^2 \cdot z_j \ j = 1,\cdots,4; k = 1,\cdots,6, \\
x_{ij}^1 \geq 0 \ i = 1,2; j = 1,\cdots,4, \\
x_{jk}^2 \geq 0 \ j = 1,\cdots,4; k = 1,\cdots,6, \\
z_j = \{0,1\} \ j = 1,\cdots,4.
\end{array}
\right.
\end{array}
\tag{8.24}
$$

Table 8.3 Transportation cost from logistic centers to customers

$\tilde{\tilde{c}}_{11}^2 = [c_{11}^2, 1, 1]_{LR}$ with $c_{11}^2 \sim N(7, 0.5)$	$\tilde{\tilde{c}}_{12}^2 = [c_{12}^1, 1, 1]_{LR}$ with $c_{12}^2 \sim N(6, 0.5)$
$\tilde{\tilde{c}}_{13}^2 = [c_{13}^1, 1, 1]_{LR}$ with $c_{13}^2 \sim N(8, 1)$	$\tilde{\tilde{c}}_{14}^2 = [c_{14}^1, 1, 1]_{LR}$ with $c_{14}^2 \sim N(9, 0.5)$
$\tilde{\tilde{c}}_{15}^2 = [c_{15}^2, 1, 1]_{LR}$ with $c_{15}^2 \sim N(5, 0.2)$	$\tilde{\tilde{c}}_{16}^2 = [c_{16}^1, 1, 2]_{LR}$ with $c_{16}^2 \sim N(6, 1)$
$\tilde{\tilde{c}}_{21}^2 = [c_{21}^2, 2, 1]_{LR}$ with $c_{21}^2 \sim N(14, 1)$	$\tilde{\tilde{c}}_{22}^2 = [c_{22}^1, 1, 1]_{LR}$ with $c_{22}^2 \sim N(9, 0.5)$
$\tilde{\tilde{c}}_{23}^2 = [c_{23}^1, 1, 1]_{LR}$ with $c_{23}^2 \sim N(13, 1)$	$\tilde{\tilde{c}}_{24}^2 = [c_{24}^1, 2, 2]_{LR}$ with $c_{24}^2 \sim N(14, 2)$
$\tilde{\tilde{c}}_{25}^2 = [c_{25}^2, 1, 2]_{LR}$ with $c_{25}^2 \sim N(12, 2)$	$\tilde{\tilde{c}}_{26}^2 = [c_{26}^1, 2, 1]_{LR}$ with $c_{26}^2 \sim N(13, 2)$
$\tilde{\tilde{c}}_{31}^2 = [c_{31}^2, 1, 1]_{LR}$ with $c_{31}^2 \sim N(1, 0.8)$	$\tilde{\tilde{c}}_{32}^2 = [c_{32}^1, 0.6, 0.6]_{LR}$ with $c_{32}^2 \sim N(7, 0.5)$
$\tilde{\tilde{c}}_{33}^2 = [c_{33}^1, 1, 1]_{LR}$ with $c_{33}^2 \sim N(9, 1)$	$\tilde{\tilde{c}}_{34}^2 = [c_{34}^1, 0.6, 0.6]_{LR}$ with $c_{34}^2 \sim N(7, 0.5)$
$\tilde{\tilde{c}}_{35}^2 = [c_{35}^2, 0.6, 0.8]_{LR}$ with $c_{35}^2 \sim N(8, 1)$	$\tilde{\tilde{c}}_{36}^2 = [c_{36}^1, 2, 2]_{LR}$ with $c_{36}^2 \sim N(10, 2)$
$\tilde{\tilde{c}}_{41}^2 = [c_{41}^2, 1, 1]_{LR}$ with $c_{41}^2 \sim N(10, 2)$	$\tilde{\tilde{c}}_{42}^2 = [c_{42}^1, 2, 3]_{LR}$ with $c_{42}^2 \sim N(15, 3)$
$\tilde{\tilde{c}}_{43}^2 = [c_{43}^1, 1, 2]_{LR}$ with $c_{43}^2 \sim N(13, 2)$	$\tilde{\tilde{c}}_{44}^2 = [c_{44}^1, 1, 1]_{LR}$ with $c_{44}^2 \sim N(10, 1)$
$\tilde{\tilde{c}}_{45}^2 = [c_{45}^2, 1, 2]_{LR}$ with $c_{45}^2 \sim N(13, 2)$	$\tilde{\tilde{c}}_{46}^2 = [c_{46}^1, 2, 1]_{LR}$ with $c_{46}^2 \sim N(12, 2)$

Note that the crisp model (8.24) is transformed from (8.23), and Model (8.24) is a crisp mixed integer programming model and it can be solved by some existing methods. Here we employ the software Lingo 9.0 to solve it, and we can obtain

Table 8.4 Demand of customer

$\tilde{\bar{d}}_1 = [\rho_1, 5, 5]_{LR}$ with $\rho_1 \sim N(800, 16)$	$\tilde{\bar{d}}_2 = [\rho_2, 4, 4]_{LR}$ with $\rho_2 \sim N(500, 25)$
$\tilde{\bar{d}}_3 = [\rho_3, 5, 5]_{LR}$ with $\rho_3 \sim N(700, 9)$	$\tilde{\bar{d}}_4 = [\rho_4, 4, 4]_{LR}$ with $\rho_2 \sim N(500, 25)$
$\tilde{\bar{d}}_5 = [\rho_5, 5, 5]_{LR}$ with $\rho_5 \sim N(600, 30)$	$\tilde{\bar{d}}_6 = [\rho_6, 10, 10]_{LR}$ with $\rho_2 \sim N(400, 9)$

the following results: this 3Pls company will choose the first and the third place to establish the logistics centers, and the cost for one period will be 38700RMB, and the transportation scheme is shown in Fig. 8.2.

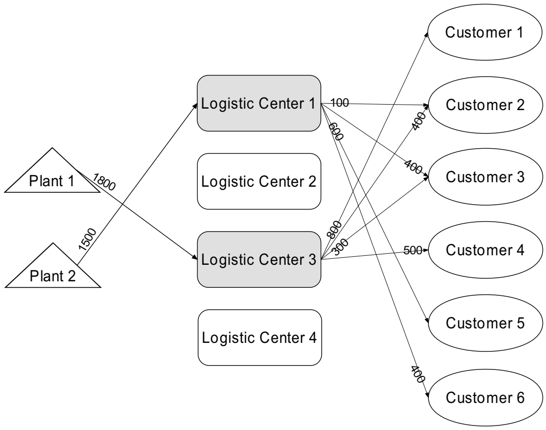

Fig. 8.2 The result of the transportation scheme

8.5 Conclusion

In this paper, for the first time, we have formulated a fuzzy random model about 3PLs network design problems in fuzzy random environments. Till now, no 3PLs network design model has been formulated in such environments. Besides, we creatively introduced the economic factors of scale which were important factors in real-life transportation problem into the proposed model, and make the model more effective. We transform the fuzzy random model into a chance-constraint model which utilize the chance operator of the fuzzy random variables, and for a special type of fuzzy random variables, a crisp equivalent model is proposed for the chance constraint programming model. At the end of this paper, we use an example problem to show the efficiency of the model.

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Chapter 9
The Optimization of the Bandpass Lengths in the Multi-Bandpass Problem

Mehmet Kurt, Hakan Kutucu, Arif Gürsoy and Urfat Nuriyev

Abstract The Bandpass problem has applications to provide a cost reduction in design and operating telecommunication network. Given a binary matrix $A_{m\times n}$ and a positive integer B called the Bandpass length, a set of B consecutive non-zero elements in any column is called a Bandpass. No two bandpasses in the same column can have common rows. The general Bandpass Problem consists of finding an optimal permutation of rows of the matrix A that produces the maximum total number of bandpasses having the same given bandpass length B in all columns. The Multi-Bandpass problem includes different bandpass lengths B_j in each column j of the matrix A, where $j = 1, 2, \cdots, n$. In this paper, we propose an extended formulation for the Multi-Bandpass problem. A given B_j may not be always efficient bandpass lengths for the communication network. Therefore, it is important to find an optimal values of the bandpass lengths in the Multi-Bandpass problem. In this approach, the lengths in each destination are defined as z_j and we present a model to find the optimal values of z_j. Then, we calculate the approximate solution of this model using genetic algorithm for the problem instances which are presented in an online library.

Keywords Combinatorial optimization · Bandpass problem · Telecommunication · Genetic algorithm

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9.1 Introduction

Since the beginning of the 21st century, usage of the internet, digital tv broadcasts and GSM networks have been dramatically increasing. Rapid growth in the number of users leads to the need for more effective communication techniques. Manufacturers research and develop to overcome these kinds of problems. Recent studies focus on data transmission speed and capacity increase in reasonable costs.

The Bandpass problem and the Multi-Bandpass problem (MBP) are problems which are aimed to reduce the costs of communication [2].

This work is organized as follows. In Sect. 9.2, we give the definition and a brief history of the bandpass problem. In Sect. 9.3, we present the mathematical model of the problem with a constant bandpass length B. In Sect. 9.4, we introduce another mathematical model for optimizing bandpass length B which is a decision variable in the model. In Sect. 9.5, we extend the bandpass problem to the MBP and give a mathematical model of it. In Sect. 9.6, we propose a new model consists of finding the optimal bandpass lengths. In Sect. 9.7, we improve genetic algorithms and present our experimental results. In Sect. 9.8, we give some concluding remarks.

9.2 The Bandpass Problem

Today, wavelengths multiplexing technology for fiber optic cables is a major milestone to increase transmission capacity and speed. This technology is called dense wavelength division multiplexing (DWDM) and provides a platform to exploit the huge capacity of optical fiber. DWDM increases the number of communication channels within a fiber-optic cable, thereby letting service providers obtain much more bandwidth without installing a new cable. The 101 Tb/s transmission, based on the wavelength division multiplexing (WDM) of 370 wavelengths each having a speed of 273 Gb/s, is the highest ever reported in the optical transmission field by NEC in 2011 [12].

An add-drop multiplexer (ADM) is one of the most important elements in a fiber optic network. An ADM is a device that can add, block, pass or redirect various wavelengths in a fiber optic network. Each ADM facilitates flows on some wavelengths to exit the cable according to their paths. In each ADM, special cards control each wavelength; they may either pass through the ADM or may be dropped at their destination. An ADM can be programmed to drop consecutive wavelengths by one special card. Thus, n consecutive wavelengths in the fiber optic cable can be dropped in a station using only one card instead of n cards.

Not only developing new technologies are important, but reducing the cost of these systems is crucial to ensure widespread use of them.

There are several wavelengths which are used by a source vertex to carry data to destinations in a communication network. In addition, some of these wavelengths are dropped at the intermediate stations. If the wavelengths are not ordered properly, we might encounter an inefficient network in terms of cost.

The bandpass problem is an optimization problem that finds an optimal permutation of wavelengths, and thus it provides an opportunity to reduce the number of cards to be used in the optical communication networks. This problem is first proposed by Babayev and Bell in 2004. Then it is proved to be NP-hard. In [3, 9, 10], Integer programming models of the bandpass problem are developed and some heuristic polynomial algorithms are presented. A library of the bandpass problem which includes the optimum and the best known solutions of 90 instances is published [1]. The MBP that includes several bandpass lengths is modeled and some approximation algorithms are given [6, 7]. In [4, 5], several genetic algorithms, in which initial population is generated randomly or using heuristic algorithms are improved for different models of the bandpass problem.

9.3 The Mathematical Model of the Bandpass Problem

Let A be a binary matrix of size $m \times n$ that represents the flow of data from the source to n destinations using m wavelengths. Such a matrix is shown in Table 9.1. The matrix is defined as follows:

$$A = [a_{ik}], a_{ik} = \begin{cases} 1, & \text{data in } \lambda_i \text{ is transmitted to destination } k\text{ ,} \\ 0, & \text{otherwise,} \end{cases}$$

where $i = 1, 2, \cdots, m$, $k = 1, 2, \cdots, n$.

We mentioned in the previous section that an ADM can drop consecutive wavelengths using one special card. Consecutive wavelengths form a bandpass. The number of wavelengths in a bandpass is called bandpass length (B). Every non-zero entry of the network flow matrix can be included in only one bandpass. This is because of that a wavelength can not be dropped in a station by two cards.

Table 9.1 Network flow matrix

	1^{st} station	2^{nd} station	$\cdots$	n^{th} station
λ_1	1/0	1/0	$\cdots$	1/0
λ_2	1/0	1/0	$\cdots$	1/0
$\cdots$	$\cdots$	$\cdots$	$\cdots$	$\cdots$
λ_m	1/0	1/0	$\cdots$	1/0

In order to minimize the number of cards used in the communication network, we should maximize the number of bandpasses. Before giving the model of the problem, let us define the decision variables as follows:

$$x_{ik}, y_{kj} \in 0, 1,\ i = 1, 2, \cdots, m,\ j = 1, 2, \cdots, n,\ k = 1, 2, \cdots, m,$$

$$x_{ik} = \begin{cases} 1, & \text{if row } i \text{ is relocated to position } k\text{ ,} \\ 0, & \text{otherwise,} \end{cases}$$

$$y_{kj} = \begin{cases} 1, & \text{if row } k \text{ is the first row of a bandpass in column } j, \\ 0, & \text{otherwise.} \end{cases}$$

The Bandpass problem can be modeled mathematically as follows:

$$\max \sum_{j=1}^{n} \sum_{k=1}^{M-B+1} y_{kj},$$

$$\text{s.t.} \begin{cases} \sum\limits_{k=1}^{m} x_{ik} = 1, \ \sum\limits_{i=1}^{m} x_{ik} = 1, \ i = 1,\cdots,m, \ k = 1,\cdots,m, \\ \sum\limits_{i=k}^{k+B-1} y_{ij} \le 1, \ j = 1,\cdots,n, \ k = 1,\cdots,m-B+1, \\ B \cdot y_{kj} \le \sum\limits_{i=k}^{M-B+1} \sum\limits_{r=1}^{m} a_{rj} x_{ri}, \ j = 1,2,\cdots,n, \ 1 \le k \le M-B+1. \end{cases}$$

In this model, there are $2m + 2n(m-B+1)$ constraints [11].

9.4 The Mathematical Model to Optimize Bandpass Length in the Bandpass Problem

In Sect. 9.3, B (bandpass length) is fixed and given as an input in the model of the Bandpass problem, but this constant length may not be so efficient for the communication network. Therefore, it is considered another model called "the mathematical model to optimize bandpass length in the bandpass problem" [8]. In this model, bandpass length is defined as a decision variable z and its optimal value is determined. We first introduce the variables for this model.

$$x_{ik}, y_{kj} \in 0,1, \ i = 1,2,\cdots,m, \ j = 1,2,\cdots,n, \ k = 1,2,\cdots,m, \ z > 1, z \in Z,$$

$$x_{ik} = \begin{cases} 1, & \text{if row } i \text{ is relocated to position } k, \\ 0, & \text{otherwise,} \end{cases}$$

$$y_{kj} = \begin{cases} 1, & \text{if row } k \text{ is the first row of a bandpass in column } j, \\ 0, & \text{otherwise.} \end{cases}$$

The mathematical model to optimize bandpass length in the bandpass problem as follows:

$$\max \ z \cdot \sum_{j=1}^{n} \sum_{k=1}^{M-z+1} y_{kj},$$

$$\text{s.t.}\begin{cases}\sum\limits_{k=1}^{m} x_{ik}=1,\ \sum\limits_{i=1}^{m} x_{ik}=1,\ i=1,2,\cdots,m,\ k=1,2,\cdots,m,\\ \sum\limits_{i=k}^{k+z-1} y_{ij}\le 1,\ j=1,2,\cdots,n,\ k=1,2,\cdots,m-z+1,\\ z\cdot y_{kj}\le \sum\limits_{i=k}^{k+z-1}\sum\limits_{r=1}^{m} a_{rj}x_{ri},\ j=1,2,\cdots,n,\ 1\le k\le m-z+1.\end{cases}$$

9.5 The Mathematical Model of the Multi-Bandpass Problem

In the models given in Sect. 9.3 and Sect. 9.4, there is only one bandpass length for all destinations in the network. But ADMs which are placed in each destinations or stations may be programmed for different bandpass lengths. In this model, we define a bandpass length B_i for each destination point i. we first introduce some notation for this model.

$$x_{ik},y_{kj}\in 0,1,\ i=1,2,\cdots,m,\ j=1,2,\cdots,n,\ k=1,2,\cdots,m,$$

B_j is the bandpass length for column j,

$$x_{ik}=\begin{cases}1, & \text{if row } i \text{ is relocated to position } k,\\ 0, & \text{otherwise,}\end{cases}$$

$$y_{kj}=\begin{cases}1, & \text{if row } k \text{ is the first row of a bandpass in column } j,\\ 0, & \text{otherwise.}\end{cases}$$

The mathematical model of the Multi-bandpass problem is as follows:

$$\max \sum_{j=1}^{n}\sum_{k=1}^{m-B_j+1} y_{kj},$$

$$\text{s.t.}\begin{cases}\sum\limits_{k=1}^{m} x_{ik}=1,\ i=1,2,\cdots,m,\\ \sum\limits_{i=1}^{m} x_{ik}=1,\ k=1,\cdots,m,\\ \sum\limits_{i=k}^{k+B_j-1} y_{ij}\le 1,\ j=1,2,\cdots,n,\ k=1,2,\cdots,m-B_j+1,\\ B_j\cdot y_{kj}\le \sum\limits_{i=k}^{M-B_j+1}\sum\limits_{r=1}^{m} a_{rj}x_{ri},\ j=1,2,\cdots,n,\ 1\le k\le M-B_j+1.\end{cases}$$

9.6 A New Mathematical Model to Optimize Bandpass Lengths in the Multi-Bandpass Problem

In the previous model given in Sect. 9.5, bandpass lengths B_i are fixed and given as inputs. But this constant lengths may not be so efficient for the communication network. Therefore, we propose another model the so called the mathematical model to optimize bandpass lengths in the Multi-bandpass problem. We define the bandpass lengths in each destination (or station) by a decision variable z_i and we focus on to create a model finding their optimal values.

9.6.1 Determination the Objective Function

Let $A_{m\times n}$ be a given binary matrix defined as follows, where $i = 1,2,\cdots,m$ and $k = 1,2,\cdots,n$.

$$A = [a_{ik}], a_{ik} = \begin{cases} 1, & \text{data in } \lambda_i \text{ is transmitted to destination } k, \\ 0, & \text{otherwise.} \end{cases}$$

Let m_j be a sum of ones in column j such that:

$$m_j = \sum_{i=1}^{m} a_{ij},\ j = 1,2,\cdots,n.$$

Bandpass length z_j in a column j must be chosen so that the sum of the total number of possible bandpasses and the total number of $1's$ which are not included in a bandpass is the minimum in the matrix. Then, we can write the objective function as follows:

$$\begin{aligned}
\min F &= \sum_{j=1}^{n} \sum_{i=1}^{m-z_j+1} y_{ij} + \sum_{j=1}^{n} \left(m_j - \sum_{i=1}^{m-z_j+1} z_j y_{ij} \right) \\
&= \sum_{j=1}^{n} m_j + \sum_{j=1}^{n} \left(\sum_{i=1}^{m-z_j+1} y_{ij} - \sum_{i=1}^{m-z_j+1} z_j y_{ij} \right) \\
&= M + \sum_{j=1}^{n} \sum_{i=1}^{m-z_j+1} (y_{ij} - z_j y_{ij}) = M + \sum_{j=1}^{n} \sum_{i=1}^{m-z_j+1} (1 - z_j) y_{ij} \\
&= M + \sum_{j=1}^{n} (1 - z_j) \sum_{i=1}^{m-z_j+1} y_{ij} = M - \sum_{j=1}^{n} (z_j - 1) \sum_{i=1}^{m-z_j+1} y_{ij},
\end{aligned}$$

z_j is a decision variable for an optimal bandpass length in column j, $\sum_{j=1}^{n} \sum_{i=1}^{m-z_j+1} y_{ij}$ is the number of total bandpasses in the matrix, $\sum_{j=1}^{n}(m_j - \sum_{i=1}^{m-z_j+1} z_j y_{ij})$ is the number of all remaining $1's$ which are not included in a bandpass in the matrix. We can easily see if $z_j = 1$ for all $j = 1,\cdots,n$ then $\min F = M$. Therefore, we suppose that $z_j > 1$ for all $j = 1,2,\cdots,n$. As it can be seen in the last form of the objective function F, M is a constant value. Hence, if we want to find the minimum value of the function F, we need to calculate the maximum value of the function $F' = \sum_{j=1}^{n}(z_j - 1)\sum_{i=1}^{m-z_j+1} y_{ij}$. Then, we can find the value of the function F in the following formula: $F = M - F'$.

9.6.2 Boolean Integer Programming Model

Now, we propose the mathematical model to optimize bandpass lengths in the Multi-bandpass problem. We first introduce the variables for this model.

$$x_{ik}, y_{kj} \in 0,1,\ i=1,2,\cdots,m,\ j=1,2,\cdots,n,\ k=1,2,\cdots,m,$$

$$z_j \in Z \text{ is the bandpass length for column } j,\ \text{where } z_j > 1,$$

$$x_{ik} = \begin{cases} 1, & \text{if row } i \text{ is relocated to position } k\,, \\ 0, & \text{otherwise,} \end{cases}$$

$$y_{kj} = \begin{cases} 1, & \text{if row } k \text{ is the first row of a bandpass in column } j\,, \\ 0, & \text{otherwise.} \end{cases}$$

Boolean integer programming model is as follows:

$$\max \sum_{j=1}^{n} (z_j - 1) \sum_{i=1}^{m-z_j+1} y_{ij},$$

$$\text{s.t.} \begin{cases} \sum\limits_{k=1}^{m} x_{ik} = 1, \sum\limits_{i=1}^{m} x_{ik} = 1,\ i=1,2,\cdots,m,\ k=1,2,\cdots,m, \\ \sum\limits_{i=k}^{k+z_j-1} y_{ij} \le 1,\ j=1,2,\cdots,n,\ k=1,2,\cdots,m-z_j+1, \\ z_j \cdot y_{kj} \le \sum\limits_{i=k}^{k+z_j-1} \sum\limits_{r=1}^{m} a_{rj} x_{ri},\ j=1,2,\cdots,n,\ 1 \le k \le m-z_j+1. \end{cases}$$

9.7 Genetic Algorithm and Computational Tests

The solution of the MBP is a permutation of the input matrix of size mxn and it is easy to adapt for using genetic algorithms. Therefore, we improve a genetic algorithm (GA) having three crossover and four mutation operators to solve the MBP. In the GA, chromosomes of initial set of population are created randomly and then the best bandpass lengths in each column are determined for each chromosome. Then, the chromosomes are sorted in increasing order by the fitting values which mean the value of objective function of the mathematical model. In the beginning of the GA, initial population size (*ps*), crossover rate (*cr*), mutation rate (*mr*), crossover number (*cn*) and mutation number (*mn*) are determined as below:

m : the number of rows in the matrix;

n : the number of columns in the matrix;

d : the density of the matrix;

$ps = (n \cdot m)/2$;

$cr = 0.9$;

$mr = 1 - cr$;

$cn = cr \cdot ps$;
$mn = mr \cdot ps$.

Two main crossover methods named as C1 and C2 have been used. The first crossover method C1 selects two parents using roulette wheel selection. This operation is repeated cn times in the population set and the new solutions (offsprings) are formed. C2 crosses the best cn parents with randomly selected parents and then the new offsprings are formed. The last crossover operator C3 uses previous crossovers sequentially.

The mutation operators M1 and M2 use 2-opt and they are differ from each other by selection. The third mutation operator M3 uses 3-opt method. In this method, a chromosome is chosen using roulette wheel selection and 5 new chromosomes are obtained by permuting of these 3 genes. The chromosome which has the maximum fitness value continues to live. The last mutation operator M4 is an exchange of a determined random row length.

Table 9.2 Computational experiments of the library problems

Problem	m	n	Min-cost	# of bpasses	Problem	m	n	Min-cost	# of bpasses
MBP-P1	64	8	107	71	MBP-P24	96	16	243	149
MBP-P2	64	8	61	39	MBP-P25	96	16	205	115
MBP-P3	64	8	96	62	MBP-P26	96	16	184	108
MBP-P4	64	8	60	27	MBP-P27	96	25	499	262
MBP-P5	64	8	69	40	MBP-P28	96	25	405	221
MBP-P6	64	8	40	24	MBP-P29	96	25	319	183
MBP-P7	64	12	159	104	MBP-P30	96	25	352	204
MBP-P8	64	12	151	88	MBP-P31	64	8	37	25
MBP-P9	64	12	129	71	MBP-P32	64	12	46	28
MBP-P10	64	12	97	58	MBP-P33	64	16	159	96
MBP-P11	64	12	115	60	MBP-P34	64	25	225	127
MBP-P12	64	12	100	70	MBP-P35	64	25	176	84
MBP-P13	64	16	240	146	MBP-P36	64	25	169	87
MBP-P14	64	16	196	132	MBP-P37	96	8	70	47
MBP-P15	64	16	199	121	MBP-P38	96	25	276	158
MBP-P16	64	16	145	90	MBP-P39	96	8	106	61
MBP-P17	64	16	152	80	MBP-P40	96	8	78	48
MBP-P18	64	16	168	75	MBP-P41	96	16	149	72
MBP-P19	96	8	128	63	MBP-P42	96	16	208	129
MBP-P20	96	8	104	59	MBP-P43	96	16	263	154
MBP-P21	96	8	106	64	MBP-P44	96	25	294	168
MBP-P22	96	8	96	68	MBP-P45	96	25	260	148
MBP-P23	96	16	299	176					

Using above 3 crossover and 4 mutation operators, 12 GA implementations have been created and these GA implementations have been tested on MBP problem instances which are published on http://fen.ege.edu.tr/ arifgursoy/mbpopt/ and the best solutions of the GA implementations are listed in Table 9.2. In this table, there are 45 instances having different number of rows and columns. Further details about the problems can be found at the web page.

9.8 Conclusion

In this paper, a new extended mathematical model are presented for optimization of the Multi-Bandpass problem. 12 genetic algorithm implementations are created using combinations of 2 crossover operators and 4 mutation operators, and an on-line problem library is created including 45 problem instances in the Web page http://fen.ege.edu.tr/ arifgursoy/mbpopt/. These problems are tested using the genetic algorithm implementations and the results are presented.

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Chapter 10
The Evolutionary Path and Process of Mutual Trust Among Members of Knowledge Networks

Tao Wang, Chenglin Tang and Xin Gu

Abstract According to its establishment and evolution process, this paper divided mutual trust among members of knowledge networks into 4 parts: tentative trust-maintenance trust, continuity trust and swift trust. On this basis, we analyzed the evolutionary path of mutual trust from three aspects: category, degree and range. Then, the evolutionary process of mutual trust was divided into four stages. At last, combined with two angles of process and overall view, a model was built to illustrate the evolutionary process of mutual trust among members of knowledge networks.

Keywords Knowledge networks · Mutual trust · Evolutionary path · Evolutionary process

10.1 Introduction

Mutual trust is the security mechanism and governance mechanism for an effectively running knowledge network. Magent [1] holds that the level of trust changes with the development of the Union. With the interactive activities carried out in the knowledge network, the mutual trust relationship among the members of the network will also produce a corresponding change.

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10.2 Category of Mutual Trust among Organizations in Knowledge Network

In addition to expected reliability to each other, trust should also include factors for the sake of each other [2]. Mutual trust means “the confidence on the other side” and “wishes for committing vulnerability”. Mutual trust between the knowledge network organizations means that all parties do not take the confidence of opportunistic behavior in the face of future uncertainty of the other parties, which is a commitment to each other and trust to each other.

Barney and Hansen in 1994, divided trust into low trust, moderate trust and a high degree of trust according to the level of trust [3]. Looking at the existing empirical research on trust we can arrive: in the course of development of exchange relationships, the relationship of trust changes as the extent of familiarity between the two sides changes. Trust relationship was established mainly based on system at the beginning [4], computational trust [5] or cognitive trust [6]; as the understanding deepened, it gradually developed to a higher degree of understanding of trust [5], emotional trust [6] or recognition-type trust [5]. In knowledge network, the relationship of mutual trust between organizations changes with the progress of intellectual activity, passed through the network reputation and continuation mechanism. In order to analyze and interpret the evolution of mutual trust, we regard the process of intellectual activity in the Network as the time dimension, starting from the relationship of trust establishment and evolution of the process, according to the stage and characteristics, divide the mutual trust between the knowledge network members into tentative trust, maintenance trust, continuity trust and swift trust.

Tentative trust occurred in the early days for the first time cooperation, which need external constraint mechanism to promote cooperation with parties taking tentative cooperative attitude; the maintenance trust holds a higher degree of trust compared with tentative trust, with the cooperation and understanding deepening, cooperation parties are easier to reach a consensus, and the behavior can be more easily be predicted; continuity trust is the cooperation of the coda or the end of the trust relationship, in a successful cooperation the continuity trust enjoys the highest level of trust, the relevant information evaluated by all parties is stored in corresponding credit assessment system, passing through the reputation mechanism or re-cooperation to inherit the trust relationship.The continuation trust includes the continuation of time and space: time continuation of the trust relationship established in the process of cooperation can be carried forward to all parties’ re-cooperation;the continuation of space is mutual trust transitivity by means of the reputation delivery mechanisms of network, trust relationships can be passed to third parties not directly involved in the cooperation network. It is because of the continuity of the trust, leading to the presence of the fourth trust relationship namely swift trust in knowledge network.When a third party in knowledge network has direct contact with the other two parties, this structure is called structural holes. The third party in the position of structural holes grasps both ends of its direct contact with the organization credibility, and when both ends of the organizations attempt cooperation they will seek from the third party in the structural holes position for partner reputation information, thus the trust relationship between the third party and both ends will be passed through the network reputation mechanism,which help both ends of the organization quickly establish a called swift trust relationship. The change of structural holes and network members is the premise to generate swift trust. The swift trust is a "continuation inherit" trust relationship, which comes from the continuity of the trust that based on a certain trust. So it has the higher level of trust than tentative trust. Accompanied by the process of intellectual activity in knowledge network, the relationship of mutual trust between network members will change as shown in Fig. 10.1.

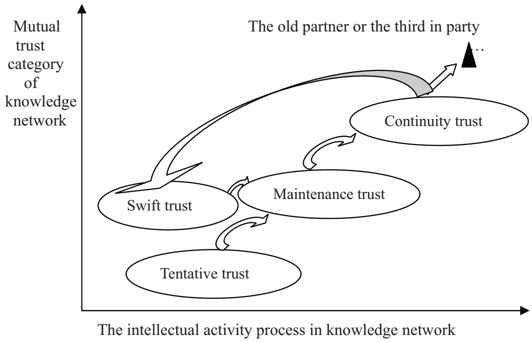

Fig. 10.1 Mutual trust category in knowledge network

10.3 The Evolution Path of Mutual Trust between Organizations in Knowledge Network

Niu [7] by using the method of western network theory's social relations analysis school pointed out that "the degree of the trust will develop from low to high due to long-term trust from members inside the network and external competition". Guo et al [8] analyzed the change trajectory in a cluster evolution process that trust mechanism from the relational trust to calculate trust and institutional trust. In addition, Chen and Feng [9], Wang and Pi [10] also believe that in the virtual enterprises cluster the trust relationship has dynamic change with the cooperation going on. Seen from Fig. 10.1 mutual trust among members of knowledge networks change with the knowledge activity. Obviously, whether it is cluster, virtual enterprise or knowledge network, along with the interaction frequency, the progress of cooperation, microstructure evolution and the changes of competitive environment, the trust relationship between members will change in degree and characteristic. Owing to the complexity of the network structure and transfer of the trust, the evolution of trust relationship between organizations in knowledge network is a long-term dynamic process. This paper first analyzes the path of the relation among the network members from three aspects, the categories, the degree and the ranges.

10.3.1 The Type and Extent Evolution Path of Mutual Trust

Fig. 10.1 showed that with the cooperation (mainly refers to the knowledge activities) between the members, the category evolutionary path of mutual trust in organizational knowledge network can be seen. The trust category directly affects trust degree. The changing of trust category means the changes to trust degree. Its evolution path is directly related to each other. If the analysis of the category and the degree of evolution path were defined in a single process of cooperation, it would be more feasible. This article gave a comprehensive analysis from the trust connotation, strength, quality, establish time, etc on evolution path of mutual trust category and degree in a single process of cooperation.

As mentioned above, tentative trust is usually established in early cooperation which based on rational calculation and external constraints. The trust behavior is tentative to obtain cooperation gains with short time consumption, but the alert to guard against each other is strong, the quality of trust relationship is low and the trust degree is not high.

Accompanied by the in-depth knowledge interaction activities among network members, the tentative trust evolved to maintenance trust. At this stage, the partners interact frequently with closer ties, deeper recognition, enhanced trust relationship, improved intensity and quality as well as trust degree. But as maintenance trust need a certain period of time for effective and continuous interactive communication, so it will take a long time to form mutual understanding and recognition.

The continuity trust is evolved from the maintenance trust at the end of the cooperation. At that time, all parties are like unified entity with high identity and consistency, the strength, quality and degree of trust relation have developed in a single partnership to the highest stage. The continuity trust is the cooperation starting from the end as the natural continuation through time or space.

Swift trust derived from the continuity trust, but existed in the early days of a new round of cooperation. Therefore, swift trust has a higher level than tentative trust. But as the cooperation is in early stage with mutual trust initially established, the strength, quality and extent of trust will advance to higher stage with in-depth cooperation.

Table 10.1 is a comparison table of the above types of trust relationship.

So as intellectual activity among the knowledge network members going on, the relationship of mutual trust among organizations evolved from tentative trust to the maintenance trust, and change into continuity trust in the end of the cooperation. The trust degree experienced changes from low to high with strength and quality of the relationship trust enhanced. However, if the third party in structural holes position joins in the initial cooperation, or each party needs further cooperation, the cooperation of all parties at early stage is agility trust. Once the swift trust is build-

Table 10.1 Various types of relationship of mutual trust comparison among knowledge network members

Trust category	Trust degree	Relation strength and quality	Establish time
Tentative trust	low	bad	Early stage (initial cooperation without the third party)
Maintenance trust	high	good	During cooperation
Continuity trust	highest	excellent	End of cooperation
Swift trust	higher	Very good	Early stage (the third party joins or re-cooperate)

ing up, with the in-depth cooperation, it will experience the evolution from maintenance trust to continuity trust. The trust relationship will improve synchronously in the quality, strength and confidence of the trust. Revised and supplemented to Fig. 10.1 there comes the evolution path of category and extent of mutual trust within members of knowledge network as shown in Fig. 10.2.

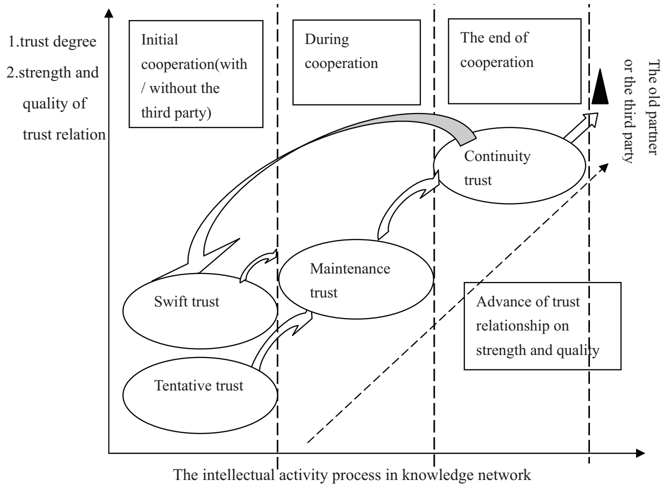

Fig. 10.2 The mutual trust category and degree evolution path within knowledge network

10.3.2 Evolution Path of Mutual Trust Range

The category and extent of the change reflects the evolution of trust in the single process of cooperation, it is a process-based research perspective. The development of the overall trust level of knowledge network change is reflected by the scope of the trust. Fukuyama proposed Radius of Trust, a concept to describe people willing to extend their trust to a certain range size. Knowledge networks and interpersonal networks have in common on complex network structure, with the knowledge network node member deeply involved in knowledge sharing and knowledge creation activities, its partner expands quickly. Therefore, this article introduced the concept of "trust radius" to knowledge network, studying from an overall perspective the changes in the scope of mutual trust between organizations in knowledge network.

The common way of node organizations participating in knowledge networks is through a certain knowledge chain, gradually take the other nodes as a clue to participate more knowledge chain, thus becoming a staggered complex network structure. Any node in the network organization may at the same time be members of more knowledge chain. To any node (call it A), its groups have at least three levels: their close contact and frequent interaction knowledge chain node members staggered constitute the first level, called the core network, which directly contact with A, with high strength in relationship and high degree in trust; Respective core network of A's core network members constitute the second layer, which is a wider range of network, called intermediate network. The intermediate network members have indirect contact with A, but the contact frequency is not too high, trust is lower than the core network; the other members of the network having no direct contact with A or sparse indirect contact with A constitute the third level, called outer layer network. Outer layer network members seldom contact A, but there exist a connection clue, and owing to function by network reputation passing mechanism, structural holes and trust continuity, they have low degree of trust on A or can quickly build swift trust. This shows that changes in the trust scope of the knowledge network member organizations can be illustrated by the expansion of the radius of trust. The driving force for increasing the trust radius comes from the node's needs to fill their own knowledge gaps. In order to fill the knowledge gap, A looks for more knowledge sharing partners through network channels, thus increase trust object, expand the scope of the trust and the scope of the core network; Because of the multi-joint network structure, the expanding of core network means intermediate network expand synchronously; Similarly, the outer layer of the scope of the network expands due to the reputation transfer and trust space continuation. Use the changes of trust radius to explain the evolution path of mutual trust in knowledge network organization as shown in Fig. 10.3.

10.4 Evolution Model of Mutual Trust Between the Knowledge Network Organization

Analysis on category, extent and scope of the evolutionary path shows that the evolution of the trust is an existing order of the dynamic process. We borrow Zhang's research [11] on dividing the stage of the virtual enterprise partnership, study the establishment and development of mutual trust between the members of the knowledge chain [12]. Intellectual activity in the knowledge network takes knowledge

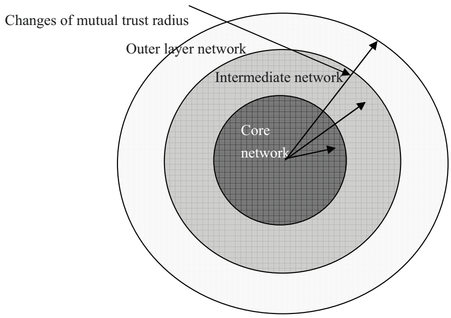

Fig. 10.3 Evolution path of mutual trust range in knowledge network organization (Note: color shades representing net overall trust level of high and low, the darker the higher degree of trust)

chain as implementation carrier, which is the basis of this research, so we further give analysis of the evolution of mutual trust in inter-organizational knowledge networks. In order to present it clearly, we still use time order to divide its different stages.

- Prediction stage: trust evolution at the primary stage. Organizations in the network use information on reputation, experience of cooperation, the balance of power as well as the network and the rules and norms of the social environment and validity assess the cost and revenue, forecast collaborators behavior and decide whether to establish a relationship of mutual trust. If the benefits outweigh the costs and the conduct of members can be predicted, willingness to cooperate is initially established. Therefore, this stage is corresponding to the stage tentative trust.
- Identify capacity stage: immediately after the prediction stage the members of the network try to determine whether the partner has the ability to exercise choice behavior, especially the ability to make a desired behavior promise. If partner's ability and technical strength to promise has been confirmed, the trust relationship based on prediction will be strengthened. At this stage, as members have learned each other's ability and strength in the cooperation process, tentative trust gradually transformed to the maintenance trust with improved reliability.
- Trust safeguards stage: a period of deep cooperation among members with goal congruence and identity enhanced. In this case, the cooperation relationship develops well, great enhancement of mutual trust and form security system of cooperative behavior among the members, the maintenance trust gradually enhanced.
- The transfer and ascension stage: a successful cooperation came to an end, cooperation parties saved partners' credibility judgment and experience summary in the database of individual credit assessment, timely transfer and diffuse through the network channels,and its a transfer and ascension stage,which is corresponding to continuity trust. At this stage, the continuity trust can be extended to the next cooperation. If it is in the position of structural holes, it can also be transferred to the new partnership and transformed into swift trust.

The analysis above shows: As for the single process of cooperation, the evolution of mutual trust is reflected in the category and extent and the evolution process can be divided into four stages; if there is no third-party sources of information in the structural holes position, category change is from tentative trust via the maintenance trust and evolved into the continuity trust; if a third party in the structural hole provide reliable information before cooperation, the initial trust is taken as agility trust, which experienced maintenance trust to the continuity trust; throughout the evolution,the trust are experiencing a change from low to high. Look the network as a whole, cooperation in network is on cycle, with each cooperation accompanied by the evolution of trust and trust radius increasing. Therefore, the scope of the trust is expanding with the cycle of interactions. From the process perspective and the overall perspective, a comprehensive model as shown in Fig. 10.4 illustrated the evolution of the mutual trust relationship among knowledge network organizations occurs along with the cooperation process.

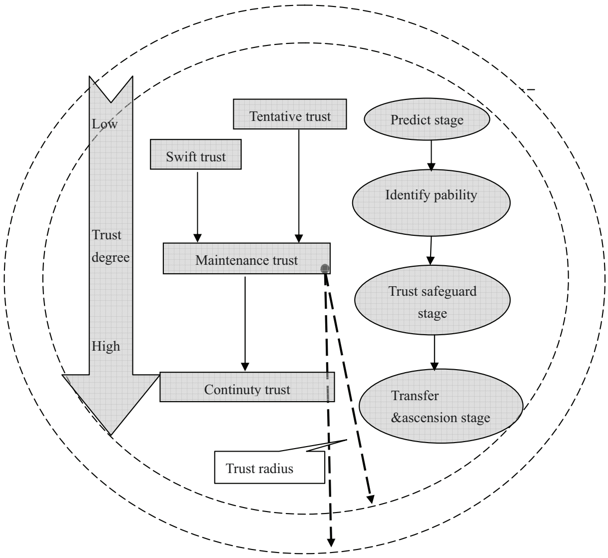

Fig. 10.4 The evolution process of mutual trust among organization in knowledge network

10.5 Conclusion

The open dynamic knowledge network has a lot of uncertainty and conflict, as Jarvenpaa et al [13] said, “trust contributes to the solution of the conflict within virtual teams, goal orientation and the formation of shared values”,The trust mechanism is not only the lubricant for a successfully running knowledge network, but also one of the governance mechanisms for network partnership. The analysis on the evolution path and process of mutual trust relationship between knowledge networks shows that the evolution of the relationship of trust is complex dynamic process that can be tracked, with different factors affecting at different stages. When managing knowledge networks and promoting knowledge cooperation in networks, one can take a variety of ways to establish standardized, improved incentive and restraint mechanisms and advocacy win-win network culture to nurture and strengthen the mutual trust relationship among network organizations according to the characteristics of the evolution path and evolution stage, for the sake of providing protection for the efficiency and effectiveness of knowledge networks.

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Chapter 11
Research on the Strategy and Effectiveness of Enterprises' Micro-blogging Interaction: Based on Chinese Electric Household Industry

Zhanheng Zhao and Weiping Yu

Abstract With the widespread application of micro-blog in business, the micro-blogging interaction of enterprise-consumer has been receiving more and more attention. However, the existing research lack of a systematic study on interactive strategy, on the basis of theoretical combing, this paper explore the strategy of enterprise's micro-blogging interaction from two categories of interactive content and interactive style. A content analysis was performed on enterprise's micro-blogging ($n = 685$) from 14 well-known enterprises in China's home appliance industry. The study found the application of interactive strategies exist significant differences on the micro-blogging interaction of enterprise-consumer. Compared with functional interactive strategy, there is a larger proportion of social interaction in the content of interaction, and proactive interactive strategy is far more reactive interaction in the style of interaction. The study further found that the effect of proactive interaction to be significantly larger than the effect of reactive interaction. Finally, the study gives some recommendations for household electrical appliance enterprise in micro-blogging marketing.

Keywords Social interaction · Functional interaction · Proactive interaction · Reactive interaction · Effectiveness

11.1 Introduction

With the rapid increase of micro-blogging users, micro-blog has become an important part of social media [1]. However, compared with other social media, the

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study of micro-blog still lag behind, current results are mainly reflected in mechanism and effect of micro-blogging propagation in the public domain [2]. Affected by the successful case of some companies in micro-blogging applications (e.g. Dell and Zappos), more scholars and businesses begin to focus on application values of micro-blog in the business world. Existing research results show, micro-blogging applications can not only be reflected in the entire process of the enterprise's marketing activities [1], but also has a significant impact on Corporate brand reputation [3], Marketing performance [4], Consumer purchase decision [5], and Consumer-Brand relationships [6], etc. But in real life, the whole enterprise's micro-blogging application is not optimistic, limited fans and lower degree of interaction lead to a large number of enterprise micro-blogging account management in an awkward position.

Recent study shows that many of higher frequency referenced papers refer to "interactivity". Kim [7] and Zhuang [8] also thought that the enterprise competence of dynamic interaction decides to enterprise's marketing performance in the new social media, but the difference of enterprise's interactive competence is reflected though interactive strategies and interactive behavior. Therefore, strengthening the study on enterprise's interactive strategy in the context of micro-blog, has an important significance on enterprise micro-blogging marketing management. In research area of micro-blogging interactive strategy, Fischer and Reube [9] explored the mechanism of social interaction when entrepreneur adopt twitter, and Jin [10] mentioned the micro-blogging account activity has an important influence on the effectiveness of enterprise marketing on micro-blog, but there are still lack of systematic research on enterprise micro-blogging interactive strategy. Although Yan and Chang [11] suggested three enterprise-consumer interactive strategies via micro-blog using grounded theory, but the classification has yet to be questionable. Moreover, the existing research does not respond to the industry differences, however, according to official statistics of Sina website in china [12], there is a clear difference between industry when enterprise interact with consumer on micro-blog.

This study follows a more mature classification system on enterprise-consumer interaction strategy, using content analysis explores the interactive strategy and effectiveness of enterprise-consumer micro-blogging interaction in China's home appliance industry. Therefore, the question of research is: Which interactive strategies are used on enterprise's official micro-blog in China's home appliance industry, and how about the effect of interaction?

11.2 Literature Review

(1) Corporate Micro-blog

Micro-blog is a new kind of social media, the micro-blogging users can achieve the timely sharing of not more than 140 characters of text, images, and video links though PC, mobile phones, even a variety of smart networked client [13]. The characteristics of fragmentary information, viral transmission, and timely interaction on micro-blog precisely meet the psychosocial characteristics of micro-blogging user with a high degree of self-exposure and self-expression [1]. Therefore, micro-blog has become an important tool or platform for sharing information, maintaining relationship, information sharing, and enhancing user's influence.

Depending on the micro-blogging registered users, there are organization user and personal user [2]. In the Chinese context, enterprises use micro-blog primarily through three account types: corporate micro-blog, departmental micro-blog, entrepreneur's micro-blog. Different users have a different motivation and centered goal in the process of using micro-blog [14]. Therefore, corporate official micro-blog refers the micro-blogging account registered by enterprise's official organization on micro-blogging platform, enterprise can interact with consumer on micro-blog, thereby affecting consumer decision and maintaining brand-consumer relationship.

(2) Micro-blogging interaction

Relative to the traditional online communication, the enterprise-consumer interaction on social media is to better enhance consumers embedded, to better enhance the credibility, and ultimately enhance the brand reputation [3]. Micro-blogging interaction, not only has the general characteristics of social media, but also has its own characteristics, such as real-time data transmission, interpersonal communication, cyberspaces presence [15]. Thus, this interaction is more conducive to enterprise to attract new consumers, to impact on consumer brand knowledge, and to enhance the brand-consumer relationship [16]. Hsu [5] also pointed out the WOM's information on the home page of the enterprise's micro-blog will affect consumer satisfaction and consumer awareness of corporate image, and ultimately influence consumer behavior intention.

(3) Micro-blogging interactive strategy

The research on enterprise-consumer interactive strategy can be traced back to Sheth's study [17] on the interaction of buyers and sellers, Sheth thought both interactive content and interactive style is two main modules of an interactive process. These two modules also have been the main research line in the interactive field recent decades, for the real word [18, 19] or the virtual world [20, 21].

On the basis of previous studies, Ruyter and Wetzels [22] suggested the enterprise-consumer interaction online should be divided into social interaction and functional interaction from interactive content, and pointed out that social interaction involves social information, but functional interaction embodies a clear commercial information, both of interactive strategies have a significant impact on the adaptability of new customer and corporate performance. They also distinguished proactive interaction and reactive interaction from interactive style, proactive interaction refers the topic of interaction originates from enterprise, and reactive interaction from consumer. These two strategies also have a significant impact on customer satisfaction. About micro-blogging interaction, other scholars such as Yan [2], Guo [23] have also done some exploratory research, but their studies tend to concern on micro-blogging interactive content to ignore the interactive style. Moreover, the micro-blogging interactive strategies which are distinguished by these scholars from interactive content often lack the generality and persuasive.

Limited the number of 140-character, the amount of information in micro-blogging interaction is limited, on the other hand, a tremendously large and constantly updated micro-blogging information stream makes it increasingly difficult for users to find content of interest [24]. During micro-blogging browse, users firstly pay attention to the focus information, then the background information, and think about the correlation of focus information with background information [25]. Therefore, this study follows the criteria for the classification of enterprise-consumer interactive strategy by Köhler et al [22], uses the focus information as a basis for evaluation of micro-blogging interactive strategies. In view of micro-blogging interactive content, if the focus information in a micro-blog explicitly references to the corporate advertising (product or brand), product promotion, even and leading transmission, this micro-blog, this micro-blog uses a functional interactive strategy, otherwise a social interactive strategy. In the same way, the focus information in a micro-blog is firstly posted out by enterprise, this micro-blog uses a proactive interactive strategy in interactive style, otherwise a reactive interactive strategy.

(4) Effectiveness of Micro-blogging interactive strategy

Previous studies often use three indicators of the number of micro-blog, follower, and the sharing to measure the effect of enterprise's micro blogging marketing [23]. This research uses two indicators of the number of follower and the number of sharing/reviewing to measure the effect of enterprise-consumer micro-blogging interaction, that is to say, the effectiveness of interaction is equal to the sharing/reviewing number divided by the follower number.

11.3 Research Design

(1) Method

In the field of information dissemination, the information content is in the center of communication process, according to certain rules, put the content of information into different categories, and using statistical tools analysis this data to draw valid reasoning repeatable, this normal and rigorous research process is often referred to as content analysis, ant content analysis is commonly used in the research on the field of information dissemination [26]. Therefore, a content analysis will be performed in this research.

(2) Object of study

The survey of Sina official network shows that the enterprise micro-blogging application in manufacturing industry is generally better than consumer industry, but there are still some enterprise's micro-blog accounts operated better in manufacturing industries. How do these enterprises operate? With this question, this research pays attention on the manufacturing industry. Moreover, the young white-collar groups (25-34 years old) is an important part of the personal micro-blogging users [27], they always are more familiar with home appliance products. Therefore, this study firstly chooses Chinese home appliance industry as a research object. In the process of selecting enterprises, if using a random sampling method, there will be extracted a lot of enterprises which mostly not have micro-blogging account or have a poor, so random sampling does not meet the needs of this study. According to the "Chinese 500 enterprises' list of the most brand value in 2012" by World Brand Lab, this study choose these well-known household enterprises in China as the object of study, a total of 17 enterprises. Then, by searching these enterprises' micro-blogging account one by one on Sina micro-blogging platform in China, 14 enterprises have their official micro-blog and a well operating (Table 11.1). So these 14 enterprises' official micro-blog will be the object of this research.

Table 11.1 The basic situation of 17 enterprises' official Micro-blog

Name of enterprise	Ranking of brand value	Having official micro-blog (Yes or No)	The number of follower	The number of micro-blog	The object of research (Yes or No)
Haier	12	Yes	880624	4558	Yes
Changhong	15	Yes	153854	1485	Yes
TCL	40	Yes	80891	4172	Yes
Gree	58	Yes	152377	5013	Yes
Hisense	81	Yes	205053	2401	Yes
Skyworth	121	Yes	627773	3863	Yes
Sacon	140	Yes	95487	2548	Yes
Vanward	171	Yes	209188	3347	Yes
Chigo	243	Yes	185067	1550	Yes
Aux	284	Yes	65051	1324	Yes
Aupu	307	Yes	83832	3283	Yes
Joyoung	313	Yes	74402	3404	Yes
Vatti	349	Yes	362163	1687	Yes
Malata	391	Yes	46793	1785	Yes
Chunlan	45	No			No
Vivo	348	No			No
Himin	403	Yes	2245	241	No

(3) Sample

In this study, in order to exclude the impact of special events on one enterprises' micro-blogging interactive content, a stratified sampling is performed. One is randomly selected from micro-blogs which one enterprise updated out one day. A total of 687 micro-blogs are selected from 14 enterprises in October and November of 2012, excluding 2 incomplete micro-blogs, finally 685 sample data ($n = 685$).

11.3.1 Reliability

An exclusive classification is adopted in the process of encoding. On the basis of further conceptualization on micro-blogging interactive strategies, two master's students are chose to encode on sample data. After the training and reliability testing to the coding staff, they coded on the samples ($n = 685$) at the same time. At last, this study tested the reliability of the coded data.

Reliability test consists of two phases: the consistency test and Scott's *Pi* test. Consistency test refers to the percentage agreement of the two coders in the same category. In this study, the consistencies of two coders in interactive content and interactive style are 89% and 94%, these two consistencies are more than the level of the minimum standards (85%). And then using Scott's *Pi* formula: $Pi = (\%OA - \%EA)/(1 - \%EA)$, test Scott's *Pi* coefficient.

OA means the observed consistency, and EA is the expectable consistency. In the inspection, Scott's *Pi* coefficient are 0.85 and 0.92, also higher than the general reliability figures 0.80, therefore, the coding of this study meets the reliability requirements of the content analysis.

Table 11.2 The distribution of Micro-blogging sample

Enterprise	Total number	Social interactive strategy (number)	Functional interactive strategy (number)	Proactive interactive strategy (number)	Reactive interactive strategy (number)
Haier	60	28	32	42	18
Changhong	59	53	6	54	5
TCL	60	28	32	29	31
Gree	61	52	9	38	23
Hisense	60	37	23	42	18
Skyworth	58	46	12	51	7
Sacon	44	27	17	26	18
Vanward	47	38	9	43	4
Chigo	40	30	10	40	0
Aux	48	34	14	32	16
Aupu	32	28	4	27	5
Joyoung	61	45	16	51	10
Vatti	31	16	15	20	11
Malata	24	23	1	15	9
total	685	485	200	510	175

11.4 Analysis and Discussions

(1) Distribution

In terms of interactive content, descriptive statistics finds there is a larger proportion of social interactive strategy (71%) than functional interactive strategy (29%) in the mass, specific to individual enterprises, in addition to the three companies (Haier, TCL, and Vatti), and other enterprises' distribution are similar to the overall distribution. About interactive style, the distribution of proactive interactive strategy and reactive interactive strategy is 3 : 1 from the whole, in addition to TCL (1 : 1), other enterprises' distribution also are similar to the overall distribution (Table 11.2). Further using the Chi-square test, fount two directories *P* value was less than the significance level (0.05), which also indicates that there are significant differences on social interaction with functional interaction, and proactive interaction with reactive interaction (Table 11.3).

Table 11.3 Chi-square test

	Interaction content	Interaction style
Chi-Square	118.577a	163.832a
df	1	1
Asymp. Sig.	0.000	0.000

(2) Effectiveness

For micro-blogging each sample, using the number of sharing/reviewing divided by the number of follower, where can get to the effectiveness of its interaction. Then using independent samples t-test explores the differences of functional interactive strategy and social interactive strategy. Analysis shows the corresponding probability $P = 0.00$, less than significant level of 0.05, so the two overall variance exist significant differences; observed value of the t statistic is 1.369, Sig. = 0.173, corresponding to the two-tailed probability is clearly greater than the significance level (0.05), therefore, there is no significant difference on the effectiveness of functional interactive strategy and social interactive strategy. The same analysis process on proactive interactive strategy and reactive interactive strategy shows, when $p = 0.017$, Sig. = 0.017, apparently less than a significant level of 0.05, therefore, there is a significant difference on the effectiveness of proactive interactive strategy and reactive interactive strategy.

(3) Discussions

Based on the above analysis, the main purpose of enterprise is to improve the consumer-brand relationship, and enhance brand value via micro-blogging interaction in Chinese household electrical appliance industry. In the process of micro-blogging interaction, social interactive strategy and proactive interactive strategy are the main strategies business used, for example, enterprise can adopt social interactive strategy to influence consumer-brand relationship though brand name mentioned, in the sample data, and there is 45% of micro-blog in social interactive strategy which mentioned brand name. Of course, they also use others strategies.

The current results have shown that there are a lot of factors which have a significant effect on the effectiveness of interaction. From the strategic perspective of interaction in this study, explore that the effectiveness of the proactive interactive strategy is significantly higher than reactive interactive strategy. Also found in the data collection process, even the micro-blog updated by an enterprise is shared once again by the enterprise, the effectiveness of interaction is still less than the original micro-blog, so the sharing on the micro-blog updated by itself still belong to reactive interactive strategy. Therefore, the enterprise should more use proactive interactive strategy in the micro-blogging interaction because that the follower still prefers the original micro-blog. Although, there is no significant difference on the effectiveness of social interactive strategy and functional interactive strategy, some micro-blogs in functional interactive strategy still is shared by more followers, especially the micro-blog with a guide sharing intention.

11.5 Concluding Remarks

With the widespread application of micro-blog in business, it is particularly necessary to study the enterprises' micro-blogging interactive strategy and effectiveness. In this study, there are four micro-blogging interactive strategies of two dimensions: social and functional, proactive and reactive, the former belong the dimension of interactive content, the latter is interactive style. By collecting and analyzing the data of China's household electrical appliance enterprises micro-blogs, these enterprises have adopted almost all the strategies in micro-blogging interaction, but there are still differences on the distribution and effectiveness of four strategies.

Firstly, proactive interaction is the strategy which is most welcome and effective in enterprise-consumer interaction via micro-blogging. Therefore, enterprises should give full play to the initiative in micro-blogging interaction, which don't means no feedback about follower's question in micro-blog, they can adopt others way of feedback. Because the micro-blog specific to individual follower is no value for others, if "accepted" too much worthless micro-blogs, those followers could tend to cancel attention on this enterprises' micro-blog. Therefore, there is a suggestion that enterprise can directly take a comment or reply without sharing on some follower's blogging.

Secondly, social interaction is an important part in enterprise-consumer micro-blogging interaction. The purpose of adopting micro-blog in early is to tell each other on "What am I doin", although there are others purpose in business, the nature will not change. Do not ignore the role of social interaction. Social micro-blogging interaction is help to enterprise establishing brand image and improving consumer-brand relationship.

At last, any behavior of enterprise is driven by profit, micro-blogging application also is no exception. Functional interaction is the main purpose of the enterprise micro-blogging interaction. Due to the contradiction of consumer, enterprise must maximize the effectiveness of functional interaction in micro-blogging interaction. At the same time, enterprise can also be combined with a variety of interactive strategies, using anthropomorphic expression explore its own micro-blogging characteristics.

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Chapter 12
Simplification of Large Scale Network in Time-cost Tradeoff Problem

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Abstract For the time-cost tradeoff problem, if the involved super large-scale CPM network is simplified, then any correlative algorithm which used to solve the problem is simplified too. According to the idea, firstly, property of free float and relation of free float and path length is analyzed, and some new conceptions and free float theorem are deduced; secondly, an algorithm of simplifying the super large-scale network in time-cost tradeoff problem is designed by using these conceptions and the theorem, and validity of the algorithm is proved; finally, application of the algorithm is discussed by illustration. The theoretic proof and illustration show that if the algorithm is used to simplify the time-cost tradeoff problem, any correlative algorithm which used to solve the problem could be greatly simplified.

Keywords CPM network planning · Time-cost trade off problem · Free float theorem · Simplification

12.1 Introduction

Through developing quickly more than ten years, modern project management not only becomes a new knowledge, but also has become a profession. According to the Project Management Body of Knowledge (PMBOK for short) which written by America Project Management Body of Knowledge (PMI for short), project management has been separated into nine domains. Thereinto, "project time management" and "project cost management" are two core domains [1]. The time-cost tradeoff problem [2–4] represents crossover of the two core domains, and it is applied very widely in practice.

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There are mainly two aspects about time-cost tradeoff problem: firstly, which activities' durations need to be shortened; secondly, how many quantities of these activities' durations need to be shortened. Current studies [5–14] have proved that using CPM network planning technology especially theory of float to analyze time-cost tradeoff problem could solve above two aspects problems more intuitionisticly. At present, there are five conceptions of float, which named total float, free float, safety float, node float and interference float respectively in international. But now common algorithms [15, 16] are difficult to solve the problem, and have biggish computation, especially when face super large scale project. One very important reason is that the whole project needs to be considered object when using these algorithms. Generally speaking, people are mainly interested to simplification of algorithm, by improving and designing algorithm to try to decrease difficult of solving problem. Although the approach is feasible, it is hard to avoid biggish difficulty, and limited algorithms could be accomplished by using the approach.

Now we could try to consider from other angle. Under many conditions, all involved objects need not to be considered, therefore, if object which might be considered in problem could be simplified, and some parts which need not to be considered are deleted, then the problem could be solved more simple by using any algorithms, and difficulty could be decreased. For example, for above time-cost tradeoff problem, if we want to shorten total duration of project by 5 days, we only need to decrease lengths of longer paths to 95 days which are bigger than 95 days in correlative network. If we could compose a sub-network with these paths whose lengths are bigger than 95 days, then it is equivalent to shorten total duration of the sub-network and original complicated network. Shorten total duration of the sub-network is simpler assuredly than shorten total float of original complicated network by using any algorithms. But find out path with certain length is very difficult in complicated network. Domestic and overseas scholars have designed many algorithms to simplify complicated network equivalently, but nearly all these algorithms have biggish complexity [17], or lack theory evidence [17, 18], and so on.

In this paper, according to the idea that simplify object of problem is equivalent to simplify any algorithms to solve the problem, through studying inherent rule of CPM network planning, properties of activity's free float and relation between free float and path's length, we deduce free float theorem. On the basis of the theory, for realizing purposes of simplifying object of problem and all correlative algorithms, we design algorithm to simplify super large-scale network equivalently in time-cost tradeoff problem, and don't affect the final result.

12.2 Conception and Theorem

12.2.1 Correlative Conception

(1) Total float

The total float of activity (i, j) which marked as TF_{ij} is defined as: $TF_{ij} = LS_{ij} - ES_{ij} = LF_{ij} - EF_{ij} = LT_j - ET_i - T_{ij}$. The total float denotes the time an activity can be delayed without causing a delay in the project.

(2) Free float

The free float of activity (i, j) which marked as FF_{ij} is computed as:

$$FF_{ij} = ES_{jr} - EF_{ij} = ET_j - ET_i - T_{ij}. \tag{12.1}$$

The free float denotes the time an activity can be delayed without affecting its immediate successor activities.

Similarly, the free float of any path μ which marked as FF_μ is computed as: $FF_\mu = \sum_{(i,j)\in\mu} FF_{ij}$. The path safety float FF_μ represents the sum of free float of all activities which are on any path μ in activity-on -arc representation network.

(3) Critical path

The critical path is the longest path in CPM network which marked as μ^∇. Activity and node on the path are named critical activity and activity node respectively.

(4) Fore main chain

The fore main chain of node (i) or activity (i, j) which marked as μ_i^* or μ_{ij}^* represents part of a path which starts from start node (i) composed of activities whose free floats are zero.

(5) Host activity, assistant activity and fundus activity

If $FF_{ij} > 0$, activity (μ, ν) on fore main chain of the activity (i, j) or node (j) is named host activity of the activity (i, j) or node (j). Immediate predecessor activity $(t, \mu) \notin \mu_i^*$ of node (μ) is named assistant activity of activity (i, j) or node (μ). And activity (i, j) is named fundus activity of its host activity and assistant activity. If $FF_{ij} > 0$, and (j) is critical node, then activity (i, j) is named assistant activity of network's terminal node (n).

(6) Eigenvalue of activity

The conception mainly contains three aspect:

- Eigenvalue which marked as $D_n(r, s)$ of assistant activity (r, s) of terminal node (n) is defined as free float FF_{rs} of the activity (r, s), viz. $D_n(r, s) = FF_{rs}$.
- Eigenvalue which marked as $D_r(t, u)$ of assistant activity (r, s) of any non-terminal node (r) is defined as sum of free float FF_{tu} and eigenvalue $D_r(r, s)$ of fundus activity (r, s) of activity (t, u), viz. $D_r(t, u) = FF_{tu} + D_r(r, s)$.
- Eigenvalue which marked as $D_r(u, v)$ of host activity (u, v) of any node (r) is defined as infinite, viz. $(u, v) \in \mu_r^*, D_r(u, v) = +\infty$.

12.2.2 Free Float Theorem

Theorem 12.1. *Margin of length of critical path μ^∇ minus length of any path μ is equal to sum of free floats of activities on the path μ, viz.*

$$FF_\mu = L(\mu^\nabla) - L(\mu). \tag{12.2}$$

Proof. Suppose any path marked as $\mu = (1) \to (a) \to (b) \to \cdots \to (e) \to (f) \to (n)$. There into node is start node and node (n) is terminal node. According to conception of path free float and Equation (12.1),

$$\begin{aligned} FF_\mu &= FF_{1a} + FF_{ab} + FF_{bc} + \cdots + FF_{ef} + FF_{fn} \\ &= (ET_a - ET_1 - T_{1a}) + (ET_b - ET_a - T_{ab}) + \cdots + (ET_n - ET_f - T_{fn}) \\ &= ET_n - ET_1 - (T_{1a} + T_{ab} + T_{bc} + \cdots + T_{fn}). \end{aligned}$$

In CPM network, $ET_1 = 0$ and $ET_n = L(\mu^\nabla)$, then length of the path μ is $L(\mu) = T_{1a} + T_{ab} + T_{bc} + \cdots + T_{de} + T_{ef} + T_{fn}$, therefore $FF_\mu = L(\mu^\nabla) - l(mu)$. Equation (12.2) is correct. □

12.3 Simplification of Super Large-scale Network in Time-cost Tradeoff Problem

12.3.1 Description of Algorithm

For time-cost tradeoff problem, if we want to shorten total duration T to ΔT, we only need to shorten length of paths which are longer than $T - \Delta T$ in CPM network. If simplifying original complicated network to sub-network composed by paths whose lengths are bigger than $T - \Delta T$, then shorten total duration of the sub-network is equivalent to shorten total duration of original network. Therefore, Simplification of super large scale network in time-cost tradeoff problem is to delete path whose lengths are smaller than or equal to $T - \Delta T$ as more as possible. The process of simplification is described as follows (Ω^k represents muster):

Step 1. Find out critical path μ^∇, and find out assistant activity (i, j) of terminal node (n), and then compute eigenvalue $D_n(i, j)$ as follows: $D_n(i, j) = FF_{ij}$.

Step 2. Make $(k) = (n)$, and compare $D_k(i, j)$ and ΔT.

(1) If $D_k(i, j) < \Delta T$, put $D_k(i, j)$ into Ω^k;

(2) If $D_k(i, j) \geq \Delta T$, delete activity (i, j).

Step 3. Check.

(1) If $\Omega^k = \emptyset$, stop;

(2) If $\Omega^k \neq \emptyset$, turn to Step 4.

Step 4. Find out the minimal value $D_r(u_0, v)$ in Ω^k, and delete the value, and then find out fore main chain $\mu^*_{u_0}$ of node (u_0), viz. find out activities without free floats from predecessor activities of node (u_0).

Step 5. Find out each assistant activity (e, u_i) of node (u_0) from predecessor activities of node (u_i), $i = 0, 1, 2, \cdots, n$, and compute its eigenvalue as follows: $D_{u_0}(e, u_i) = FF_{eu_i} + D_r(u_0, v)$. Then make $(k) = (u_0)$, substitute $D_k(i, j)$ by $D_{u_0}(e, u_i)$, and turn to Step 2.

12.3.2 Analysis on Correctness of Algorithm

(1) Correctness of Step 4 could be proved by the conception of fore main chain.
(2) Correctness of Step 1 and 5 could be proved by the conception of eigenvalue.
(3) In Step 2-(2), now we prove that if deleting activity (i,j), lengths of disappeared paths are all smaller than or equal to $T-\Delta T$.
(a) According to conception, $D_k(i,j)=FF_{ij}+D_k(u_1,v_1)$, there into (u_1,v_1) is fundus activity of activity (i,j); in the same way, $D_k(u_1,v_1)=FF_{u_1v_1}+D_k(u_2,v_2)$, there into (u_2,v_2) is fundus activity of activity (u_1,v_1); $\cdots$; until to $D_k(k,v_n)=FF_{kv_n}$, there into node (v_n) is critical node, then: $D_k(i,j)=FF_{ij}+FF_{u_1v_1}+\cdots+FF_{kv_n}$. Suppose

$$\begin{aligned}\mu=\ &\mu_i^*+(i)\to(j)\to\cdots\to(u_1)\to(v_1)\to\cdots\to(u_2)\to(v_2)\\&\to\cdots\to(u_{n-1})\to(v_{n-1})\to\cdots\to(k)\to(v_n)+\mu^{\nabla}_{v_n\to n},\end{aligned}$$

thereinto, for activities which locate between node (i) and (v_n) but don't be list in formula of μ, according to conception of host activity, they locate on fore main chains respectively and their free floats are all zero. Then we could deduce: $FF_\mu=FF_{ij}+FF_{u_1v_1}+\cdots+FF_{u_{n-1}v_{n-1}}+FF_{kv_n}$.

According to above Equation,

$$FF_\mu=D_k(i,j). \tag{12.3}$$

According to Step 2-(2), $D_k(i,j)\geq\Delta T$, then according to free float theorem, the difference of path lengths is: $L(\mu^{\nabla})-L(\mu)=FF_\mu$. For $T=L(\mu^{\nabla})$, then $L(\mu)=L(\mu^{\nabla})-FF_\mu=T-D_k(i,j)\leq T-\Delta T$. If deleting (i,j), for path μ passes activity (i,j), then path μ disappears at the same time.
(b) Suppose any paths which pass activity (i,j) are:

$$\begin{aligned}\mu'=\ &(1)\to\cdots\to(u_1)\to(s_1)\to\cdots\to(u_t)\to(s_t)\to(i)\to(j)\to\cdots\to(e_1)\\&\to(f_1)\to\cdots\to(e_2)\to(f_2)\to\cdots\to(e_m)\to(f_m)\to\cdots\to(w)\\\mu''=\ &(1)\to\cdots\to(i)\to(j)\to(e_1)\to(f_1)\to\cdots\to(e_2)\\&\to(f_2)\to\cdots\to(e_m)\to(f_m)\to\cdots\to(w),\end{aligned}$$

therefore, free floats of activities (e_r,f_r) and (u_p,s_p) is nonzero, $r=1,2,\cdots,n;p=1,2,\cdots,t$, and free floats of other activities are all zero.

It is obvious that $FF_{\mu'}>FF_{\mu''}$, and according to free float theorem, the paths' lengths satisfy with:

$$\mu'<\mu''. \tag{12.4}$$

It is similarly with μ that:

$$\begin{aligned}D_{e_m}(i,j)\ &=FF_{ij}+D_{e_m}(e_1,f_1)\\&=FF_{ij}+FF_{e_1f_1}+D_{e_m}(e_2,f_2)\\&\quad\cdots\end{aligned}$$

$$\begin{aligned} &= FF_{ij} + FF_{e_1f_1} + \cdots + FF_{e_{m-1}f_{m-1}} + D_w(e_m, f_m) \\ &= FF_{ij} + FF_{e_1f_1} + \cdots + FF_{e_{m-1}f_{m-1}} + FF_{e_mf_m} \\ &= FF_{\mu''}, \end{aligned}$$

viz.

$$FF_{\mu''} = D_{e_m}(i, j). \tag{12.5}$$

① If $D_{e_m}(i, j) \geq D_k(i, j)$, then $FF_{\mu''} > FF_{\mu}$. According to free float theorem, then $L(\mu'') \leq L(\mu)$.

② If $D_{e_m}(i, j) < D_k(i, j)$, according to Equation (12.4), $D_{e_m}(e_1, f_1), D_{e_m}(e_2, f_2), \cdots$, $D_1(e_m, f_m)$ are all smaller than $D_{e_m}(i, j)$, therefore:

$$\begin{cases} D_{e_m}(e_1, f_1) < D_k(i, j), \\ D_{e_m}(e_2, f_2) < D_k(i, j), \\ \cdots\cdots \\ D_n(e_m, f_m) < D_k(i, j). \end{cases} \tag{12.6}$$

For $D_n(e_m, f_m) < D_k(i, j), D_k(i, j) < \Delta T$, then $D_n(e_m, f_m) < \Delta T$. According to Step 1 and 2, $D_n(e_m, f_m) \in \Omega^k$.

i. If $D_n(e_m, f_m)$ dose not be chosen all along in process of choosing the minimal value $D_r(u, v_0)$ in Step 4, thus it dose not be deleted all along and is still in Ω^k. Then in this choosing, for $D_n(e_m, f_m) < D_k(i, j)$, $D_n(e_m, f_m)$ should be chosen to replace $D_k(x, y)$, which is dissociable.
ii. If $D_n(e_m, f_m)$ being chosen in process of choosing the minimal value $D_r(u, v_0)$ in Step 4, according to Equation (12.6), $D_{e_m}(e_{m-1}, f_{m-1}) < D_k(i, j) < \Delta T$.

According to Step 5 and 2-(1), $D_{e_m}(e_{m-1}, f_{m-1}) \in \Omega^k$, then $D_{e_m}(e_{m-1}, f_{m-1}) < D_k(i, j)$. Therefore, according to Step 5, $D_{e_m}(e_{m-1}, f_{m-1})$ should be chosen to replace $D_k(x, y)$, which is also dissociable.

Similarly, If $D_{e_m}(e_{m-1}, f_{m-1})$ is chosen, according to Equation (12.5), $D_{e_m}(e_{m-2}, f_{m-2}) < D_k(i, j) < \Delta T$.

According to Step 2-(1), $D_{e_m}(e_{m-2}, f_{m-2}) \in \Omega^k$, but $D_{e_m}(e_{m-2}, f_{m-2}) < D_k(i, j)$, and according to Step 5, choosing $D_k(x, y)$ is also dissociable.

Deducing in turn similarly, until $D_{e_m}(i, j) < D_k(i, j)$, and choosing $D_k(x, y)$ is still dissociable.

From above analysis, $D_{e_m}(i, j) < D_k(i, j)$ is not correct, therefore $D_{e_m}(i, j) \geq D_k(i, j)$.

Then according to conclusion which proved in ①), $\mu'' \leq \mu . \mu' < \mu''$ has been proved, therefore $\mu' < \mu$.

For arbitrariness of μ', μ is the longest path which pass activity (i, j). If deleting (i, j), the lengths of disappeared paths are all no longer than μ. And for $L(\mu) \leq T - \Delta T$, the lengths of disappeared paths are all not bigger than $T - \Delta T$, therefore Step 2-(2) is correct.

(4) The algorithm is to reserve all paths whose lengths are bigger than $T - \Delta T$.

According to Equation (12.3), $FF_{\mu} = D_k(i, j)$. If $D_k(i, j) < \Delta T$, then $FF_{\mu} < \Delta T$. According to free float theorem, $L(\mu^{\nabla}) - L(\mu) = FF_{\mu}$. And for $L(\mu^{\nabla}) = T$, then

$L(\mu) = T - FF_\mu > T - \Delta T$. In Step 2-(1), if $D_k(i,j) < \Delta T$, then reserve the value in Ω^k, which means the paths longer than $T - \Delta T$ are reserved.

Therefore, according to Step 2-(2), if $D_k(i,j) \geq \Delta T$, delete paths whose lengths are smaller than or equal to $T - \Delta T$. According to Step 2-(1), if $D_k(i,j) < \Delta T$, put $D_k(i,j)$ into Ω^k, then reserve all paths whose lengths are bigger than $T - \Delta T$. According to Step 4, delete one $D_k(i,j)$ from Ω^k every time. According to Step 3-(2), if $\Omega^k \neq \emptyset$, the process need continue, and delete all paths whose lengths are smaller than or equal to $T - \Delta T$ by using Step 2-(2). And according to Step 3-(1), if $\Omega^k = \emptyset$, the process should stop. Therefore, by the process of simplifying, the paths whose lengths being smaller than or equal to $T - \Delta T$ are deleted as more as possible, and the network is simplified to the simplest sub-network equivalently.

12.4 Illustration

The CPM network planning of one project engineering could be showed as Fig. 12.1. If we want to shorten total duration of the project by 30 days, try to simplify the network to the simplest sub-network for solving the time-cost tradeoff problem equivalently.

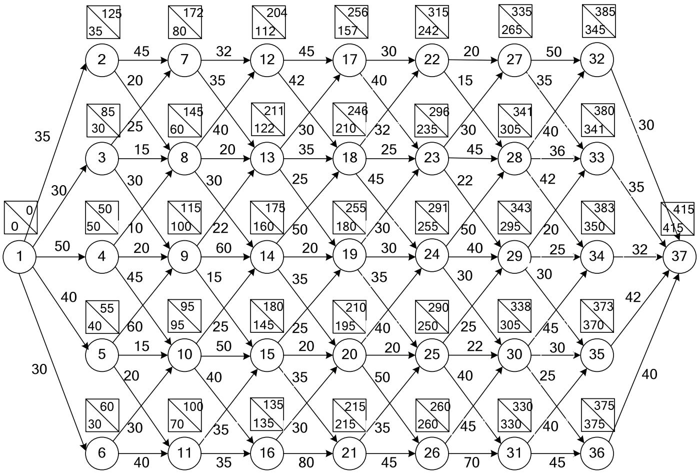

Fig. 12.1 CPM network planning

Step 1. Find out critical path μ^∇, $\mu^\nabla = (1) \to (4) \to (10) \to (16) \to (21) \to (26) \to (31) \to (36) \to (37)$.

Step 2. According to Equation (12.1), for immediate predecessor activities of critical nodes, $FF_{35,37} = 3 < 30$, $FF_{20,26} = 15 < 30$, eigenvalues of other immediate predecessor activities of critical nodes are all bigger than or equal to 30. Delete these activities except activities $(20,26)$ and $(35,37)$, and delete activities which don't connect other activities. Put $FF_{35,37} = 3$ and $FF_{20,26} = 15$ into Ω^{37}, and get Fig. 12.2.

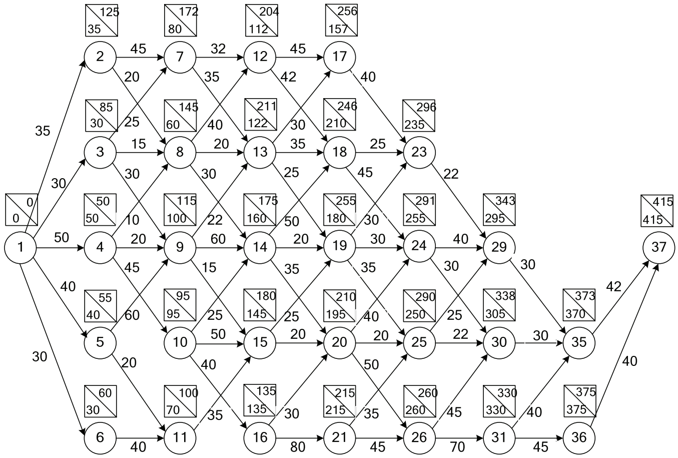

Fig. 12.2 The network after running Step 2

Step 3. Choose minimal eigenvalue $D_{37}(35,37) = 3$ from Ω^{37}.
Step 4. Make activity (35,37) as fundus activity, and find out its fore main chain μ_{35}^*, $\mu_{35}^* = (1) \to (4) \to (10) \to (16) \to (21) \to (26) \to (31) \to (35)$. Free float of each activity on μ_{35}^* is zero.

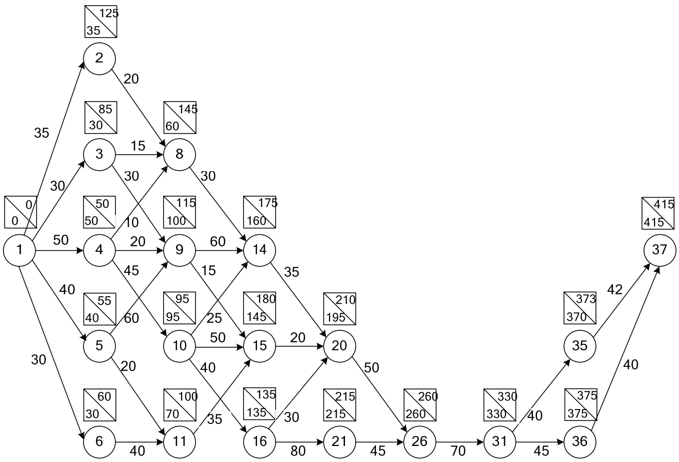

Fig. 12.3 The network after running Step 5

Step 5. For immediate predecessor activities of nodes on μ^*_{35}, according to Equation (12.1), $FF_{29,357} = 45 > 30$, $FF_{30,35} = 35 > 30$. Delete the two activities, and delete activities which don't connect other activities, then get Fig. 12.3.
Step 6. Choose the rest activity $(20,26)$ of Ω^{37} as new fundus activity, then $\mu^*_{20} = (1) \rightarrow (5) \rightarrow (9) \rightarrow (14) \rightarrow (20)$. For $FF_{3,9} = 40 > 30$, $FF_{4,9} = 30$, $FF_{8,14} = 70 > 30$, $FF_{10,14} = 40 > 30$, $FF_{15,20} = 30, FF_{16,20} = 30$, then delete these activities, and get Fig. 12.4.

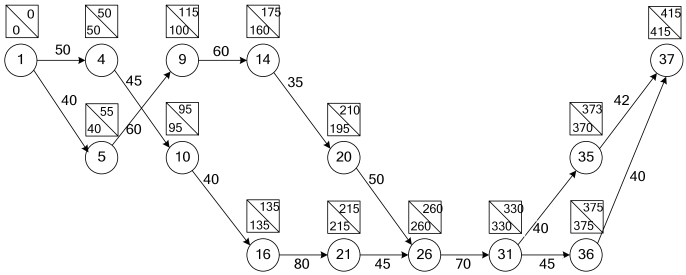

Fig. 12.4 The network after running Step 6

Step 7. Here $\Omega^{37} = \emptyset$, then stop. Fig. 12.4 is the simplest equivalent sub-network of original network.

It is equivalent to shorten total duration by 30 days in Fig. 12.1 and Fig. 12.4, but it is obvious that Fig. 12.4 is simpler than Fig. 12.4.

12.5 Conclusions

In this paper, according to the idea that simplify object of problem is equivalent to simplify any algorithms to solve the problem, problem of how to simplify super large-scale network to simple sub-network equivalently in time-cost tradeoff problem is analyzed mostly, which for realizing the purpose of any algorithms could be simplified to solve time-cost tradeoff problem, and final result would not be affected.

In the paper, firstly, the properties of free float are analyzed, the relations between free float of activity and length of path are found out, the free float theorem is deduced, and then the algorithm is designed to simplify super large-scale network when solving time-cost tradeoff problem by using the theory. The algorithm is simply and applied, and realizes the effect of simplifying object of problem and all correlative algorithms, which could decrease computation of solving time-cost tradeoff problem.

Free float theorem is important basic theory to study and apply CPM network planning, and help to study inherent rule of CPM network and properties of float more deeply. As direction of studying in future, we will deeply study the theory, open out inherent rule of CPM network, analyze and solve more correlative problems by combining these theories with practices.

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Chapter 13
Analysis on Forming Mechanism and Realization Path of Innovative Cluster

Hongchang Mei and Lingrui Liao

Abstract The traction of innovative cluster in the regional economic development is gradually highlighted. In this paper, the forming mechanism of its innovative ability and the realization path would be discussed. Through the theoretical analysis of the literature, combining with the analysis of the practical issues in the operation of innovative cluster at home and abroad, the article suggests that this forming mechanism derives itself from various factors, such as knowledge spillover, entrepreneurs, government leadership, the stimulation of entrepreneurship, different stages of industry life cycle and so on. At the same time, this paper offers some successful experiences of the innovative clusters all over the world to explain realization path. The paper argues that the problems existing in the developing process are associated with the lack of forming mechanism. Finally, the preliminary countermeasures about overall planning, introducing the subject of cultivation and developing the middle cooperative organization are proposed.

Keywords Innovative cluster · Forming mechanism · Realization path

13.1 The Definition and Feature of Innovative Cluster

Innovative cluster refers to the network system of new product production, value-added product processing and service which comes to be due to the cluster of related enterprises, universities, research institutions, and intermediate organization in certain area out of their demand for resources and historic reasons. Innovative cluster is a kind of enterprise group which is developed from mutual promotion and evolution between independent innovation and industrial cluster. The independent innovation

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covers component innovation, integrated innovation and re-innovation based on introduction and digestion, including technology and process innovation, organization and market innovation, system and culture innovation [8]. Innovative cluster does not share the same prominent features with ordinary industrial cluster. Their feature is different from that of the ordinary innovative cluster. For example, high-tech park of Silicon Valley is a high-tech cluster which is highly innovative. Silicon Valley enjoys absolute advantages in popularization and application of network informing technology, and biotechnology which runs after network informing technology. It utilizes new economy and new knowledge, attracts excellent scientist and venture capital to pursue highly efficient development. Bangalore industrial cluster, Zhongguancun IT industrial cluster and Cambridge computer soft hardware technology, space hardware and scientific instrument industrial cluster etc. are high-tech or high and new technology industrial clusters. But Italian industrial cluster can be regard as traditional industrial innovative cluster composed mainly of micro business. Its innovation and brand innovation closely connect to the family culture. The innovative cluster of logistics and commercial service has a more prominent feature in innovative organization network and commercial model. Innovative cluster can also transform from a traditional cluster to a modern one, from a manufacturing one to a R&D and design one, or to some brand new cluster with promising new energy technology. Their feature can be the favorable to lead the next economic prosperity.

13.2 Theoretical Analysis of Innovative Cluster Forming Mechanism

Many vital changes in the forming of innovative cluster cannot be traceable by researchers and demonstration is not suitable in analyzing its forming mechanism. Actually, there are a lot of relevant studies about its forming mechanism, mechanization, and ways. They can be concluded to five aspects:

(1) Utilizing the spillover effect of new economic knowledge

New economic growth theory shows that the increase of knowledge return in certain areas will contribute to the growth difference in areas. Because innovation and technology transforming are more dependent on economy than other business activities do. Therefore, economics pay more attention to analyzing the effect which the increased return, brought by spillover of institutions and enterprises, has on the economy growth. Although transportation cost, natural resources input, capital intensive, economic scale etc. will affect industries' geographic cluster, knowledge spillover in new economy has a strong impact on industrial cluster.That is why labs in universities can push private enterprises' innovative activities, and give birth to new biotechnology enterprises and NT enterprises.

(2) Entrepreneurs leading innovative cluster mechanism

Experience and network of entrepreneurs are the key factors to launch new enterprises. Entrepreneurs as representatives of economic transforming is capable of creating personal greater profit by promoting institutional environment favorable to local emerging industries in the way of servicing the society, utilizing the government resources to the utmost. Entrepreneurs, through provocative learning and practice, interest accumulation and expertise input, expanding the relation with universities government R&D institutions, forms a new entrepreneurial business, build and strengthen the new cluster with long term effect. However, the cluster given birth by entrepreneur leading mechanism will take a long time to form. The clusters' final allocation and sustainability are decided by policy environment and other resource bases during its growth [1].

(3) Government leading cluster innovative mechanism

Innovative cluster is a comprehensive network covers many aspects such as technology and economy. Many of its items involve government. The government pays attention to the innovative cluster's external mechanism and internal mechanism. Based on different mechanisms and policies, developing industrial cluster shall choose between externally oriented and internally oriented policies. External policy is through external way to utilize external network and attract foreign founded enterprises and talents to play leading roles in cluster building or to attract cluster investment. The reason why it is feasible is that the government does not allow the enterprises under the regional administration to get profit in their competition with each level of the society and it adjusts the strategic resources by advantageous means such as politics and legislations to reach its goal. For example, Singapore's biomedical cluster is formed through external mechanism. The Singapore government took four steps: First, Singapore set oversea strategic resident office. Second, Singapore introduced in global pharmaceutical industry giants by providing special tax preference. Third, Singapore attracted international senior scientists and engineers to lead R&D [3]. Forth, it built the local enterprises' R&D capacity. Internal mechanism is to develop local emerging industries dependent on local SME and to establish localization HR pool and build international enterprises with core competitive edge and global brands through providing tax exemption and subsidies to emerging enterprises and financially supporting cluster talents training in the universities.

(4) Entrepreneurship and innovative culture stimulating mechanism

How can a potential entrepreneurial idea be transformed into an initiative entrepreneurship. Some scholars already propose to encourage individuals to undertake risks and actively develop market innovation in the face of economic crisis and unemployment. Industrial reduction or huge unemployment may be caused by external factors, but it may also because the large-scale companies don't have the mechanism for the individuals with entrepreneur potential to set up their own business. Therefore, individual entrepreneurial ideas should have the condition to realize and entrepreneurial mechanism should be built through both internal and external mechanism policies. Developing venture capital inside the cluster shall be an effective way for the new company which just breaks away from the parent company. There are several ways to encourage the forming and development of the cluster such as to set up intermediate organization to serve the talent flow, the social network, for example, which connects managers of high level and technical personnel [2], to build infrastructure of high quality in the industrial park, and to provide first class working and living environment for R&D staff. Man has the in-depth motivation to start a business and realize their self-actualization through entrepreneurship and innovation. That can be an inner mechanism of entrepreneurship stimulating mechanism.

(5) Innovative cluster with different life cycle

Based on the geographic cluster tendency of innovative activities and the number of enterprises at different life stage [4], cluster innovative mechanism has its stages (See Fig. 13.1). Precisely speaking, innovative cluster with different life cycle cannot be included to innovative cluster forming mechanism. To put it in a specific way, the active innovation of universities and R&D institutions mainly lead industries' cluster of innovation at introduction stage. At the growing stage, skilled work force can promote the innovative. During this stage, venture investment begins to flood in. Enterprises enter the process of "trial and error" and "learning while doing". At the mature and declining stage, the industry enters the entrepreneurial environment with complete functions and the passive innovation begin to centralize due to enterprises. From the following forming mechanism, building innovative cluster needs to lay different emphasis on different stages.

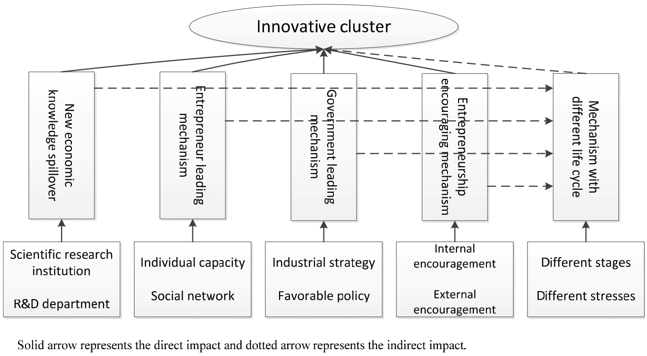

Fig. 13.1 Innovative cluster forming mechanism

13.3 Realization Path of an Innovative Cluster

(1) Utilize knowledge spillover effect

The entire developing process of innovative cluster is accompanied by the spillover effect of knowledge. After absorbing the new knowledge, individuals inside the cluster achieve self-study, mutual learning and re-innovation. We should be aware of the fact that knowledge spillover is not only limited to the inside of the cluster, the outside of the cluster can also be a main source of spillover. In an open environment, cluster's knowledge updating speed will be accelerated. Therefore, strengthening the connection between the cluster and the external enterprises or institutions might as well be an effective approach to enhance the innovation capacity of cluster.

Bangalore, the well-known high-tech city all over world, contributes its huge development of software technology cluster to the utilization of new technology and new knowledge spillover to the utmost. Through the flow of these high-tech talents who master the technique and innovation knowledge among enterprises, Bangalore successfully utilizes the knowledge spillover effect. A large number of high-tech talents does not only put forward the cluster development, but also attract a lot of world known software companies to set subsidiaries and seek partnership here. Industrial tycoons such as IBM, Microsoft, Oracle, Hewlett Packard, and Motorola come to Bangalore to set R&D institutions. Their annul input into R&D takes up 9% of their annual earnings, far higher than that of the local enterprises in Bangalore.

During the technology exchange with the world first class multinational corporation, India gets product outsourcing from 185 of 500 fortunes which take up one forth of the IT tycoons. Therefore, Bangalore grasps firmly of the opportunities brought by outsourcing. It vigorously carries out technician trainings and enhances project management capacity to bear more complicated projects so that can realize the upgrade from low side of original equipment manufacturer to high side of the value chain. The multinational corporations bring more foreign direct investment to Bangalore. With the flow of FDI, new technology and knowledge are also brought to the cluster. Undoubtedly, it is utilizing knowledge spillover effect to pursue technology and management innovation that speeds up the IT upgrade in Bangalore.

(2) The government leads the way

The formation and development of the innovative cluster cover many aspects such as technology, economy, policies, so the cluster is not able to enjoy a fast development within this comprehensive network by only relying on the entrepreneurs. Therefore, it is necessary for the government to engage into some parts of its development. Actually, from the experience form the cluster development both home and abroad, we can see that governments of local or even state level do not only take part into this process by providing relevant favorable policies, but also play a leading role among the cluster. During the process, the government's focus shall be helping the cluster to resolve two problems. One is that leading enterprises shall drive the development of the cluster. The other one is the cost that the enterprises care the most.

Within four years, Chonqing Laptop Industry has developed into a cluster in the "$5+6+700$" model that "brand + manufacturer + supporting enterprise", a model of government leading. In order to introduce investment of the world famous enterprises into Chongqing, Chongqing as an inland city shall solve the high logistic cost first. Given that the "whole machine+ parts" vertical integration plan proposed by laptop processing trade cluster of Chongqing, the target of localizing 70%-80% of the parts highlight the urgent need for Chongqing to construct more inland ports. Then, most of the products produced by laptop manufacturers in China got to Europe mainly by sea. However, after more than 30 days transport time, the market price of the product would fall a lot. Therefore, the Chongqing Municipal Government officially requested General Administration of Customs and Ministry of Railways to launch five fixed trains, which opened the south front Eurasia Land Bridge with the reputation of "new silk" road. Actually, the land bridge had been opened for more than 20 years. But due to the monopoly of the countries along the bridge and the severely lack of port capacity, the land transportation was far more expensive than the sea transportation and product storage was severely large. Therefore, although the south front land bridge was the shortest channel connecting China and West Europe, enterprises were not able to utilize it. In order to change the situation fundamentally, Chongqing government has Germany, Poland, Russia, the Republic of Belarus, Kazakhstan, holds six parties talk among five countries which set a multilateral negotiation mechanism and test experimental trains twice. Through one year and some, "Cooperation Memorandum on Promoting the Formal Transportation of "Yuxinou" International Railway" (See Fig. 13.2) was signed among countries and "Yuxinou" company was set up to realize interest share and to guarantee product from Chongqing can reached Germany in 14 day. "Yuxinou" international railway transportation also came into use. During this process, the convenient custom clearance treaty signed among China, Russia and Kazakhstan pushed forward the negotiation. It sets that products sent by the three countries can undergo the custom only once, which make Chongqing the only western city to enjoy a fast and convenient custom clearance.

Fig. 13.2 "Yuxinou" international railway

Meanwhile, Chongqing's success in getting the Hewlett Packard project in its fierce competition with Chengdu shall be contributed to the government who can grasp the opportunity and adapt to the changing circumstance. As the Wenchuan earthquake happened, Chongqing Delegation was negotiating with the heads of Hewlett Packard. Hearing about the earthquake, the delegation immediately revised the report, and explained thoroughly to them the stability of the geologic structure. Their preparation convinced the heads of HP, and erased their concerns about the security of their investment in Chongqing. Firstly, in its real effort to solve the housing problem of "sandwich class", including fresh college graduates, migrant workers and new urban residents, Chongqing has taken the lead in initiating the public rental housing project under the proposed general principle of "required oversupply" in China. In pursuing its objective to construct 40 million squire meters or more for its housing project, Chongqing government encountered the problem of shortage of both land and capital. However, thanks to its land banking system initiated in 2002, the land problem has been resolved nicely. In 2002, the government authorized eight state-owned investment enterprises in unifying its efforts of land expropriation and regulation, which has reserved enough land for its rental housing project through such means as industrial restructuring, relocation of old factories, replacements between colleges, requisition of rural collective land, etc. To be specific, it was no longer necessary for government to repurchase the land from the property developers, reducing the initial cost of 150 billion yuan to 70 billion, which became the largest hit in the Chongqing rental housing project. With respect to the collection of construction fund, a ratio of 3 : 7 between government investment and financing credit was adopted by the Chongqing government. Put together, three channels of capital investments have been utilized, of which the first was the fees paid by the government for land expropriation in the previous years, the second was 5% of the annual proceeds generated by land leasing while the third was the special funds earmarked by the central government and the annual financial budget fund of the Chongqing government. The remaining financial deficit was dealt with market means like bank loan, housing fund, social security fund and commercial insurance. Consequently, it enabled the employees of the enterprises to rent a satisfactory house with a price below the market standard, relieved the pressure of enterprises to build more staff quarters. Furthermore, the reform of household registration system of Chongqing has transformed thousands of rural residents who meet the requirements into the urban population without any compromise regarding their social benefits of employment, housing, health care and education when comparing with urban residents, changing the tradition of "agricultural people to be given non-agricultural status". Put more concisely, they could continue to keep the contracted land and housing land and benefit from the farming policies formulated by the central government. Combined, these policies have greatly promoted the number of rural residencies transforming to the urbanized, securing the needed workforce of Chongqing industry, solving the problem of shortage of labor that was common in the coastal areas.

(3) Paths in realizing the entrepreneurship and culture of innovation

The essence of realizing entrepreneurship and innovation culture is to foster a sense of individual pioneering and independent innovation, setting up a platform to transform this spirit into the specific actions. However, this path proves to be very time-consuming as the cultivation of spirit and culture is not a matter of a single day, but a long-term accumulation for an area. Thus, on the one hand, an incentive mechanism for starting business shall be built within the cluster, reducing the threshold of business pioneering and inviting the high-tech talents to join and fostering new enterprises. On the other hand, a culture to encourage adventurism shall be formed, in order to reduce the loss of business failure and motivate enterprises to make mistakes.

The success of Silicon Valley, the forerunner and model of innovative industry cluster, has demonstrated that the development of a cluster cannot be attained without high technology, capital and the support of government policies, and particularly, the huge impetus of individual pioneering spirit and innovation culture deeply rooted in that area. It is exactly the lack of this impetus that fails the efforts of other areas to replicate another Silicon Valley despite their huge investment of manpower, material and financial resources. Feathering the adventurism, failure tolerance and valuing talents in their free flow, the innovation culture has to a great extent inspired the free pioneering work of people in the Silicon Valley.

The reason that the rapid development of Silicon Valley is not hurdled and the passion of starting businesses is not discouraged is the incentive mechanism for starting businesses that tolerates failure. In the initial stage of business, the pioneering team will quantify the technological achievements to determine the stock share taken up by each person. This means that the personal value outweighs the collective one, informing the start-ups that their returns will be completely determined by the business performance and development potential of the company and their intellectual investment and efforts will be repaid in stock rights. In this mechanism, the pioneering spirits will be greatly unleashed and people will give full play to their intelligence and wisdom and work diligently to reap the huge economic benefits and realize their social values.

Meanwhile, the proximity of Silicon Valley to such world-wide famous universities as Stanford University and University of California, Berkeley also plays an important role in its development. Silicon Valley has benefited from these top-notch specializations and first-class laboratories whose continuous scientific achievements have offered a driving force and guarantee to the Silicon's development. A research initiated by Sequoia in 2011, a venture-capital firm, indicated that the establishment of 39,900 enterprises in Silicon Valley could date back to Stanford, put together as a nation; they could be nine times larger than the world GDP. Namely, each year, these enterprises will create 5 400 000 jobs for society and their general revenue totals 27 00 billion USD [5]. Undoubtedly, Stanford has become the most important source of innovation for Silicon Valley. The alumnus of Stanford, from common employees to founders of world-wide outstanding enterprises, often goes back to their alma mater to conduct activities like exchanging with students, recruitment, giving speeches and co-research with the university [7]. The connection with the universities has not only enabled them to have access to the latest research resources, but also kindled the passion of students to start their own businesses. In addition, opportunities for participating in the social practices are offered by Stanford to let students master more skills of starting a business.

These policies greatly mobilize the scientific research staff on entrepreneurship and strengthen the capability of scientific research institutions of enterprises and universities, which enables the enterprises in the Silicon Valley to utilize the scientific research resources to a maximum degree.

13.4 Cultivation Mechanism Deficiency of Domestic Innovative Clusters

Innovative cluster forming is determined by multiple factors and the completeness of forming mechanism in the cluster operation is relative and preliminary, therefore, to identify and solve these problems is the task embodied in the developing process of innovative cluster.

Currently, most industrial clusters in China are driven by foreign-funded enterprises or big companies, whereas the small and medium-sized enterprises or domestic enterprises choose to upgrade their products and technology through learning and imitating new knowledge and technology, which helps them save high development costs and avoid risks involved in innovation investment and technological spillovers. Moreover, they can share the profits brought up by model change in the short term [6]. However, in the long run, this would lead to the stagnation of domestic technology development and deficiency of capability of independent innovation. The acquisition of standardized technology for foreign-funded enterprises or big companies by simply relying on enterprise network outside cluster, or limiting the application of its critical technologies for keeping their advantage and safety of technological innovative ability, would greatly undermine the technology spillover effects that can be utilized by domestic enterprises, which, together with the deficiency of independent innovation, will result in their extrusion of cluster network. This is harmful to the growth of cluster. Meanwhile, unreasonable distribution mechanism for technological innovation profits and property order in big state-owned enterprises that have the ability to become independent innovative entities, and unsound incentive system for bolstering innovation in enterprises, have contributed to low initiative of R&D staff.

There is another problem facing the small and medium-sized enterprises or domestic ones in the innovative cluster, which is, the entrepreneurs are not equipped with needed educational experiences and knowledge level. Despite their adventure spirit, they can only rely on their experiences to manage enterprises and move cautiously due to their deficiency of relevant knowledge system. Alternatively, they may have a certain background of professional skill, but lack scientific operation principle and management methods, igniting a kind of blindness in business management. They are unable to pinpoint the orientation of the company in the cluster, but blindly follow the trend, which places the enterprises in a passive position in the market. Such enterprises will not attach importance to and have consciousness and capability of innovation, a big disadvantage for the growth of enterprises and the cluster as well.

While leading the development of innovative cluster, the government is also beset with the problem of improperly handling complementary relationship between endogenous development and outside imports. It is hard to promote the industrial innovation if the government's aim for developing innovative cluster exceeds its own function and meaning.

Another important issue is that the development process of many of our innovative cluster is accompanied by the whole transfer of industry chain. The transfer of transnational enterprises or leading enterprises in the cluster drives the matching manufacturers to move along with them, realizing the whole package-type transfer. In such a cluster, a strong connection network has been established among enterprises, resulting in promotion of mutual trust between organizations and their exchange of knowledge information, and reducing their operational costs. For the time being, the domestic enterprises in the new place can not easily enter this connection network. Meanwhile, for protecting the key technology, some cluster tends to exclude outsiders, further limiting the driving effect of the cluster. For instance, in the transfer of the cluster of Taiwan laptop to the mainland, the contractors of Taiwan designated two or three components suppliers through the certification system, whereas the technology transfer does not happen in the fundamental innovation, but on a scale of process model change [9].

What's more, because of the impact that the market competing environment and poor credit condition have on the upgrading and transforming of industry, lack of coordination between local government and enterprises have highlighted the messy division of labor in the industry [10]. Problems also exist in aspects like coordinating different areas and developing a sound vertical and horizontal system for division of labor, repeated layout of cluster and similar industrial structure. Furthermore, numerous newly introduced enterprises have battled for resources against the local, worsening the constraint of resources. In addition to lack of mutual trust, subjects in the cluster area have not developed a close partnership with universities and R&D institutions. The weakness in incubation and technological diffusion and absence of effective professional cooperation mechanism for labor division prevented the innovative cluster from becoming a powerhouse for regional economic development in many areas.

13.5 Conclusion and Suggested Measures

Based on the analysis of problems about innovative cluster, our measures and suggestions focus on the following aspects:
(1) Strengthen people's awareness of cluster innovation, give play to the leadership role of government and make strategic planning for developing innovative cluster

We must fully realize the important role of innovative cluster in restructuring and industrial upgrading, cultivate new economic powerhouse, seize the opportunities of economic and technological development, take the commanding height of growing high-end industry and emerging industry in the post-crisis era and take a comprehensive view on planning the positioning, objective, strategic measures and organizing mechanism of developing a innovative cluster. We must properly handle the relationship between industrial planning and cluster growth, between innovative model and core competitiveness, between the interests of cooperating enterprises in the cluster and economic prosperity in the region, so that a innovation community, policy system and supporting mechanism for the sustainable development of innovative cluster will be formed.

(2) Reinforce importing and cultivating innovative entities and improve the capability of cluster in producing new products through scientific and technological achievements

Innovation-oriented enterprises, entrepreneurs and technological staff are the driven force for developing innovative cluster. On the industrial cluster' way to independent innovative capability, the medium and small-sized enterprises are easy to take their roots, but we shall always put the policy of introducing big innovation-type enterprises and talents in the first place as these subjects can lead to the introduction of an entire innovative cluster at a particular time. Meanwhile, we must prioritize expanding the army of high-level innovative entrepreneurship, encourage the R&D investment in enterprises, build a R&D platform and organization for technological innovation service, perfect the functions for informing service, products R&D, design demonstration, technical training in order to promote the technological innovation activities in the cluster.

(3) Build and improve such professional service organizations in the cluster as technology alliance and upgrade the capability of the cluster in the cooperation for innovation

Innovative cluster consists of enterprises that focus on industrial cooperation around new technology, new products and new market. To establish professional service organizations like industrial technology alliance could help coordinate the government's policy on industry, strengthen cooperation between different industries, improve the image of the entire cluster on one hand, and deepen mutual learning, increase innovation opportunities and help realize cluster innovation and win-win cooperation by means of jointly developing technology in the program and product technology market, learning through exchanges of knowledge and technology, friendly communications, etc.

(4) Strengthen the intellectual property right protection and establish a corresponding property right system, encourage the independent innovation in the cluster

In the early development stage of the cluster, properly loose intellectual right protection is beneficial to enhancing the spillover effect of technology and knowledge, the overall technological progress in the cluster and cultivation of new enterprises. With the development of the cluster, in order to gain a continuous competitiveness edge, the sustainable development driving force shall come from independent innovation in the innovative cluster. To secure the fair return and just compensation of the proprietor of innovation and knowledge and stimulate the passion of scientific research staff, a accommodative property right system must be set up.

(5) Establish a complete social service mechanism, reinforce the professional training for entrepreneurs and encourage the flow of resources to small and medium-sized enterprises

Through professional learning and exploration in practice, entrepreneurs accumulate human capital whose number in return would influence their decision on operating management. Therefore, government agency shall strengthen its efforts to improve the education and training of entrepreneurs, planning a professional training that covers the knowledge of professional skill, economic management and the latest development in world economy, and updating their consciousnesses. In the meantime, the support on capital, technology and policy shall be strengthened accordingly, decreasing the market barrier and encouraging resources to flow to small and medium-sized enterprises in the cluster.

(6) Breed a garden culture that inspires entrepreneurship and innovation

An innovative garden culture can exert its spontaneous effect in the developmental process of cluster and promote the R&D and innovation inside the cluster, which is indispensable to a innovative cluster. To this end, local government shall provide subsidies and draft incentive policies to support university R&D and individual entrepreneurship. Meanwhile, enterprises in the cluster shall make efforts to stimulate the passion for innovation, encourage their bold attempt so as to create a cultural tradition that incite risk-taking, challenging new technology summit and tolerate failures and errors, so that generations of innovative talents in the industrial cluster will be cultivated.

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Chapter 14
The Study of User Download Behavior in Application Stores and Its Influencing Factors

Changzheng He, Wei Shu and Dongyue Du

Abstract The study of user download behavior and its influencing factors will contribute to a deep understanding of the application stores and provide some practical guide to the operation of application stores. Based the classic RFM model and the actual situation of the application stores, this paper develops the TDRFM model to describe the application stores' user download behavior. We use the K-means clustering and Group Decision Making method based the behavioral indicators and obtains four user types: the high-value uses, general-value users, loss user. Then, we study the impact of the system upgrade and the product attributes to users' download behavior by using the statistical analysis. The results show that the application store upgrade has no significant impact on the high-value users while have a significant effect on the general-value and potential-value users download behavior. The impact of application type, development type price, review and application size on users has been verified. This paper provides a method of studying user behavior in application stores.

Keywords Application store · User download behaviour · TDRFM model · Influencing factors

14.1 Introduction

The mobile internet is innovative business mode, which is growing fast. It combines the mobile communications and the internet as a whole. Its pace of development has caught up with the traditional internet. It's an important driving force for the network

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economic. The application stores are the key nodes of the mobile internet industry chain. After the App Store pioneered by Apple gained great success, various types of application stores are springing up all over the world. The study of application stores' user download behavior and its influencing factors will contribute to a deep understanding of the application store and provide some practical guides for the operation of application stores.

As a new business mode, little attention has been paid to the study of the application stores. Current research consists of three parts. First, the product development in application stores. For example, Bergvall-Kareborn and Howcroft [1] considered the problem of application product development; Liu et al [2] analyzed the development trend of the medical applications in the application stores; Ning [3] analyzed the developer's incentive strategy in application stores. Second, the operating strategy of application stores. For example, Ghezzi et al [4] analyzed core competitiveness of the application store industry. Tuunainen [5] discussed the critical factors for application stores' success. Third, marketing strategy in application stores. For example, Bellman [6] verified the validity of brand strategy. Gans [7] explored product pricing issues in application stores. In addition, the study also included empirical analysis of the consumers' use intention and usage behavior by Li [8].

The application store is a typical two-sided market platform. The platform operators provide application product services to both buyers and sellers to facilitate transactions. On the one hand, the application stores provide one-stop service from purchase (downloads) to use for mobile internet users. Therefore, how to match the interests of the both sides and enhance the integrated value of each node of the industrial chain has become the urgent problem of the application stores. Therefore, the research on user download behavior as well as customer value evaluation plays a vital role.

14.2 User Segments Based on Behavioral Variables in Application Stores

14.2.1 Behavior Variable Selection

User value identification is the basis of value-oriented differentiation in marketing. The classic approach use the RFM model to measure the user value by using past buying behavior [9]: purchase time (Recency, R), the number of purchases (Frequency, F) and the purchase amount (Monetary, M). For the application store operators, they are not only concerned about the direct profit of application download but also indirect profit caused by the free application download. So this paper develops a TDRFM model based on the original RFM model which describes the user's download behavior in the application stores. The meaning of each variable in the

TDRFM model as follows:

T : last download time, which measures the time interval of last users download.

D : users' total number of download in the study period.

R : last purchase time, which measures the time interval form the most recent purchase.

F : total number of purchases.

M : total purchase amount in the study period.

14.2.2 Data Processing

The data for model building was from the database of China's W application store, including users download recorded data from May 10, 2010 to September 22, 2011. We sorted out TDRFM variable values by excel.

First, delete the users which download less than 10 times and the users have more than 180 days away from last download. This is because these users enter into the application stores by chance. Obviously they do not belong to regular users. We gained 1280 users' download records (N) as the sample data, which includes 245 purchase records (n). The statistics describe the characteristics of the users are shown in Table 14.1.

All the data are standardized; because the indicator variables T, D and R, F, M in the model have different units of measurement. The Max-Min standardization method is used as follow:

$$X' = (X - X^s)/(X^l - X^s), \tag{14.1}$$

$$X' = (X^l - X)/(X^l - X^s), \tag{14.2}$$

where X' is the standardized value, X is the original value, X^s is the minimum value of the variable , X^l is the maximum value of the variable.

There is a negative relationship between $T(R)$ and customer value, so their standardization should use Equation (14.3). However, the index D, F and M have a positive relationship with user value, so their standardization should use Equation (14.1).

Table 14.1 Sample descriptive statistics ($N = 1280$, $n = 245$)

Variable indicators	Mean	Std.Dev.	Min	Max
Last download time (T)	205	174.936	1	500
users' total number of download (D)	94.86	119.067	1	1395
Last purchase time (R)	297.66	118.464	1	499
Total number of purchase (F)	5.20	5.810	1	48
Total amount of purchase (M)	14.873	20.261	0.1	195.07

14.2.3 *K*-means Clustering

K-means is a commonly used clustering method in marketing segmentation. The algorithm flow is simply described as follow:
Step 1. Randomly selected K object from the data set as initial cluster centers;
Step 2. Find which cluster it belongs to for each object based on its distance from the initial centers;
Step 3. Update the cluster centers based on the average of each cluster;
Step 4. Repeat Step 2 until each cluster centers no longer change.

Numerous studies of user value clustering based on the RFM model [10–12] have been done. Similarly, we get final number of clusters of 5. After clustering, we will analyze each cluster to see if the indicators are greater than (equal) or less than the overall customer base average. Table 14.2 shows the clustering results.

Table 14.2 K-means clustering result

Cluster number	Count	T-means	D-means	R-means	F-means	M-means	Type represents
I	568	77.268	98.364	445.586	2.172	5.56	$T\downarrow D\uparrow R\uparrow F\downarrow M\downarrow$
II	527	393.918	40.524	444.385	3.385	9.98	$T\uparrow D\downarrow R\uparrow F\downarrow M\downarrow$
III	165	60.176	194.982	242.697	4.909	13.04	$T\downarrow D\uparrow R\uparrow F\downarrow M\downarrow$
IV	9	94.556	294.333	185.667	27.556	98.41	$T\downarrow D\uparrow R\downarrow F\uparrow M\uparrow$
V	11	12.455	851.636	319.333	6.667	18.47	$T\downarrow D\uparrow R\uparrow F\uparrow M\uparrow$
Overall	1280	205	94.86	297.66	5.20	14.873	—

Definition 14.1. If a cluster average of R (or F, M, T, D) value is greater than (or equal to) the R (or F, M, T, D) mean over all the customers. We denote this cluster of as R (or F, M, T, D)↑; If a cluster average of R (or F, M, T, D) values less than the mean R (or F, M, T, D), then this cluster of is represented by R (or F, M, T, D)↓.

From the Table 14.2, we can see:
Cluster I: Users have the shorter download cycle times. They have higher D-value than the overall average. Their purchase frequency and purchase amount are very small.
Cluster II: Users in this cluster have the largest T-value and the second largest R-value which indicates that there is a long time that these users are not logged in the application stores. Their purchase frequency and purchase amounts also are very low.
Cluster III: Users download a large amount, but the number of purchases and the purchase amount is smaller or slightly lower than the overall average.
Cluster IV: has the highest number of download (F), the largest total amount of purchase (M-value).
Cluster V: Users have a very short period for download (T). They often login on the

application store application to download and belong to the stores' loyal users, but they rarely pay for the applications.

14.2.4 User Value Evaluation

Application store is an innovative business mode. Different people have different behavior which is reflected in the weight of the variables in TDRFM model. In order to determine these weights, we use the famous group decision making method Analytic Hierarchy Process (AHP) [13]. Eight members are invited which consist of two applications store personnel, two loyal users, two mobile internet observers and two scholars. The relative importance of behavioral variables in TDRFM is obtained by the formation of scale judgment matrix through pairwise comparison. The final weight is calculated as follows.

$$W = (W_T, W_D, W_R, W_F, W_M) = (0.0601, 0.2632, 0.1098, 0.2829, 0.2840).$$

After getting the weights, we use the following formula to calculate the composite score to measure the customer value.

$$\text{Score}_i = \sum_{k=T,D,R,F,M} (k_b - \text{means})_i \times W_k \; (i = 1, 2, 3, 4, 5), \tag{14.3}$$

where Score_i represents the value scoring for the customer in cluster i. It is the weighted average of the variable after the standardization. After calculating, we gained the value of each cluster of application store user as shown in Table 14.3.

Table 14.3 User value segmentation

Cluster number	T_W-means	D_W-means	R_W-means	F_W-means	M_W-means	Score	Ranking
I	0.0509	0.0184	0.0118	0.0071	0.008	0.096	4
II	0.0128	0.0075	0.0120	0.0144	0.0144	0.061	5
III	0.0530	0.0366	0.0565	0.0235	0.0189	0.1887	3
IV	0.0488	0.0554	0.0691	0.1598	0.1432	0.476	1
V	0.0587	0.1606	0.0396	0.0341	0.0268	0.320	2

We can see from Table 14.3, the value of cluster IV and V users rank the highest, then come cluster III and I. The value ranking of cluster II is the lowest of all, which is also consistent with our previous qualitative description. The users of high loyalty correspond to the higher value. The users' loyalty is low because a long time not logging in the application stores (such as cluster II), so their value is low.

14.2.5 Analysis of User Behavior Characteristics

We combine the results of Tables 14.2 and 14.3 to analyze the characteristics of the user download behavior of different sub-groups. Table 14.4 gives the description.

Table 14.4 The description of user type

Cluster number	Number of users	Number of purchase	Value ranking	Type description
I	568	29	4	Regular free users
II	527	39	5	Loss user
III	165	165	3	Regular paid users
IV	9	9	1	Golden paid users
V	11	3	2	Golden free users

(1) High-value users

Users in cluster IV download a large amount and buy the highest number. The amount of consumption is also the largest for this cluster and their value rank the highest. We call them the gold paid subscribers. They are the direct source of application store revenue.

Users in cluster V have the largest number of download and the download cycle is very short. They often login on the application stores to download and belong to the stores' loyal customers. Their value rank the second. They are called the application store golden free users. Although such users will not directly provide profit to the stores, they play a crucial role in the operation of the entire application store platform.

The golden paid users and golden free users belong to the high-value users with high degree of loyalty. Application stores should pay more attentions to maintain good client relationships with them.

(2) General-value users

Users of cluster III are regular paying customers. They download a large amount. Each user has purchase behavior, but the purchase amount is smaller than the overall average. Their values rank the third. They are the general-value user.

Such users are mainly paid subscriber. They have the habit of buying application software. They have great consumption potential. So the application store operators should stimulate and guide their purchase. For example, they should take the promotional tools to enhance their buying consumer strength. However, they only occupy 12.89% of the overall users, which indicates that the few people are willing to pay customers in the application stores and most users are unwilling to pay.

(3) Potential-value of the users

Users in cluster I are regular free users which represent the typical user groups of the application stores in China. They do not want to spend money to buy mobile phone application software. Only a handful of users will accidentally buy the product.

Regular free users are the users with potential-value. Their free consumption behavior is caused by consumption habits. The application stores cannot expect to change their spending habits, but can gather the profit by business mode innovation such as advertising. They will bring indirect profit. So to develop the value of such users can also become an important source of profit.

(4) Loss users

Users in this cluster are loss users. They have a very long time (mean 13 months) not logging in the application stores to download. The operators do not need to put more efforts to this users.

14.3 Impact of Application Stores' Upgrade on the User Download Behavior

Application store upgrade is the operational development of a series of functions carried out by the application stores which include the improving, repairing, and operation. The purpose of upgrade is to make the application stores basis platform more complete and powerful and attract more users.

In this paper, we select a major upgrade in the W Application Store on March 6, 2011 to analyze the customer value change before and after this upgrade. The study time period is divided into two stages:

Before the upgrade: May 10, 2010 to March 2011, 5th, a total of 300 days.

After the upgrade: March 6, 2011 to September 2011, 21, a total of 200 days.

Table 14.5 The results of t-test of user value change before and after upgrade

Categories of users	Behavioral indicators	Test results	Analysis
High-value users	Number of download per hundred days Number of download per hundred days Purchase amount per hundred days	Accept the null hypothesis Accept the null hypothesis Accept the null hypothesis	Application stores upgrade had no significant effect on high-value users' download behavior
General-value users	Number of download per hundred days Number of download per hundred days Purchase amount per hundred days	Reject the null hypothesis Reject the null hypothesis Reject the null hypothesis	Application stores upgrades have a significant effect on the general-value and potential-value users download behavior
Potential-value users	The number of download per hundred days	Reject the null hypothesis	

We set the research hypothesis H_0 as: There is no significant change in behavioral indicators before and after the application store upgrade. By using independent samples t-test analysis, we try to verify this hypothesis. The results are shown in Table 14.5.

Table 14.6 Various types of classification standards used on the indicators

Type of application	Price level (x stands for price)	Score level (x stands for score)	Review number (x stands for the number of review)	Application size (x stands for application size, units: M)
Game class	Low price ($x < 3$) Medium price ($3 \leq x < 5$) High price ($x \geq 5$)	Poor evaluation ($x \leq 3$) Medium evaluation ($3 < x \leq 4$) High evaluation ($x > 4$)	Less review ($x \leq 1$) Medium review ($1 < x \leq 3$) Much review ($x > 3$)	Small applications ($x \leq 0.5$) Medium applications ($0.5 < x \leq 2$) Large applications ($x > 2$)
Tools class	Low price ($x < 5$) Medium price ($5 \leq x < 10$) High price ($x \geq 10$)	Poor evaluation ($x \leq 3$) Medium evaluation ($3 < x \leq 4$) High evaluation ($x > 4$)	Less review ($x \leq 1$) Medium review ($1 < x \leq 3$) Much review ($x > 3$)	Small applications ($x \leq 0.5$) Medium applications ($0.5 < x \leq 1$) Large applications ($x > 1$)
Reading class	Low price ($x < 2$) Medium price ($2 \leq x < 4$) High price ($x \geq 4$)	Poor evaluation ($x \leq 3$) Medium evaluation ($3 < x \leq 4$) High evaluation ($x > 4$)	Less review ($x \leq 1$) Medium review ($1 < x \leq 3$) Much review ($x > 3$)	Small applications ($x \leq 0.5$) Medium applications ($0.5 < x \leq 1$) Large applications ($x > 1$)

14.4 Impact of Product Attribute on User Download Behaviour

The product attributes of application of include application type, developer type, quality, price, review, and application size. During the time of the download, users more or less will consider these attributes factors. By using independent samples t-test and ANOVA analysis, we investigate the impact of above factors on the applications downloads. We focus on the high-value, general-value and potential-value users of and of the user. A total of 1749 applications are selected, which include 517 game applications, 483 application of the tool and 749 reading class application. In order to facilitate the examination and analysis of price level, score level, the number of reviews and application size, these four indicators is discretized into three types. The criteria for the classification are shown in Table 14.6. The test results are shown in Table 14.7.

Table 14.7 Various types of classification standards used on the indicators

Factors		Test methods	Test results
Application type (games, tools and reading)		Single factor analysis of variance	Application type has impact on download
The type of developer Individual (developers and corporation developers)		Independent samples t-test	Developer type has effect on download
Pricing	Whether free	Independent samples t-test	Whether free has a significant effect on application downloads
	Price level	Single factor analysis of variance	Price level has significant effect on the tool application but no effect on the game and reading application
Review	With or without reviews	Independent samples t-test	Users download more applications with review than application without reviews
	Score level	Single factor analysis of variance	Only high score level only tools have significant impact on download.
	Number of reviews		The more number of comments, the more the downloads
Application size		Single factor analysis of variance	Application size has effect on the game and reading application download but no significant effect on tool application downloads

14.5 Conclusions

Based on the user data in application stores, this paper analyzed the users' download behavior variables, segments users based on their value. Three types of user are identified: high-value customers, general-value of users and potential-value user. We also analyzed the impact of application store upgrade and product attributes on the user download behavior. The following conclusions can be drawn:

- High-value users are golden users in application stores and they are direct source of profit. The general-value users are accustomed to pay to download applications. Application stores operators should through enhance their purchase motivation by using operator promotions;
- Upgrade of the application stores significantly affect user download behavior of high-value user but do not have a greater impact on the general-value users and potential-value users.

- Application type, pricing, reviews and application size have a significant effect on users download behavior.

This paper provides a deep understanding of customer behavior in application stores.

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Chapter 15
An Empirical Study of Customer Behavior Online Shopping in China

Minxi Wang, Huimin Zhi and Xin Li

Abstract With the rapid development of e-commerce, the transaction size online increased rapidly, so the e-commerce service quality and customer satisfaction become more and more important. How to increase service quality and improve customer satisfaction is becoming the research focus. In the paper, we construct an online customer satisfaction model which includes technology acceptance model (TAM) and quality-value-satisfaction (QVS). And design a questionnaire including 27 questions. Then investigate and collect empirical data through internet. Use method Structural Equation Model (SEM) to process data and analyze the reliability and verify the hypothesis. The results of the study demonstrate that security, privacy and positive online shopping experience have important implications to customer behavior online shopping in China.

Keywords E-commerce · Customer behavior · Customer satisfaction · Technology acceptance model (TAM) · Quality-value-satisfaction (QVS)

15.1 Introduction

According to the 31th China Internet Development Statistics Report published by China Internet Network Information Center (abbreviated as CNNIC) in January 2013, the internet users was up to 564 million in china, and the online shopping users reached 242 million, Online shopping utilization rate increased to 42.9%. The

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scale of e-commerce applications, including online shopping, online payment, online banking, travel reservations grow rapidly [1]. With the rapid development of e-commerce, the e-commerce service quality and customer satisfaction become more and more important. How to increase service quality and improve customer satisfaction is becoming the research focus. The third-party e-commerce platform is an independent business acts as a resource integration role, integrate each of the participating parties into the organism based transactions and services, such as Taobao, Tmall, Jindong, Amazon etc. The third-party e-commerce platform is the subject of a service provider, it's service model, service quality, customer satisfaction raised a higher and more standardized requirement.

In this paper, we construct an online customer satisfaction model which includes technology acceptance model (TAM) and quality-value-satisfaction (QVS). We design a questionnaire including 27 questions. Investigate and collect empirical data through internet. Use method Structural Equation Model (SEM) to process data and analyze the reliability and verify the hypothesis. The results of the study demonstrate that security, privacy and positive online shopping experience have important implications to customer behavior online shopping in China. The results should be a reference to improve the service strategy for e-commerce.

15.2 Literature Review

15.2.1 Technology Acceptance Model (TAM) in E-commerce

(1) The emergence and development

Technology Acceptance Model (TAM) was put forward by Davis in 1986, which based on the theory of Reasoned Action [2], was mainly used to study the problem of effectively predict acceptance of information technology, give a user acceptance model to the information system. The initial purpose is to make an explanation of decisive factor for computer widely accepted model. In this model, there are two major determinants on the technology acceptance [3]: perceived usefulness (PU), which reflect a person considers that the degree of work performance can be improved using a specific system; perceived ease of use (PEOU), which reflect a person considers that the system uses the degree of ease.

TAM model Think the use of a system is determined by the behavioral intention (BI), the BI is determined by the desired attitudes and perceived usefulness, perceived usefulness and perceived ease of use determine the attitudes. Perceived ease of use influence perceived usefulness, and related variables influence. The related variables include system design features, user characteristics, the nature of the development or implementation process, organizational structure, etc. [4].

With the wide application of the TAM, the initial model was found inadequate. Venkatesh and Davis [5] have been many times improvements for this model. They proposed an extended technology acceptance model in order to improve the explanatory power. In extensive model, the related variables were divided into: social impact (subjective norm, voluntary, Impression) and cognitive structure (applicability, output quality, possibility of the results). Then experience was added to variables, through the influence on perceived usefulness and perceived ease of use to the final system usage behavior. This model states that customer decision on whether use information technology on two main factors: usefulness and ease of use [6, 7]. After this time, many studies have proved that inherent causal relationship in the model of the various factors [8]. In 1995, Straub [9] use TAM model to research the relationship between perceived usefulness and behavioral effects, confirmed the direct impact, then published the improved technology acceptance model. In 2000, Venkatesh [10] gave a further research, added social impact, perception site operational efficiency and other factors to the model.

(2) TAM and online shopping

Online shopping is a new shopping way, customer need to use the computer and Internet technology, so TAM model was widely used in the study of online shopping behavior [11], which can be used to predict consumer online shopping behavior. Lin and Judy use TAM model to test the degree of consumer acceptance for online shopping website. The results showed that: Perceived ease of use was not significant direct effect on purchase intention [12]. Aron and Tino [13] use TAM to analyze the online shopping behavior of customer, their findings indicate that TAM is a valid theoretical framework, also Internet users' perceived usefulness and perceived ease of use were effected positively to online shopping attitude. Pavlou and Donna [14, 15] add trust factor and risk factor to TAM model, use questionnaire and scenario test method, the result showed the two factors directly affect the intended use. Im et al [16] add four potential variables to TAM: perceived risk, technology type, user experience, and gender - in users' technology adoption. Their moderating effects were tested in an empirical study of 161 subjects. Results showed that perceived risk, technology type, and gender were significant moderating variables. However the effects of user experience were marginal after the variance of errors was removed.

15.2.2 Quality-Value-Satisfaction Model (QVS)

Cronin et al's research [17] showed that influential factors of Behavioral Intentions include: Service Quality (SQ), Service Value (SV), Customer Satisfaction (SAT). The QVS model is a better explain to consumer behavior compare other competing models, it has been verified in B2B and entities in the retail environment.

(1) Service quality

Service Quality is customer compare with service expectation and actual performance [18]. The electronic Service Quality is customer perceived service quality when shop online, it's subjective [19]. Zeithaml [20] defined e-Service Quality as the effective shopping, purchasing, and delivery of products and service. Most of service quality research focuses on the influencing factors and measurement, five influencing factors were reliability, responsiveness, security, Empathy and tangible

[21]. But few service quality research are from the point of view of the consumer's perception [22].

(2) Service value

Zeithaml [23] defined Service Value as: customer compare perceived service quality and pay for the obtained, also as Multiplier Model. And proposed service value model. Haksever et al [24] put forward six elements for service value model: perceived quality, internal attributes, external properties, currency prices, non-monetary prices and time. Katariina et al [25] divided service value into four levels: service attributes, service quality, service value and service personal value.

(3) Customer satisfaction

Customer satisfaction is a state of mind after the customer's needs are met, is the assessment the gap between expectation and actual perception [26], it reflects the level of customer perception. Brady [27] think customer satisfaction significant impact on purchase intention or buying behavior, and service quality is the pre-variable to satisfaction. Lin and Wu [28] find: network customer expectation is the direct cause affect their satisfaction, the formation of expectation result from combined effects of various factors. For example: past experience in online shopping, purchase specific needs and Web sites reputation.

From the literature research we know: the external variables of TAM model will produce perceived usefulness and ease of use, both of them determine customer behavior intention, then promote specific purchase behavior. Online shopping experience has impact on online shopping behavior. And demonstrate that there is a causal relationship between service quality and customer satisfaction. All these research are basis for this research hypothesis.

15.3 Empirical Study

15.3.1 Research model and Hypothesis

(1) Research model

According to the literature study, we construct a causal model of online shopping customer satisfaction for the third-party e-commerce website.

Hypothesis theoretical model is shown in Fig. 15.1.

Behavior intention determines purchase behavior, and purchase behavior is combined affected by service value, service quality, customer satisfaction, personal preferences and online shopping experience. Service value and service quality are combined affected by usefulness, ease of use, privacy and security, at the same time, service quality affect service value and customer satisfaction, customer satisfaction also affected by expected utility.

Detailed function is expressed as follows:

- Purchasing behavior= f(Behavior intention),

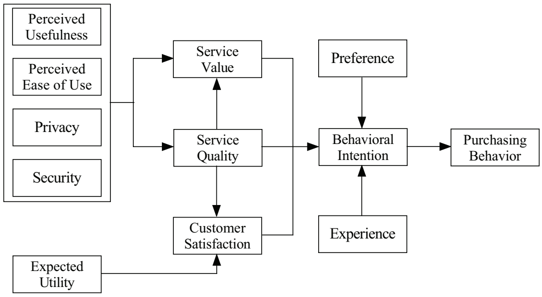


Fig. 15.1 Hypothesis theoretical model

- Behavior intention= f(service value, service quality, customer satisfaction, personal preference, experience),
- Service value= f(service quality, usefulness, ease of use, privacy, security),
- Service quality= f(usefulness, ease of use, privacy, security),
- Customer satisfaction= f(service quality, expected utility),

where, Behavior intention is customer subjective intention and the possibility for purchasing behavior in the future. Usefulness is the effects when customer shopping on the third-party e-commerce website. Ease of use is the ease level of using e-commerce website. Privacy is the trust e-commerce website protect the privacy when shopping online. Security is the assurance of safety for third-party e-commerce website payment system, payment process. Experience is successful online shopping experience in the past. It can increase purchase confidence and promote behavior intention. Preference is customer special preference to certain commodities, shops or shopping channels, It can promote behavior intention.

(2) Research hypothesis

Construct the research model based on behavior intention include 17 kinds of hypothesis as follows:

H1a : usefulness have a positive impact on the service value;
H1b : usefulness have a positive impact on the service quality;
H2a : ease of use have a positive impact on the service value;
H2b : ease of use have a positive impact on the service quality;
H3a : privacy have a positive impact on the service value;
H3b : privacy have a positive impact on the service quality;
H4a : security have a positive impact on the service value;
H4b : security have a positive impact on the service quality;
H5 : there are certain relationship between expected utility and customer satisfaction;
H6 : service quality have a positive impact on the service value;
H7 : service quality have a positive impact on customer satisfaction;
H8 : customer satisfaction have a positive impact on behavior intention;
H9 : service quality have a positive impact on behavior intention;
H10 : service value have a positive impact on behavior intention;

H11 : there are certain relationship between personal preference and behavior intention;

H12 : experience (positive in the past) have a positive impact on behavior intention;

H13 : behavior intention have a positive impact on purchasing behavior (actual transaction practice).

The research model based on behavior intention includes 12 structural variables (11 antecedent variables, 1 outcome variable). They are usefulness, ease of use, privacy, security, service value, service quality, customer satisfaction, personal preference, experience, expected utility, behavior intention, purchasing behavior.

15.3.2 Questionnaire Investigation

According to the model variables, we design a questionnaire, the detailed information in Table 15.1.

The questionnaire includes 27 questions. We use Likert scale, 1means strongly opposed, 7 means strongly agree, the other numbers between them. All respondents give scoring according to one's own online shopping experience. At the end of questionnaire, we design an open question, respondents can supplement based on their own experiences.

Based on questionnaire items, we get hypothesis model as Fig. 15.2.

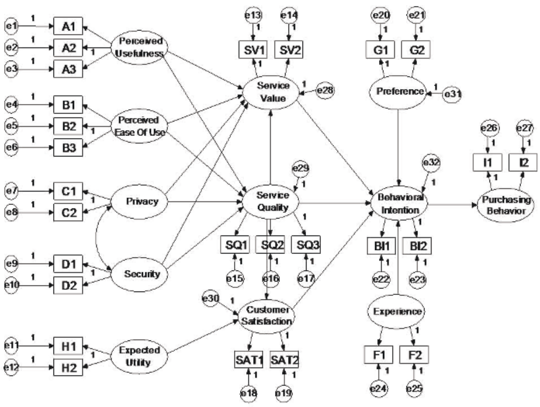


Fig. 15.2 Hypothesis model map

Table 15.1 Questionnaire items

Variable		Indicator	Item
Usefulness (A)	A1	Shopping speed	Online shopping complete quickly
	A2	Shopping comparison	Easy to make a comparison shopping
	A3	Information request	Easy to obtain the useful information
Ease of use (B)	B1	Started guide	Easy to learn to use the Internet online shopping
	B2	Easy to use	Easy to find what I want
	B3	Flexible interaction	Flexible interaction
Privacy (C)	C1	Secure storage	Privacy on the website will not be compromised
	C2	Merchants credit	Web site protects information about credit card
Security (D)	D1	Purchase security	It's security to use credit card on the web site
	D2	payment security	Payment is security
Expected utility (E)	E1	Online shopping results	Online shopping product meet demand
	E2	Online shopping	Online shopping bring surprise
Experience (positive) (F)	F1	Online shopping experience	Positive online shopping experience
	F2	Sellers comparison	I get from the online shopping service is excellent
Personal preference (G)	G1	Preference	It's a good idea using online shopping
	G2	Like	Like using online shopping
Service value (SV)	SV1	Value for purchased	Online shopping goods is worthy
	SV2	Value returns	Additional process of online shopping is worthy
Service quality (SQ)	SQ1	Goods consistent	Purchased goods is consistent to the description
	SQ2	Sellers attitude	Good sellers attitude
	SQ3	Service remedy	Service failure occurs, quickly resolve and reach your requirements
Customer satisfaction (SAT)	SAT1	Web site evaluation	Be satisfied with the website
	SAT2	Service evaluation	Be satisfied with the online shopping experience
Behavior intention (BI)	BI1	Lifestyle	Online shopping fit my lifestyle
	BI2	Intention	I would participate in online shopping
Purchasing behavior	I1	Behavior	I carefully compare the goods when purchase
	I2	Application	I prefer to Group buy

15.3.3 Data Collection and Analysis

We use the designed questionnaires to collect data, the survey objects include students in university, teachers and company staffs who have online shopping experience. Others as a sample supplement. The data collection method is random.

(1) Sample analysis

We distributed 2000 questionnaires, and received 1657 questionnaires, the effective questionnaires were 1072 except some unqualified questionnaires. Questionnaire recovered efficiency is 64.96%, some missing values in the questionnaire filled with average value by SPSS18.0. The obtained sample data characteristics are shown in Table 15.2.

Table 15.2 Sample data characteristics

Index	Item	Frequency	Percentage	Index	Item	Frequency	Percentage
Sex	Male	591	55.1	Monthly	¥0-1000	816	76.12
	Female	481	44.9	income	¥1001-2000	90	8.39
Education	Ba	862	80.4		¥2001-3000	128	11.94
	Ma or above	210	19.6		¥3001-4000	30	2.8
Age	Less than 20	172	16.04		More than ¥4001	8	0.75
	20-40	892	83.21				
	More than 40	8	0.75				

(2) Reliability analysis

We use Cronbach's Alpha coefficient as the standard of reliability test, in this scale, the Cronbach's Alpha is 0.946, general condition, the internal consistency and stability of the collected sample data are good (see Table 15.3).

Table 15.3 Reliability table

Cronbach's Alpha	Standard of Cronbach's Alpha	Item
.945	.946	27

And we check reliability for every potential variable in questionnaires, the results in Table 15.4.

The Cronbach's Alpha coefficient in every subscale is > 0.9, and in the total scale the Cronbach's Alpha coefficient is up to 0. 945, it shows this scale with high reliability.

(3) Model hypothesis test

(a) Model adaptation degree analysis

Table 15.4 Reliability of potential variable

Potential variable		Cronbach's Alpha	Potential variable		Cronbach's Alpha
Usefulness (A)	A1	.943	Personal preference (G)	G1	.942
	A2	.942		G2	.942
	A3	.942	Service value (SV)	SV1	.942
Ease of use (B)	B1	.942		SV2	.943
	B2	.943	Service quality (SQ)	SQ1	.942
	B3	.942		SQ2	.942
Privacy (C)	C1	.942		SQ3	.944
	C2	.944	Customer satisfaction (SAT)	SAT1	.944
Security (D)	D1	.944		SAT2	.943
	D2	.943	Behavior intention (BI)	BI1	.943
Expected utility (E)	E1	.943		BI2	.944
	E2	.944	Purchasing behavior	I1	.942
Experience (positive) (F)	F1	.943		I2	.943
	F2	.943			

Richard et al [29] suggested using χ^2/df to test the model adaptation degree, the ratio should be the smaller the better. Some researchers believe that the value of the ratio χ^2/df should be within 3. In this test, the ratio $\chi^2/\mathrm{df} < 3$, GFI < 0.9, AGFI > 0.8, RMR > 0.0572, RMSEA < 0.08, most of them meet the requirements. The details showed Table 15.5.

Table 15.5 Model adaptation degree test

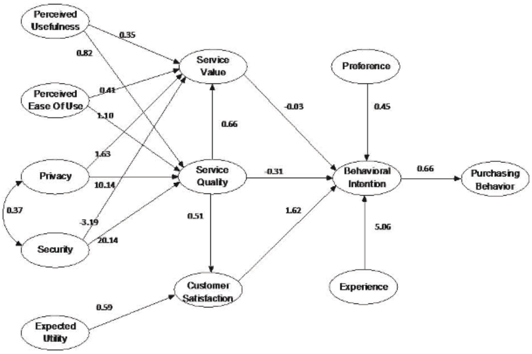
Statistical tests	Result data	Model adaptation degree
Absolute adaptation index		
χ^2/df	2.537	yes
RMSEA	0.044	yes
GFI	0.889	no, but acceptable
AGFI	0.957	yes
PGFI	0.514	yes
CFI	0.957	yes
RMR	0.0572	no, but acceptable

General considerations, most of the indicators are within the reference range, so we can use improved SEM model to process the raw data, and to assess customer perceived service quality.

(b) Path map analysis

After the software AMOS 18.0 analyze, we obtained the non-standardized path model map, showed as Fig. 15.3. Where, double arrow symbol number is the co-variance of two variables, Digital above single arrow symbol is path coefficients external variables to internal variables. The data upper right the potential variable and error item is variance.

Fig. 15.3 Path coefficient map



The detailed hypothesis test results shown in Table 15.6.

Table 15.6 Hypothesis test results

Hypothesis	Hypothesis content	Support	Hypothesis value
H1a	Usefulness have a positive impact on the service value	yes	0.35
H1b	Usefulness have a positive impact on the service quality	yes	0.82
H2a	Ease of use have a positive impact on the service value	yes	0.41
H2b	Ease of use have a positive impact on the service quality	yes	1.10
H3a	Privacy have a positive impact on the service value	yes	1.63
H3b	Privacy have a positive impact on the service quality	yes	10.14
H4a	Security have a positive impact on the service value	no	−3.19
H4b	Security have a positive impact on the service quality	yes	20.14
H5	There are certain relationship between expected utility and customer satisfaction	yes	0.59
H6	Service quality have a positive impact on the service value	yes	0.66
H7	Service quality have a positive impact on customer satisfaction	yes	0.51
H8	Customer satisfaction have a positive impact on behavior intention	yes	1.62
H9	Service quality have a positive impact on behavior intention	no	−0.31
H10	Service value have a positive impact on behavior intention	no	−0.03
H11	There are certain relationship between personal preference and behavior intention	yes	0.45
H12	Experience (positive in the past) have a positive impact on behavior intention	yes	5.06
H13	Behavior intention have a positive impact on purchasing behavior (actual transaction practice).	yes	0.66

The results meet the research hypothesis.

(4) The empirical results analysis

From the path map, we can see 66% of customer purchase behavior can be explained by the behavior intention (0.66), indicate that the hypothesis model have strong predictive ability. Simultaneously, we can see from the potential variable path coefficients:

- Among the five factors influencing behavior intention. All factors have significant impact to behavior intention except service value, the descending order by influence degree is: satisfaction (1.62), preference (0.45), service quality (−0.31).
- The path coefficients of expected utility to customer satisfaction is 0.59, there is a positive correlation between expected utility and customer satisfaction. According to the gap hypothesis model, the higher expected utility, the greater positive impact on customer satisfaction.
- The path coefficients of service quality to customer satisfaction is 0.51, there is a positive correlation between service quality and customer satisfaction, the service quality is a pre-variable with a positive effect on customer satisfaction.
- Among the five factors influencing service quality, the descending order is: security (20.14), privacy (10.14), ease of use (1.10), usefulness (0.82).
- The path coefficients of service value to behavior intention is −0.03, service value is a little negative relationship, not very significant effect on behavior intention, this variable can be removed.

15.4 Conclusions

The empirical research showed: security, privacy and experience are the pre variables to behavior intention. And behavior intention is the unique variable to effect purchase intention. In other words, security, privacy and positive online shopping experience has important implications on customer purchase behavior.

According to this conclusion, the third-party e-commerce website should improve security, and the protection of customer privacy, and effective customer satisfaction. In addition, the third-party e-commerce website should integrate resources, improve usefulness and ease of use of website, reduce the customer cost of learning and searching information.

But there are some limitations in this research, such as survey object and scope of investigation are limited, the variables, model, data processing method could be further improved. In addition, environmental factors, customer individual characteristics and psychological factors can also affect behavior intention, and then affect customer purchase behavior. With the deep research, the quality - value - satisfaction model could be constantly adjusted and improved. They are going to be improved in our future research.

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Chapter 16
The Periodic Solutions of the Model of Drop Formation on a Coated Vertical Fibre

Zehra Pinar 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 Painlevé expansion. Here, we present a well known auxiliary equation method that 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 sixth-degree nonlinear term are presented to obtain novel exact solutions of the leading-order evolution equation which is the model of drop formation on a coated vertical fibre.

Keywords The auxiliary equation technique · The model of drop formation on a coated vertical fibre · Wave solutions

16.1 Introduction

Over the past decades, it is greatly significant to find travelling wave solutions to nonlinear evolution equations have been proposed or developed and furthermore modified [1–3]. Varied methods for obtaining exact travelling wave solutions to nonlinear equations have been presented, such as the Hirota's bilinear method, the Backlund transformation, the Painlevé expansion method, the Homogeneous balance method, the tanh function method, the Jacobi elliptic function method and the F-expansion method. Among these methods, one of the current methods is so called auxiliary equation method [20–24]. The technique of this method consist of the solutions of the nonlinear evolution equations such that the target solutions of

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the nonlinear evolution equations can be expressed as a polynomial in an linearly independent elementary function which satisfies a particular ordinary differential equation which 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 [25, 26, 30, 32]. A concise observation shows that novel exact solutions of the auxiliary equations may fabricate original exact travelling wave solutions of nonlinear equations. Therefore, it is very important to find novel exact solutions of the auxiliary equations.

In this paper, we will examine the consequences of the choice of the auxiliary equation for determining the solutions of the model of drop formation on a coated vertical fibre in consideration and to seek more types of new exact solutions of nonlinear differential equations which satisfying a first-order nonlinear ordinary differential equation with a sixth-degree nonlinear term.

16.2 Auxiliary Equation Technique and Some Remarks

We assume that the given nonlinear partial differential equation for $u(x,t)$ to be in the form:

$$P(u, u_x, u_t, u_{xx}, uxt, u_{tt}, \cdots) = 0, \tag{16.1}$$

where P is a polynomial in its arguments, which includes nonlinear terms and the highest order derivatives.

Then, using the transformation $u(x,t) = u(\xi)$, $\xi = \mu(x - ct)$ one can reduce Equation (16.1) to the ordinary differential equation:

$$Q(u, u_\xi, u_{\xi\xi}, u_{\xi\xi\xi}, \cdots) = 0. \tag{16.2}$$

Now, we seek the exact travelling wave solutions of Equation (16.2) 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 (16.2), let us assume that the exact solution can be expressed as simple expansion in the form of:

$$u(\xi) = \sum_{i=0}^{N} a_i z^i(\xi), \tag{16.3}$$

where a_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 a_i, $(i = 0,1,\cdots,N)$, where $u(\xi) = \sum_{i=0}^{N} a_i z^t(\xi)$. 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 a_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 (16.3) in general.

Fan [27] developed a new direct algebraic method to seek additional types of new exact solutions of evolutionary nonlinear differential equations that can be expressed as polynomials in several elementary or special functions which satisfy a first- order nonlinear ordinary differential equation with a fourth-degree nonlinear term:

$$\left(\frac{dz}{d\xi}\right)^2 = a_0 + a_1 z(\xi) + a_2 z^2(\xi) + a_3 z^3(\xi) + a_4 z^4(\xi), \tag{16.4}$$

where a_i $(i = 0,1,3,4)$ are constants. The method has been applied to find many exact traveling wave solutions of various types of nonlinear equations [27–29]. Sirendaorejii [21] and Abdou [30] utilized Equation (16.4) for the case a_i $(i = 2,3,4)$. Perhaps, it is significant to point out that the choice of the case i.e. a_i $(i = 2,3,4)$ permits analytical solution of the first- order nonlinear ordinary differential equation with a fourth-degree nonlinear term as Nickel's. This property of the nonlinear ordinary differential equation with a fourth-degree nonlinear term used in large in the references [20–23], for example, for the case a_i $(i = 0,2,4)$ and in the references [21, 22] for the case a_i $(i = 2,3,4)$ for Equation (16.4) to find many exact travelling wave solutions of various types of nonlinear equations.

In this paper, we seek for the solution of Equation (16.2) in terms of ansatz (16.3) with $z(\xi)$ satisfying the following new auxiliary equation with a sixth-degree nonlinear term i.e.

$$\left(\frac{dz}{d\xi}\right)^2 = a_0 + a_2 z^2(\xi) + a_4 z^4(\xi) + a_6 z^6(\xi), \tag{16.5}$$

where a_i $(i = 0,2,4,6)$ are real constants. The new solutions of the auxiliary Equation (16.5) 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 (16.5) provides numerous types of special solutions. Hence, in Equation (16.3), the parameter N is a positive integer and can determined by balancing the higher order derivative term and highest power nonlinear terms in Equation (16.2) The highest degree of $\frac{\partial^p u}{\partial \xi^p}$ can be calculated by:

$$\begin{cases} \mathscr{O}\left[\frac{\partial^P u}{\partial \xi^p}\right] = N + p, \quad p = 0,1,2,\cdots \\ \mathscr{O}\left[u^q \frac{\partial^P u}{\partial \xi^p}\right] = qN + p, \quad p = 0,1,2,\cdots \end{cases} \tag{16.6}$$

Consequently substituting Equation (16.3) and Equation (16.5) into Equation (16.2) 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 (16.3) and the auxiliary Equation (16.5), we can get the exact solutions for Equation (16.1).

16.3 Exact Travelling Wave Solutions

In this section, we are going to combine the auxiliary equation method with the new solutions of original auxiliary Equation (16.6) with a six-degree nonlinear term to consider the leading-order evolution equation derived by Trifonov [36] and Frenkel [35] for $(h_0 = R) \ll 1$:

$$h_t + \left(\delta h^3 (h_{xxx} + h_x) + \frac{2}{3} h^3\right)_x = 0, \tag{16.7}$$

where $= \frac{2ah_0}{3\rho g R^3} = \frac{2H^2 h_0}{3R^3}$, measures the ratio of curvature-driven flow of the Rayleigh instability to the gravity driven mean flow. The film thickness h_0 is taken to be that of the initial waveless film and it has been used to scale the interfacial height. The fibre radius R is used to scale the axial coordinate x and the characteristic time used is $R = U$ where $U = (gh_0^2/2\nu)$ is the interfacial velocity of the film. As a result of the scaling, the thickness of the initial wave less film is always unity. The critical condition $h_0 = h_c$ now corresponds to a critical $\delta_* = 1.12$. It is sometimes convenient to present the graphics in a frame becomes:

$$h_t + \left(\delta h^3 (h_{xxx} + h_x) + \frac{2}{3} h^3 - ch\right)_x = 0. \tag{16.8}$$

Typically, c is chosen to be the pulse speed of an equilibrium subcritical pulse at the particular value of δ. It is hence well-defined only for subcritical values of δ, $\delta < \delta_*$. To find the travelling wave solutions for Equation (16.8), we use the wave variable $\xi = \mu(x - mt)$, where $m \neq 0$ and $\mu \neq 0$. The wave variable ξ carries Equation (16.8) into the ordinary differential equation:

$$mh' + 3\delta h\mu^4 h^2 h'{}'' h' + 3\delta\mu^2 h^2 h'^2 + \delta\mu^4 h^3 h^{(4)} + \delta\mu^2 h^3 h'' + 2\mu h^2 h' - c\mu h' = 0. \tag{16.9}$$

From Equation (16.3), and using Equation (16.9) we have $N = 1$. Therefore, the ansatz yields:

$$\mu(\xi) = g_0 + g_1 z(\xi), \tag{16.10}$$

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.

Example 16.1. We first consider, the auxiliary equation with six-degree nonlinearity, i.e.

$$\left(\frac{dz}{d\xi}\right)^2 = a_2 z^2(\xi) + a_6 z^6(\xi). \tag{16.11}$$

The solution of Equation (16.11):

$$z(\xi) = \frac{e^{(\sqrt{a_2}(-\xi+c_1))}2^{1/4}}{\left(\frac{a_6 e^{(4\sqrt{a_2}(-\xi+c_1))}}{a_2 \mathrm{Lambert}w\left(-\frac{a_6 e^{(4\sqrt{a_2}(-\xi+c_1))}}{2a_2}\right)}\right)^{1/4}}, \tag{16.12}$$

we believe, a new solution in the literature.

Hence, substituting Equation (16.10) and Equation (16.11) into Equation (16.9) and letting each coefficient of $z^i(\xi)\sqrt{a_2 z^2(\xi) + a_6 z^6(\xi)}$, $(0 \le i \le 8)$ to be zero, we obtain:

$$\begin{cases} 36 + 741 a_2 \mu^2 = 0, \\ 4\delta g_0^3 - 4c + 79\delta\mu^2 a_2 g_0^3 = 0, \\ m + 2\mu g_0^2 = 0. \end{cases} \tag{16.13}$$

Solving the system (16.13) by the aid of Maple 13, we can determine the coefficients:

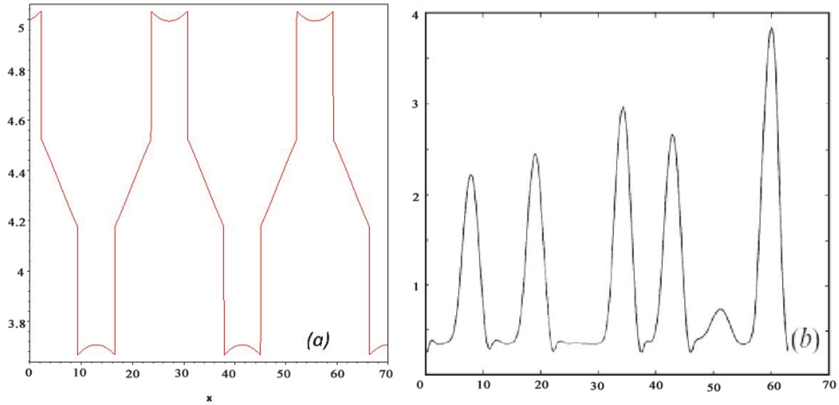
$$c = \frac{10}{247}\delta g_0^3,\ m = 2\mu g_0^2,\ \mu = \mu,\ a_2 = -\frac{12}{247\mu^2},\ g_0 = g_0.$$

Substituting the above coefficients into ansatz (16.10) with the solution (16.12) of auxiliary equation, we obtain one of new solution of the leading-order evolution equation:

$$\begin{aligned} h(x,t) = {} & \frac{24700^{(1/3)}(c\delta^2)^{(1/3)}}{10\delta} + g_1\Bigg(\cosh\Bigg(-\frac{1}{4}\mathrm{LambertW}\Bigg(\frac{247}{24}a_6\mu^2 \\ & \Bigg(\cosh\Bigg(4\sqrt{-\frac{12}{247\mu^2}}\Bigg(-\mu(x - \frac{\mu 24700^{(2/3)}(c\delta^2)^{(2/3)}t}{50\delta^2}) + \_CI\Bigg)\Bigg) \\ & +\sinh\Bigg(4\sqrt{-\frac{12}{247\mu^2}}\Bigg(-\mu\left(x - \frac{\mu 24700^{(2/3)}(c\delta^2)^{2/3}t}{50\delta^2}\right) + \_CI\Bigg)\Bigg)\Bigg)\Bigg) \\ & + \frac{\left(-4\mu\left(x - \frac{\mu 24700^{(2/3)}(c\delta^2)^{(2/3)}t}{50\delta^2}\right) + 4\_CI\right)\sqrt{-\frac{12}{247\mu^2}}}{4}\Bigg) \end{aligned}$$

$$
\begin{aligned}
&+\sinh\left(\frac{1}{4}\mathrm{LambertW}\left(\frac{247}{24}a_6\mu^2\left(\cosh\left(4\sqrt{-\frac{12}{247\mu^2}}\right.\right.\right.\right.\\
&\left.\left(-\mu\left(x-\frac{\mu 24700^{(2/3)}(c\delta^2)^{(2/3)}t}{50\delta^2}\right)+\_CI\right)\right)+\sinh\left(4\sqrt{-\frac{12}{247\mu^2}}\right.\\
&\left.\left.\left.\left(-\mu\left(x-\frac{\mu 24700^{(2/3)}(c\delta^2)^{(2/3)}t}{50\delta^2}\right)+\_CI\right)\right)\right)\right)\\
&\left.\left.+\frac{\left(-4\mu\left(x-\frac{\mu 24700^{(2/3)}(c\delta^2)^{(2/3)}t}{50\delta^2}\right)+4\_CI\right)\sqrt{-\frac{12}{247\mu^2}}}{4}\right)\right).
\end{aligned}
\tag{16.14}
$$

The graph of the Equation (16.14) is illustrated for selected values of coefficients given in Fig. 16.1.



(a) **(b)**

Fig. 16.1 Graph of Equation (16.14) (a) is the extended auxiliary solutions for the values $\delta = 3, c = 10, g_1 = 1, a_6 = 1$, (b) is for the same values obtained by Chang and Demekhin [33]

As it is seen in Fig. 16.1, the solution is obtained by the extended auxiliary equation method is more stable than the solution which is obtained by a high-order finite-difference scheme method in Chang and Demekhin [33].

Example 16.2. We, next, consider the auxiliary equation with six-degree nonlinearity, i.e.

$$\left(\frac{dz}{d\xi}\right)^2 = a_4 z^4(\xi) + a_6 z^6(\xi). \tag{16.15}$$

The solution of Equation (16.15):

$$z(\xi) = \frac{\sqrt{(-a_6 + a_4^2\xi^2 - 2a_4^2\xi c_1 + a_4^2 c_1^2)a_4}}{-a_6 + a_4^2\xi^2 - 2a_4^2\xi c_1 + a_4^2 c_1^2}, \tag{16.16}$$

we believe, a new solution in the literature.

Substituting Equation (16.10) and Equation (16.15) into Equation (16.9) and letting each coefficient of $z^i(\xi)\sqrt{a_2 z^2(\xi) + a_6 z^6(\xi)}$, $(0 \le i \le 8)$ to be zero, we obtain

$$\begin{cases} -2c + 2\delta g_0^3 = 0, \\ 2\mu g_0^2 + m = 0, \\ 465 g_0^2 a_6 + 669 g_1^2 a_4 = 0, \\ a g_0 + \beta g_0^3 = 0, \\ 3a_6\delta g_0^3 - 3a_6 c + 24\delta\mu^2 g_0^3 a_4^2 + 12\delta g_1^2 g_0 a_4 = 0, \\ 21 a_6 g_1^2 + 543 a_6 a_4 \mu^2 g_0^2 + 150\mu^2 g_1^2 a_4^2 + 12 a_6 g_0^2 + 5 a_4 g_1^2 + 90\mu^2 g_0^2 a_4^2 = 0. \end{cases} \tag{16.17}$$

Solving the system (16.17) by the aid of Maple (16.13), we can determine the coefficients:

$$c = \frac{12639}{3215648}\sqrt{8013126}\,\delta g_1^3, \quad g_0 = \frac{g_1\sqrt{8013126}}{1268}, \quad g_1 = g_1, \quad \mu = \mu,$$
$$a_4 = -\frac{1268}{12639\mu^2}, \; a_6 = \frac{717089504}{24760369755\mu^2}, \quad m = -\frac{12639}{1268}\mu g_1^2.$$

Substituting the above coefficients into ansatz (16.11) with the solution (16.16) of auxiliary equation, we obtain another new solution of the leading-order evolution equation:

$$\begin{aligned} h(x,t) = \;& \sqrt{8013126}104161346087065377^{(1/3)}(c(121411\sqrt{8013126} \\ & +\sqrt{118118532889469046})\delta^2)^{(1/3)}/(11754374398 14\delta) \\ & +2104161346087065377^{(1/3)}(c(121411\sqrt{8013126} \\ & +\sqrt{118118532889469046})\delta^2)^{(1/3)}\Bigg(-1268\Bigg(-\frac{717089504}{24760369755\mu^2} \\ & +1607824(x-\mu 104161346087065377^{(2/3)}(c(121411\sqrt{8013126} \\ & +\sqrt{118118532889469046})\delta^2)^{(2/3)}t/(86211871304437923\delta^2))^2/ \\ & (159744321\mu^2) - 3215648\_CI(x-\mu 104161346087065377^{(2/3)} \\ & (c(121411\sqrt{8013126}+\sqrt{118118532889469046})\delta^2)^{(2/3)}t/ \\ & (86211871304437923\delta^2))/(159744321\mu^3) + \frac{1607824\_CI^2}{159744321\mu^4}\Bigg)/ \\ & (12639\mu^2)\Bigg)^{(1/2)}\Bigg/\Bigg(1854002271\delta\Bigg(-\frac{717089504}{24760369755\mu^2} \\ & +1607824(x-\mu 104161346087065377^{(2/3)}(c(121411\sqrt{8013126} \end{aligned}$$

$$+\sqrt{118118532889469046})\delta^2)^{(2/3)}t/(86211871304437923\delta^2))^2/$$
$$(159744321\mu^2) - 3215648\_CI(x - \mu 104161346087065377^{(2/3)}$$
$$(c(121411\sqrt{8013126} + \sqrt{118118532889469046})\delta^2)^{(2/3)}t/$$
$$(86211871304437923\delta^2))/(159744321\mu^3) + \frac{1607824\_CI^2}{159744321\mu^4}\Bigg)\Bigg). \tag{16.18}$$

The graph of the solution is illustrated for selected values of coefficients given in Fig. 16.2.

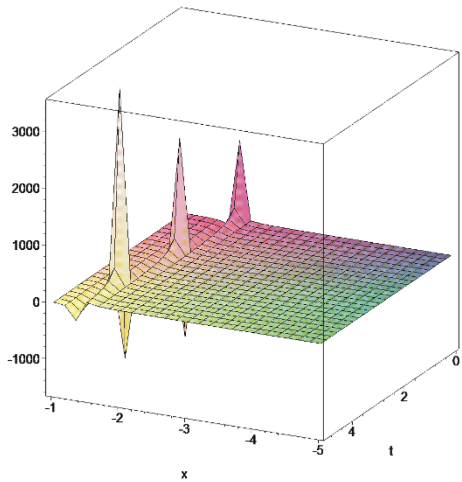


Fig. 16.2 Graph of Equation (16.18) for $\delta = 1, \mu = 1, C1 = 0$

16.4 Conclusions

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 (16.5)):

$$\left(\frac{dz}{d\xi}\right)^2 = a_0 + a_2 z^2(\xi) + a_4 z^4(\xi) + a_6 z^6(\xi),$$

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 (Equation (16.5)) 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 et al [20], Sirendaoreji [21], Jang [22], Lv et al [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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Part II
Information Technology

Chapter 17
Searching a Fit in IT Alignment for Japanese Firms

Michiko Miyamoto, Shuhei Kudo and Kayo Iizuka

Abstract A firm develops a business strategy, chooses the structure and management processes, aligns IT, and ensures that employees are trained and their roles are well designed in traditional theories of how information technology applied [27]. This paper empirically investigates a fit between the strategy, organization's structure, management processes, individual roles and skills, and IT, in order to achieve the strategy to gain a competitive advantage among Japanese enterprises by using the MIT90s framework [18]. 258 Japanese firm-level data collected have been analyzed using structural equation modeling. These results would contribute for achieving a strategic sit for the Japanese firms by showing effective tasks and environment to be focused.

Keywords Strategy · Fit · MIT90s model · SEM

17.1 Introduction

Information technology has become an important field of corporate investment in all sectors in Japan. The competitive and ever fluctuating market is forcing many companies to spend huge amounts of money in the Information Technology (IT) sector, since it has been increasingly accepted as a vital requirement for organizations to obtain competitive advantage and innovation. According to IDC Japan, in 2011 alone, large Japanese companies with more than 1,000 employees were expected to spent more than 5,783 billion yen, where 826 billion yen for medium size companies with 500-999 employees, 1,518 billion yen for small to medium size companies with

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100-499 employees, and even small companies were expected to spend 1,140 billion yen on information technology[1]. With IT activities becoming increasingly critical to business success, optimizing technology investments is the priority agenda for many companies. In line with business requirements, an effective IT investment has become one of the main research areas for recent years. Some investigates the relationships between organizational investment in information technology (IT) and organizational performance and productivity [1]. There are works such as analyses of the relationship between macro-economic data on IT investment [7] and financial data on IT investment [13], or evaluation methods of IT investment [5]. These works have contributed to determining the importance of IT and provides evaluation methods of IT investment effects. Another important research area is cost effectiveness of IT from the perspective of IT project management [14]. These studies offer project management know-how and methodologies for improving the effectiveness of IT. Recently, there have been studies analyzing the relationship between leadership and the activities of the chief information officer (CIO) and IT effectiveness [12]. These studies contribute to showing the effective actions of CIO.

This paper empirically investigates a fit between the organization's structure, management processes, individual roles and skills, and IT, in order to achieve the strategy to gain a competitive advantage among Japanese enterprises by using the MIT90s framework [9]. The framework is generally recognized in IT management literature, and posits that success in managing the deployment of IT in organizations is down to managing the balance between six inter-related factors; the external environment, the organizational strategy, individuals and their roles, the organizational structures, the technology being used, and the management processes. The diagram of this framework is shown in Fig. 17.1. The MIT90s model argue that a successful organization has a high fit among its strategy, structure, roles and skills, management processes and technology, and between that configuration and its business environment. The conventional alignment model suggests that there is one path for strategic alignment, and starts with a change in strategy. This changes structure, which in turn leads to change in processes, technology and individuals and roles. Yetton et al [16] demonstrate that it is possible for technology to be the driver of change, and this path was to develop individuals, then change the management structure. Yetton et al [15] argues that the adoption of technology led to identify other uses, in particular as a means of cost reduction and improving efficiency. Competitiveness may depend on organizations' abilities to derive new competencies as much as the determination of strategic direction enabled by IT [2].

For estimating a fit between factors, advanced quantitative techniques of structural equation modeling (SEM) has been employed. SEM has been established as an analytical tool, leading to hundreds of published applications per year. Overviews of the state of the method can be found in Cudeck et al. [3], Jöreskog [4], Mueller [10], Yuan and Bentler [16]. In this study, a SEM connecting factors such as structure, management process, technology and individuals roles, using firm-level data collected through a survey of 258 Japanese firms.

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[1] http://www.itmedia.co.jp/enterprise/articles/1201/12/news050.html

17.2 Research Background -MIT 90's IT Framework [18]

It is important to consider how firms' competitive advantage evolved in order to understand how strategic fit was achieved [15]. According to Miles and Snow [8], the concept of fit plays an important role in managerial behavior and organizational analysis. Fit seeks to align the organization with its environment and to arrange resources internally in support of that alignment. The basic alignment mechanism is strategy, and the internal arrangements are organization structure and management processes. The most frequently cited model of strategic alignment is the MIT90s framework.

Fig. 17.1 MIT90 framework (Source: Morton [18])

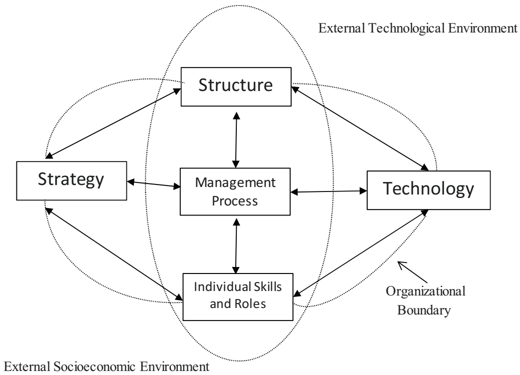

Fig. 17.1 shows the interdependence between technology and strategy and how this is influenced by the organizational culture. The model also shows the connection may be influenced by internal and external technological and socio-economic environments. This means that the organization may be highly dynamic and alignment may need to be continually reexamined, monitored and adjusted.

The framework proposes that the organization's strategy, structure, management processes, individual roles and skills and IT should be consistent with each other. Optimal performance will only be possible if there is a fit between them. The implications of the study are regrouped and focused to represent the five forces in an organization that can be influenced. The impacts of these forces are explained using (1) Technology, (2) Individual and Roles, (3) Structure, (4) Management Processes, (5) Strategy. MIT 90's frameworks are developed in relation to Information Systems success, and they can be effectively used to measure contemporary IS.

17.3 Research Model

In this paper, by modifying the MIT90s model, we would like to propose a different path for Japanese firms; fit is achieved based on the management process which determines the structure of the organization, as well as affects individual skills and roles, and implementing through various technologies as shown in Fig. 17.1. A Japanese management style is different from those of western countries, and described as "managers place trust in employees and make them feel like a part of a group," which leads to higher levels of production [11]. Different characteristics of American and Japanese organizational types described by Ouchi and Jaeger [11] are shown in Table 17.1.

Table 17.1 Characteristics of two familiar organizational ideal types: A and J

Type A (American)	Type J (Japanese)
Short-term employment	Lifetime employment
Individual decision-making	Consensual decision-making
Individual responsibility	Collective responsibility
Rapid evaluation and promotion	Slow evaluation and promotion
Explicit, formalized control	Implicit, informal control
Specialized career path	Nonspecialized career path
Segmented concern	Holistic concern

Source: Ouchi and Jaeger [20].

Management style is inseparable from cultural uniqueness, and Japan has developed its own unique style. In Japanese corporations, especially in manufacturing, there is a sense of unity, which has been fostered beyond the demarcation between employers and employees. This is "participatory management," unifying the efforts of employers and employees who share the same management ideals[2]. Bensaou and Earl [3] identify five principles or patterns that the Japanese follow when using IT and explain how these principles have led to success. The Japanese framing of IT includes strategic instinct, performance improvement, appropriate technology, organizational bonding, and human design. Strategic instinct differs from strategic alignment in the sense that Japanese management focus on operational goals as opposed to devising a strategic IT plan. Managers in Japan simply implement technologies that will enhance their capabilities. Performance improvement differs from the value for money approach traditionally taken in the West. Japanese investments are not made based on rational financial metrics, but rather based on their ability enhance operations. The traditional metrics often overlook projects that just do not meet the criteria. Appropriate technology differs from the technology for technology's sake mindset in North America. Often times this mindset leads to organizations adopting technology that is too advanced for their purposes. Japanese companies tend to adopt the appropriate technology for the task at hand, which may not be on the leading edge. Organizational bonding is emphasized in Japan as compared to IS user relations. A typical complaint in a North American firm is that the IT group does

[2] Morishita Y. (Chairman, Matsushita Electric Industrial Co., Ltd) "Globalization and Japanese-Style management", http://www.glocom.org/opinions/essays/200108_morishita_globalization/index.html

not know what managers actually do, and thus the system does not suit the organizational needs. In Japan, managers are rotated into the IT function and develop the systems on-site while working with line managers. Finally, the Japanese advocate for human design as opposed to system design. The Japanese develop their systems to fit the people who use them and do not try to force workers into systems that do not match their work patterns. Bensaou and Earl (1998) warn that exact of replication of the Japanese systems is not advisable. Rather, North American and European managers should use the principles outlined in this article in order to make more effective IT decisions.

According to Ministry of Economy, Trade and Industry of Japan, leading Japanese IT user companies are using more packaged software but heavily customizing it to work with their proprietary systems, something called semi-customization (see Table 17.2).

Table 17.2 IT services market in Japan, sales by categories

	July 2012		Compared to July 2011
	Mil. Yen	(%)	(%)
Total	674,524	100	104.7
Customized software	383,231	56.8	105.2
Software products	80,222	11.9	117.1
Information processing services	55,211	8.2	99.5
Facility management	105,383	15.6	100.4
Database services	10,390	1.5	96.9
Research	8,488	1.3	109.9
Others	31,598	4.7	98.2

This survey covers approximately 70-80% of Japanese IT Services Market. Source: Ministry of Economy, Trade and Industry (http://www.meti.go.jp/Retrieved 26 December, 2012).

While U.S. and European firms are creative users of IT, Japanese firms historically consider software as an integrating element in their production and distribution of a good and service [23]. Due to differences upon system on Japanese firms' computers with foreign partners and sales of computers promoted by government, they tried to offer highly customized software packages to their consumers in order to keep them. It produces the situation that captive IT developers are part of the parents' vertical group, and they are forced to specialize by industry with its own large proprietary system. Rapp [23] looks for the reason in Japanese long term employment, in which firms can train engineers for those unique systems spending long time. The long-term employment system helped Japanese firms to train and retain the personnel needed to manage and upgrade the IT systems. This situation was further promoted by the firms' experience in technology acquisition and in successful management of unique production systems through integrated organizational structures. Thus, Japanese IT strategies to a degree are a continuation by other means of their traditional strategic focus on growth, cutting costs, and increasing market share through constant improvement and technological advances [9, 21]. Customized IT plays a key role in Japanese firms' intra-industry development strategies, including their emergence and competitive impact as multinational enterprises.

IT effective use depends on how firms incorporate IT service management into their overall business strategies and management practices.On the basis of Japanese management style, we would like to identify main elements that are central to the evolution of Japanese firms' IT strategy.

In structural equation modeling, we consider the causalities among all variables, especially between the result and the latent variables. Latent variable enables us to find many compiled observed variables at the same time based on the notion of structure. This works for generating and verifying hypothesis to find factors and causalities.

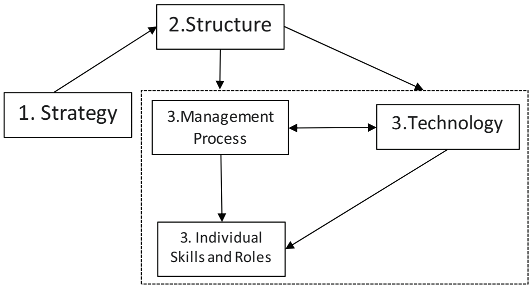

Fig. 17.2 The path to strategic fit for Japanese firms

Based on the path to strategic fit for Japanese Firms, we introduced latent variables based on the properties of the questionnaire as follows; (1) Strategy, (2) Management Process, (3) Structure, (4) Individuals Skills and Roles, and (5)Technology as shown in Fig. 17.2.

We had formed 8 hypotheses based on this framework as follows.

H1 : There is a significant, positive relationship between strategy and structure.
H2 : There is a significant, positive relationship between strategy and technology.
H3 : There is a significant, positive relationship between strategy and management process.
H4 : There is a significant, positive relationship between strategy and individual skills and roles.
H5 : There is a significant, positive relationship between management process and structure.
H6 : There is a significant, positive relationship between management process and individuals skills and roles.
H7 : There is a significant, positive relationship between structure and technology.
H8 : There is a significant, positive relationship between technology and individuals skills and roles.

17.4 Survey

17.4.1 Data

Data were collected through a survey of Japanese listed and not-listed companies in August 2007. A sample of the survey was randomly selected from the database of Diamond, the book publishing company of Japan. The survey was sent to 2,000 companies of all sizes from various industries which divided into the four sectors (manufacturing, distribution, finance, service, and others), and amassed 258 valid responses. Its response rate was 13 percent of the total mailed questionnaires and the response rate of the survey targeted at managers in charge of divisions was said to be 13% $\sim$ 17%. However, this rate applies to IS managers or CIO [5, 18, 19], and the response rate for business planning divisions is usually considered rather low. Accordingly, survey data from various divisions for 13% can conceivably be valuable for our analysis. The questionnaire was sent by mail to the information system division, the corporate planning division, and the internal audit division of the firms. During the period, the recipients who had any questions were answered by phone. Most of the questionnaires are asked by 5 point scale. A list of sample size by different industry classification is shown in Table 17.3.

Table 17.3 Sample size by industry classification

Classification	Frequency	
Manufacturing	123	(48.0%)
Distribution	36	(14.1%)
Finance	19	(7.4%)
Services	34	(13.3%)
Others	44	(17.2%)
Total	256	

17.5 Variables

The list of variables, used in this analyses, is shown in Table 17.4.

17.6 Result of Analysis

Testing the efficacy of the structural model was conducted by AMOS 19, and the major results of analysis are shown in Fig. 17.3.

Table 17.4 The list of variables from the survey

Strategy	
	Q4.1 Implementation of the project for management and IT tasks
	Q4.2 Strengthen Corporate policy for business restructuring and improvement
	Q4.3 Strengthen Relationship between IT and business restructuring and improvement
	Q4.4 Strengthen Corporate policy for business efficiencies and information securities
	Q4.5 Strengthen Corporate policy for internal control
Management Process-Management Organization	
	Q5.1 Existence of division for business process management
	Q5.2 Existence of division for Internal control and risk management
	Q5.3 Practical use of outside resource (consulting firms)
	Q5.4 Practical use of outside resource (system development firms)
Structure	
	Q2.1 Establish Relationship between IT department and corporate planning department Communication closeness between departments
Technology: i.e. Effectiveness of these technologies	
	BPR Business Process Re-engineering
	BSC Balanced Scorecard Project
	ICP Internal Control Project [including those to support Sarbanes-Oxley Act of 2002]
	ISRP Information Security Restructuring Project
Individuals Skills and Roles	
	Q6(a) Proficiency for adjustment goals between departments and projects
	Q6(b) Less Frequent occurrence of project send backs
	Q6(c) Proficiency for setting goals
	Q6(d) Timely completion of the projects
	Q6(e) Commitment of top management
	Q6(f) Fewer gap between management's instruction and implementation by engineers
	Q6(g) Achieving satisfactory results across the organization
	Q6(h) Easiness of achievement of project results by setting goals

In order to confirm the hypotheses we proposed in Sect. 17.6 to study the underlying relations among components of Strategy, Management Process, Structure, Individuals Skills and Roles, and Technology, depicted in Fig. 17.3 to the data by fitting the structural model. The path diagram highlights the structural relationships. In this diagram, the measured variables are enclosed in boxes, latent variables are circled, and arrows connecting two variables represent relations, and open arrows represent errors. By means of various goodness-of-fit indexes, including the comparative fit index (CFI) [3], the incremental fit index (IFI) [6], and the root mean squared error of approximation (RMSEA) [8], the estimated matrix can be evaluated against the observed sample covariance matrix to determine whether the hypothesized model is an acceptable representation of the data. In general, incremental fit indexes (i.e., CFI, and IFI) above 0.90 signify good model fit. RMSEA values lower than .08 signify acceptable model fit, with values lower than .05 indicative of good model fit [8]. Based on these indexes, our result was regarded as acceptable.

The followings are results of hypotheses.

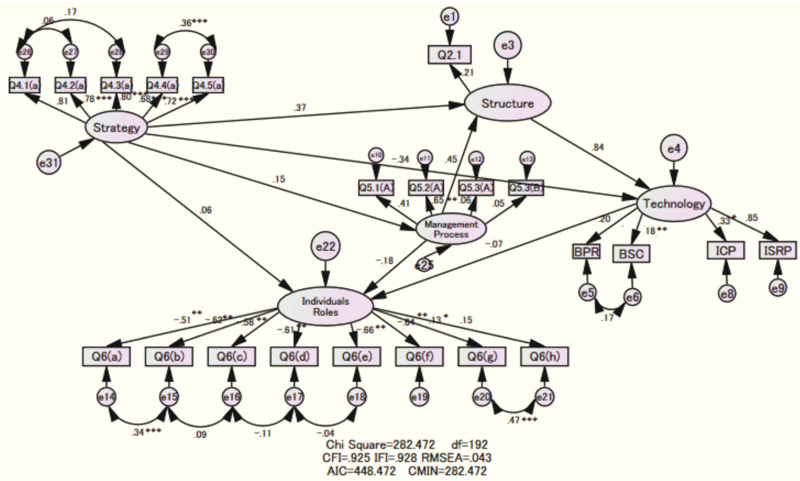

Fig. 17.3 The estimated structural model

H1 : There is a positive relationship between strategy and structure.
H2 : There is a negative relationship between strategy and technology.
H3 : There is a positive and relatively weak relationship between strategy and management process.
H4 : There is a positive but weak relationship between strategy and individual skills and roles.
H5 : There is a positive and strong relationship between management process and structure.
H6 : There is almost no relationship between management process and individuals skills and roles.
H7 : There is a positive and very strong relationship between structure and technology.
H8 : There is a negative and very weak relationship between technology and individuals skills and roles.

The results show that the strategy is more related to structure of the firms than other elements, such as management process and individual skills and roles. Relationship between strategy and technology is negative, which implies that the effectiveness of various restructuring technologies is seen separately from strategies which firms set.

Our hypothesis on a relationship between Management Process and Individual Skills and Roles, Technology and Individual Skills and Roles were weak and negative, and rejected. We would like to further research on these relationships.

17.7 Conclusions and Future Research

Based on a modified MIT90s model, we conducted the SEM on the survey data from 258 Japanese firm-level data.

In this study, we found that the strategy is not closely related to management process, individuals' skills and roles and technology, but closely related to the structure of firms. These results imply that the most significant relation is structure and technology, along with management process and structure, and a success of effective IT technology delivery relies on how firms' structure are created. The management organization would affect such a structure.

Among various technologies, the internal control project (including those to support Sarbanes-Oxley Act of 2002) and Balanced Scorecard (BSC) project are positive and significant.

The largest earthquake and Tsunami in the Japanese history occurred off the Pacific coast of northeastern Japan on March 11, 2011. We expect certain influence of this Great Eastern Japan Earthquake on IT investment and business performance of many Japanese firms, so that we have a plan to conduct survey in 2012 to investigate what issues Japanese firms' are facing after March 11.

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Chapter 18
Multi-Attribute Group Decision Making based on Proportional 2-tuple Linguistic Model

Congcong Li and Yucheng Dong

Abstract The proportional 2-tuple linguistic model provides a tool to deal with linguistic term sets that are not uniformly and symmetrically distributed. This study further develops multi-attribute group decision making methods with linguistic assessments and linguistic weights, based on the proportional 2-tuple linguistic model. Firstly, this study defines some new operations in proportional 2-tuple linguistic model, including weighted average aggregation operator with linguistic weights, ordered weighted average operator with linguistic weights and the distance between proportional linguistic 2-tuples. Then, two multi-attribute group decision making methods are presented. They are the method based on the proportional 2-tuple linguistic aggregation operator, and technique for order preference by similarity to ideal solution (TOPSIS) with proportional 2-tuple linguistic information. Finally, an example for IT governance is given to illustrate the effectiveness of the proposed methods.

Keywords Multi-attribute group decision making · Proportional 2-tuple linguistic model · Linguistic weight · TOPSIS

18.1 Introduction

Due to the complexity and uncertainty of decision making environment, some problems cannot be dealt with by precise and exact models. A possible way to solve such problems is the use of linguistic approaches. There are two different linguistic models used in decision making, such as the models based on extension principle [1–4] and the symbolic methods [5–7]. The models based on extension principle perform the retranslation step as an approximation process to express the results in the initial term set provoking a lack of accuracy [8]. To avoid such inaccuracy, Herrera

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and Martínez [9] proposed the 2-tuple linguistic model. Although the Herrera and Martínez model has no loss of information, it only guarantees accuracy in dealing with uniformly and symmetrically distributed linguistic term sets. And in the real decision-making environment, the linguistic term sets that are not uniformly and symmetrically distributed are often used to express the preferences. In order to deal with this type of linguistic term sets, two different approaches based on linguistic 2-tuples have been presented.

- Herrera et al [10] defined the concept of unbalanced linguistic term sets, and proposed the methodologies based on linguistic 2-tuples to deal with unbalanced linguistic term sets.
- Wang and Hao [11] developed the proportional 2-tuple linguistic representation model, and the Wang and Hao model is based on the concepts of symbolic proportion and the canonical characteristic values (CCVs).

Numerous decision making models based on unbalanced linguistic term sets have been presented. For example, Cabrerizo et al [12, 13] presented a consensus-based group decision making with unbalanced linguistic terms. Martínez [14] applied the model with unbalanced linguistic terms to sensory evaluation. Herrera-Viedma and López-Herrera [15] developed a model of information retrieval system with unbalanced fuzzy linguistic information. However, although the Wang and Hao model can also deal with linguistic term sets that are not uniformly and symmetrically distributed, there are little studies about the decision model based on the Wang and Hao model. The main aim of this paper is to develop multi-attribute group decision making methods with linguistic assessments and linguistic weights, based on the Wang and Hao model (i.e., the proportional 2-tuple linguistic model).

The remainder of this paper is organized as follows. In Sect. 18.2, we introduce the basic knowledge regarding the proportional 2-tuple model. Then, Sect. 18.3 proposes some new operations in proportional 2-tuple linguistic model. In Sect. 18.4, two multi-attribute group decision making methods with proportional 2-tuple linguistic assessments and weights are presented. In Sect. 18.5, an illustrative example is provided and, finally, concluding remarks are included in Sect. 18.6.

18.2 Preliminaries: Proportional 2-tuple Linguistic Model

This section presents the basic knowledge regarding the proportional 2-tuple linguistic model.

Herrera and Martinez [8] proposed the linguistic 2-tuple model, but it is only suitable for linguistic variables with equidistant labels, and this model do not directly take into account the underlying vagueness of the words [16]. In order to overcome these limitations, Wang and Hao [11] proposed the proportional 2-tuple linguistic model, which is a new fuzzy linguistic representation model for computing with words. This proportional 2-tuple model can help make a more accurate expression of the results, such as $(0.2S_i, 0.8S_{i+1})$ for the case when someone's grades in the answerscripts of a whole course are distributed as $20\%S_i$ and $80\%S_{i+1}$. We make note that if S_{i+1} is used as the approximative grade then some performance information will be lost.

Definition 18.1. Let $S = \{s_0, s_1, \cdots, s_n\}$ be an ordinal term set, and $IS = I \times S = \{(\alpha, s_i)\}$, $\alpha \in [0,1]$, $i = 0, 1, \cdots, n$.

Given a pair (s_i, s_{i+1}) of two successive ordinal terms of S, any two elements $(\alpha, s_i), (\beta, s_{i+1})$ of IS is called a symbolic proportion pair and α, β are called a pair of symbolic proportions of pair (s_i, s_{i+1}) if $\alpha + \beta = 1$. Let $\bar{S} = \{(\alpha s_i, (1-\alpha)s_{i+1})\}$, $\alpha \in [0,1]$, $i = 0, 1, \cdots, n$, then $\bar{S}$ is called ordinal proportional 2-tuple set.

In general, the element semantics in a linguistic term set are given by fuzzy numbers (defined in the $[0,1]$ interval), which are described by linear triangular membership functions or linear trapezoidal membership functions. For instance, the linear trapezoidal membership function is achieved by a 4-tuple (a, b, c, d), b and c indicate the interval in which the membership value is 1, and a and d are the left and right limits of the definition domain of a trapezoidal membership function. Wang and Hao [11] proposed an interesting generalized version of the 2-tuple fuzzy linguistic representation model. The semantics of linguistic terms used in the Wang and Hao's model are defined by symmetrical trapezoidal fuzzy numbers. If the semantics of S_i is defined by $T[b_i - \sigma_i, b_i, c_i, c_i + \sigma_i]$ in the Wang and Hao model the canonical characteristic value (CCV) of s_i is $\frac{b_i + c_i}{2}$, i.e., $\mathrm{CCV}(s_i) = \frac{b_i + c_i}{2}$.

Definition 18.2. Let $S = \{s_0, s_1, \cdots, s_n\}$ be an ordinal term set, $\alpha \in [0,1]$, $c_i \in [0,1]$, and $c_0 < c_1 < c_2 \cdots < c_n$, for $\mathrm{CCV}(s_i) = c_i$, $(\alpha s_i, (1-\alpha)s_{i+1}) \in \bar{S}$, define the function CCV on S by:

$$\mathrm{CCV}(\alpha s_i, (1-\alpha)s_{i+1}) = \alpha \mathrm{CCV}(s_i) + (1-\alpha)\mathrm{CCV}(s_{i+1}) = \alpha c_i + (1-\alpha)c_{i+1}.$$

Definition 18.3. Let S, $\bar{S}$ and CCV on S be as before, $\alpha \in [0,1]$, for $\mathrm{CCV}(s_i) = c_i$, $(\alpha s_i, (1-\alpha)s_{i+1}) \in \bar{S}$, the function CCV^{-1} is defined as:

$$\mathrm{CCV}^{-1}(\beta) = \mathrm{CCV}^{-1}(\alpha c_i + (1-\alpha)c_{i+1}) = (\alpha s_i, (1 - \alpha s_{i+1})).$$

Definition 18.4. Let $S = \{s_0, s_1, \cdots, s_n\}$ be an ordinal term set and $\bar{S}$ be the ordinal proportional 2-tuple set generated by S.

For any $(\alpha s_k,\ (1-\alpha)s_{k+1})$, $(\beta s_l,\ (1-\beta)s_{l+1}) \in \bar{S}$, if $(\alpha s_k,\ (1-\alpha)s_{k+1}) < (\beta s_l,\ (1-\beta)s_{l+1})$, then

$$\alpha k + (1-\alpha)(k+1) < \beta l + (1-\beta)(l+1) \Leftrightarrow k + (1-\alpha) < l + (1-\beta).$$

Thus, for any two proportional 2-tuple $(\alpha s_k,\ (1-\alpha)s_{k+1})$, $(\beta s_l,\ (1-\beta)s_{l+1})$, (1) if $k < l$, then

- $(\alpha s_k,\ (1-\alpha)s_{k+1})$, $(\beta s_l,\ (1-\beta)s_{l+1})$ represents the same information when $\alpha = 0,\ \beta = 1, k = l - 1$.
- $(\alpha s_k,\ (1-\alpha)s_{k+1}) < (\beta s_l,\ (1-\beta)s_{l+1})$ otherwise.

(2) if $k = l$, then

- $\alpha = \beta$, $(\alpha s_k,\ (1-\alpha)s_{k+1})$, $(\beta s_l, (1-\beta)s_{l+1})$ represents the same information.
- if $\alpha < \beta$, $(\alpha s_k,\ (1-\alpha)s_{k+1}) > (\beta s_l,\ (1-\beta)s_{l+1})$.
- if $\alpha > \beta$, $(\alpha s_k,\ (1-\alpha)s_{k+1}) < (\beta s_l,\ (1-\beta)s_{l+1})$.

(3) Define the usual negation operator over proportional 2-tuples as:

$$Neg(\alpha s_i,\ (1-\alpha)s_{i+1}) = ((1-\alpha)s_{n-i-1},\ \alpha s_{n-i}).$$

18.3 New Operations in Proportional 2-tuple Linguistic Model

For the multi-attribute group decision making problems, it is better for decision makers to give linguistic assessment information if the attribute of schemes is mostly subjective evaluation index. While for the weight of each attribute, it also needs linguistic information to express, if we only use numerical values to express, then some information will be lost. So it is necessary to introduce the aggregation method with linguistic weights, thereby thinning the decision-making process, and can also ensure the accuracy of the data. Based on proportional 2-tuple model, this section defines some new operations in proportional 2-tuple linguistic model, including weighted average aggregation operator with linguistic weights, ordered weighted average operator with linguistic weights and the distance between proportional linguistic 2-tuples.

Definition 18.5. Let $S = \{s_0, s_1, \cdots, s_n\}$, $S' = \{s'_0, s'_1, \cdots, s'_g\}$ be the ordinal linguistic term sets, $L = \{l_0, l_1, \cdots, l_m\}$ be a set of proportional 2-tuple in $\bar{S}$; $H = \{h_0, h_1, \cdots, h_m\}^T$ be their associated weights, $h_j \in \bar{S}'$, the proportional 2-tuple weighted average operator is defined as:

$$\bar{L} = \mathrm{CCV}^{-1}\left[\frac{\sum\limits_{j=0}^{m}(\mathrm{CCV}(l_j)\times \mathrm{CCV}'(h_j))}{\sum\limits_{j=0}^{m}\mathrm{CCV}'(h_j)}\right],\ j = 0, 1, \cdots, m.$$

Definition 18.6. Let $L = \{l_0, l_1, \cdots, l_m\}$ be a set of ordinal proportional 2-tuples, $l_j \in \bar{S}$; $W = \{w_0, w_1, \cdots, w_m\}$ be their associated proportional 2-tuple weighting vector, $w_j \in \bar{S}'$. Then, the proportional 2-tuple linguistic ordered weighted average (OWA) operator is defined as:

$$\bar{L}' = \mathrm{CCV}^{-1}\left[\frac{\sum\limits_{j=0}^{m}\mathrm{CCV}(l_{\gamma(j)})\times \mathrm{CCV}'(w_j)}{\sum\limits_{j=0}^{m}\mathrm{CCV}'(w_j)}\right],\ j = 0, 1, \cdots, m.$$

$l_{r(0)}, l_{r(1)}, \cdots, l_{r(m)}$ is a permutation of $l_0, l_1, \cdots l_m$ such that $l_{r(0)} \geq l_{r(1)} \cdots \geq l_{r(m)}$. (Note that in this paper, we use the proportional 2-tuple weighted average operator to aggregate the linguistic assessment information, the methods are similar if we use the OWA operator.)

Definition 18.7. Let $L_1 = \{l_0^1, l_1^1, \cdots, l_m^1\}$, $L_2 = \{l_0^2, l_1^2, \cdots, l_m^2\}$ be two sets of proportional 2-tuples, and $l_i^1 \in L_1$, $l_i^2 \in L_2$. Then, the distance between $L_1,\ L_2$ is defined as:

$$D(L_1, L_2) = \sqrt{\sum_{i=1}^{m} (\mathrm{CCV}(l_i^1) - \mathrm{CCV}(l_i^2))^2}.$$

18.4 Approaches to Group Decision Making with Linguistic Assessments and Linguistic Weights

The main process of multi-attribute decision making is to find the best alternative from all of the feasible alternatives where all the alternatives can be evaluated according to a number of attributes, and some these problems have to deal with uncertain and imprecise information. In order to deal with that information, we develop multi-attribute group decision making methods with linguistic assessments and linguistic weights, based on the proportional 2-tuple linguistic model.

The method based on the proportional 2-tuple linguistic aggregation operator is employed to aggregate the linguistic assessment information using the weighted average operator, to obtain the best alternative(s). TOPSIS, developed by Hwang and Yoon [17], is a simple ranking method in conception and application. According to the TOPSIS with proportional 2-tuple linguistic information the optimal alternative(s) is determined by calculating the distances of every alternative and the positive-ideal solution and negative-ideal solution. It is based on the concept that the optimal alternative should have the shortest distance from the positive ideal solution and on the other side the farthest distance of the negative ideal solution.

Before going into detail, we first introduce some basic definitions which will be used through the rest of this paper. Let $A = \{A_1, A_2, \cdots, A_m\}$ $(m \geq 2)$ be a set of alternatives, $C = \{C_1, C_2, \cdots, C_n\}$ $(n \geq 2)$ be the set of attribute and $H = [h_1, h_2, \cdots, h_n]^T$ be the weighting vector of attributes where $h_k \in \bar{S}'$. Let $E = \{E_1, E_2, \cdots, E_q\}$ $(q \geq 2)$ be the set of decision makers, and $W = [w_1, w_2, \cdots, w_q]^T$ be the weighting vector of decision makers, where $w_k \in \bar{S}'$. Then the decision-making matrix of kth decision maker can be expressed as:

$$X^k = \begin{pmatrix} x_{11}^{(k)} & \cdots & x_{1n}^{(k)} \\ \vdots & \ddots & \vdots \\ x_{m1}^{(k)} & \cdots & x_{mn}^{(k)} \end{pmatrix}, \quad x_{ij}^{(k)} \in \bar{S}.$$

18.4.1 Method Based on the Proportional 2-Tuple Linguistic Aggregation Operator

Step 1. Utilizing the proportional 2-tuple linguistic aggregation operator, linguistic evaluation matrices $X^1, X^2, \cdots, X^q$ and decision maker weighting vector $w_1, w_2, \cdots, w_q$ are aggregated into an overall proportional 2-tuple linguistic comprehensive evaluation matrix L_{ij}.

$$L_{ij} = \mathrm{CCV}^{-1}\left[\frac{\sum\limits_{k=1}^{q}\mathrm{CCV}(x_{ij}^k)\times\mathrm{CCV}'(w_k)}{\sum\limits_{k=1}^{q}\mathrm{CCV}'(w_k)}\right],\ i=1,2,\cdots,m,\ j=1,2,\cdots,n.$$

Step 2. Utilizing aggregation operator with linguistic weights to derive the collective overall preference values L_i of the alternative A_i.

$$L_i = \mathrm{CCV}^{-1}\left[\frac{\sum\limits_{j=1}^{n}\mathrm{CCV}(l_{ij})\times\mathrm{CCV}'(h_j)}{\sum\limits_{j=1}^{n}\mathrm{CCV}'(h_j^)}\right],\ i=1,2,\cdots,m.$$

Step 3. Rank all the alternatives A_i $(i=1,2,\cdots m)$ and select the best one(s) in accordance with L_i. If any alternative has the highest L_i value, then, it is the most important alternative.

18.4.2 TOPSIS with Proportional 2-Tuple Linguistic Information

Step 1. Using the proportional 2-tuple linguistic aggregation operator to aggregate linguistic rating values of all experts for each alternative and then the linguistic rating matrix L can be represented as:

$$L_{ij} = \mathrm{CCV}^{-1}\left(\frac{\sum\limits_{k=1}^{q}\mathrm{CCV}(x_{ij}^k)\times\mathrm{CCV}'(w_k)}{\sum\limits_{k=1}^{q}\mathrm{CCV}'(w_k)}\right),\ i=1,2,\cdots,m;\ j=1,2,\cdots,n.$$

Step 2. Define the positive-ideal solution and negative-ideal solution l^+, l^-, respectively, that is,
• the positive-ideal solution $l^+ = \{l_1^+, l_2^+, \cdots, l_n^+\}$, $l_j^+ \in l^+$,
• the negative-ideal solution $l^- = \{l_1^-, l_2^-, \cdots, l_n^-\}$, $l_j^- \in l^-$,
where $l_j^+ = \max\{l_{ij}\}$, $l_j^- = \min\{l_{ij}\}$, $i=1,2,\cdots,m$.
Step 3. Calculating the distances of each alternative from the positive-ideal solution and negative-ideal solution using the following equation, respectively,

$$D_i^+ = \sqrt{\sum_{j=1}^{n} (\mathrm{CCV}(l_{ij}) - \mathrm{CCV}(l_j^+))^2}, i = 1, 2, \cdots, m,$$

$$D_i^- = \sqrt{\sum_{j=1}^{n} (\mathrm{CCV}(l_{ij}) - \mathrm{CCV}(l_j^-))^2}, i = 1, 2, \cdots, m.$$

Step 4. Calculating the relative closeness degree of each alternative from the positive-ideal solution using the following equation:

$$\xi_i = \frac{D_i^-}{D_i^+ + D_i^-}.$$

According to the values of D_i^+ and D_i^-, define the ranking of A_i. If any alternative has the highest ξ_i value, then, it is the most important alternative.

18.5 Illustrative Example

In this section, we present an example to illustrate some of the power of the new operations in proportional 2-tuple linguistic model and the two methods based on proportional 2-tuple.

Table 18.1 The linguistic evaluation matrix X^1 provided by the decision maker D_1

X^1	C_1	C_2	C_3	C_4	C_5
A_1	$(0.8S_0, 0.2S_1)$	$(0.5S_2, 0.5S_3)$	$(0.6S_3, 0.4S_4)$	$(0.7S_2, 0.3S_3)$	$(0.5S_5, 0.5S_6)$
A_2	$(0.5S_0, 0.5S_1)$	$(0.2S_1, 0.8S_2)$	$(0.3S_2, 0.7S_3)$	$(0.5S_4, 0.5S_5)$	$(0.7S_5, 0.3S_6)$
A_3	$(0.4S_1, 0.6S_2)$	$(0.2S_1, 0.8S_2)$	$(0.5S_5, 0.5S_6)$	$(0.2S_2, 0.8S_3)$	$(0.1S_3, 0.9S_4)$
A_4	$(0.3S_4, 0.7S_5)$	$(0.2S_0, 0.8S_1)$	$(0.1S_3, 0.9S_4)$	$(0.4S_0, 0.6S_1)$	$(0.2S_1, 0.8S_2)$

Table 18.2 The linguistic evaluation matrix X^2 provided by the decision maker D_2

X^2	C_1	C_2	C_3	C_4	C_5
A_1	$(0.3S_1, 0.7S_2)$	$(0.5S_2, 0.5S_3)$	$(0.6S_4, 0.4S_5)$	$(0.2S_3, 0.8S_4)$	$(0.9S_5, 0.1S_6)$
A_2	$(0.2S_0, 0.8S_1)$	$(0.3S_2, 0.7S_3)$	$(0.3S_2, 0.7S_3)$	$(0.7S_5, 0.3S_6)$	$(0.1S_3, 0.9S_4)$
A_3	$(0.5S_4, 0.5S_5)$	$(0.8S_3, 0.2S_4)$	$(0.1S_0, 0.9S_1)$	$(0.5S_2, 0.5S_3)$	$(0.4S_4, 0.6S_5)$
A_4	$(0.6S_5, 0.4S_6)$	$(0.4S_4, 0.6S_5)$	$(0.2S_3, 0.8S_3)$	$(0.4S_1, 0.6S_2)$	$(0.7S_5, 0.3S_6)$

Table 18.3 The linguistic evaluation matrix X^3 provided by the decision maker D_3

X^3	C_1	C_2	C_3	C_4	C_5
A_1	$(0.6S_2, 0.4S_3)$	$(0.5S_0, 0.5S_1)$	$(0.2S_3, 0.8S_4)$	$(0.9S_5, 0.1S_6)$	$(0.5S_5, 0.5S_6)$
A_2	$(0.2S_0, 0.8S_1)$	$(0.3S_2, 0.7S_3)$	$(0.5S_2, 0.5S_3)$	$(0.3S_2, 0.7S_3)$	$(0.3S_5, 0.7S_6)$
A_3	$(0.4S_3, 0.6S_4)$	$(0.2S_3, 0.8S_4)$	$(0.7S_5, 0.3S_6)$	$(0.2S_0, 0.8S_1)$	$(0.5S_2, 0.5S_3)$
A_4	$(0.2S_3, 0.8S_4)$	$(0.1S_3, 0.9S_4)$	$(0.2S_1, 0.8S_2)$	$(0.1S_2, 0.9S_3)$	$(0.4S_1, 0.6S_2)$

Many organizations are experiencing that information technology is becoming not only a significant expense, but also their largest production means and cornerstone of the organization. In order to sustain the competitive positions, A company decided to enhance their IT construction. After preliminary screening, four feasible governance programs A_1, A_2, A_3, A_4 remain for further evaluation. An expert committee of four decision makers D_1, D_2, D_3, D_4 has been formed to conduct the evaluation and to select the most suitable IT Governance programs for the company. Five criteria in accordance with characteristics of IT governance are considered:
C_1−IT principles; C_2−Enterprise Architecture; C_3−Infrastructure; C_4−Application requirements; C_5−IT investment/priority;

Assume that the managers express their opinions by means of linguistic assessments from the ordered linguistic term set of seven labels: $S = \{S_0 = VB(\text{Very Bad}), S_1 = B(\text{Bad}), S_2 = MB(\text{Medium Bad}), S_3 = M(\text{Medium}), S_4 = MG(\text{Medium Good}), S_5 = G(\text{Good}), S_6 = VG(\text{Very Good})\}$. The initial evaluation matrices X^k given by the decision makers D_k $(k = 1,2,3,4)$ are listed as Tables 18.1 $\sim$ 18.4.

Table 18.4 The linguistic evaluation matrix X^4 provided by the decision maker D_4

X^4	C_1	C_2	C_3	C_4	C_5
A_1	$(0.8S_2, 0.2S_3)$	$(0.3S_2, 0.7S_3)$	$(0.1S_0, 0.9S_1)$	$(0.5S_2, 0.5S_3)$	$(0.2S_5, 0.8S_6)$
A_2	$(0.7S_1, 0.3S_2)$	$(0.2S_0, 0.8S_1)$	$(0.2S_3, 0.8S_4)$	$(0.4S_0, 0.6S_1)$	$(0.9S_3, 0.1S_4)$
A_3	$(0.5S_0, 0.5S_1)$	$(0.4S_3, 0.6S_4)$	$(0.3S_5, 0.7S_6)$	$(0.4S_4, 0.6S_5)$	$(0.5S_4, 0.5S_5)$
A_4	$(0.5S_5, 0.5S_6)$	$(0.7S_5, 0.3S_6)$	$(0.2S_0, 0.8S_1)$	$(0.6S_3, 0.4S_4)$	$(0.3S_5, 0.7S_6)$

Table 18.5 The CCV and trapezoidal fuzzy number in $[0,1]$ of each label in S

Linguistic Variable	Fuzzy number	CCV
S_0	[0,0,0,0]	0
S_1	[0,0.03,0.10,0.13]	0.065
S_2	[0.10,0.20,0.25,0.35]	0.225
S_3	[0.25,0.30,0.5,0.55]	0.4
S_4	[0.5,0.6,0.65,0.75]	0.625
S_5	[0.7,0.8,0.9,1]	0.85
S_6	[1,1,1,1]	1

Table 18.5 defines both the CCV and trapezoidal fuzzy number in $[0,1]$ of each label. We can express the weights of manger and attribute by means of linguistic assessments from the ordered linguistic term set of five labels: $S' = \{S'_0 = HN(\text{None}), S'_1 = N(\text{Not Important}), S'_2 = Y(\text{Medium}), S'_3 = Z(\text{Important}), S'_4 = VZ$ $(\text{Very Important})\}$. Table 18.6 defines both the CCV and trapezoidal fuzzy number in $[0,1]$ of each label in S'. The information about the weights of decision makers and the attributes are known as follows:

$$\begin{aligned}
W^T &= \{(0.2Z, 0.8VZ), (0.7Y, 0.3Z), (0.5HN, 0.5N), (0.4N, 0.6Y)\} \\
&= \{(0.2S'_3, 0.8S'_4), (0.7S'_2, 0.3S'_3), (0.5S'_0, 0.5S'_1), (0.4S'_1, 0.6S'_2)\}. \\
H^T &= \{(0.3Z, 0.7VZ), (0.4Y, 0.6Z), (0.2HN, 0.8N), (0.1N, 0.9Y), (0.8Y, 0.2Z)\}
\end{aligned}$$

$$= \{(0.3S'_3, 0.7S'_4), (0.4S'_2, 0.6S'_3), (0.2S'_0, 0.8S'_1), (0.1S'_1, 0.9S'_2), (0.8S'_2, 0.2S'_3)\}.$$

Utilizing the equation:

$$L_{ij} = \mathrm{CCV}^{-1}\left(\frac{\sum_{k=1}^{4}\mathrm{CCV}(x_{ij}^{k}) \times \mathrm{CCV}'(w_k)}{\sum_{k=1}^{4}\mathrm{CCV}'(w_k)}\right), \; i = 1,2,3,4; \; j = 1,2,3,4,5,$$

to aggregate linguistic rating values of four experts for each alternative and then we can obtain the overall proportional 2-tuple linguistic comprehensive evaluation matrix L, as shown in Table 18.7. In the following, we shall utilize the proposed two

Table 18.6 The CCV and trapezoidal fuzzy number in $[0,1]$ of each label in S'

Linguistic variable	Fuzzy number	CCV
S'_0	[0,0,0,0]	0
S'_1	[0,0.2,0.3,0.5]	0.25
S'_2	[0.3,0.45,0.5,0.65]	0.475
S'_3	[0.5,0.7,0.8,1]	0.75
S'_4	[1,1,1,1]	1

Table 18.7 The overall proportional 2-tuple linguistic comprehensive evaluation matrix L

L	C_1	C_2	C_3	C_4	C_5
A_1	$(0.64S_1, 0.36S_2)$	$(0.56S_2, 0.44S_3)$	$(0.66S_3, 0.34S_4)$	$(0.94S_3, 0.06S_4)$	$(0.56S_5, 0.44S_6)$
A_2	$(0.84S_0, 0.16S_1)$	$(0.04S_1, 0.96S_2)$	$(0.07S_2, 0.93S_3)$	S_4	$(0.54S_4, 0.46S_5)$
A_3	$(0.46S_2, 0.54S_3)$	$(0.28S_2, 0.72S_3)$	$(0.73S_4, 0.27S_5)$	$(0.12S_3, 0.88S_4)$	$(0.87S_4, 0.13S_5)$
A_4	S_5	$(0.8S_3, 0.2S_4)$	$(0.46S_3, 0.54S_4)$	$(0.28S_1, 0.72S_2)$	$(0.37S_3, 0.63S_4)$

approaches in this paper getting the most desirable alternative(s).
(1) Ranking the alternatives: method based on proportional 2-tuple linguistic aggregation operator

According to the group comprehensive evaluation matrix L, utilizing the formula:

$$Z(A_i) = \mathrm{CCV}^{-1}\left[\frac{\sum_{j=1}^{5}\mathrm{CCV}(l_{ij}) \times \mathrm{CCV}'(h_j)}{\sum_{j=1}^{5}\mathrm{CCV}'(h_j)}\right], \; i = 1,2,3,4,$$

to calculate the comprehensive evaluation value of the four alternatives, and we can obtain: $Z(A_1) = (0.25S_2, 0.75S_3), Z(A_2) = (0.34S_2, 0.66S_3), Z(A_3) = (0.71S_3, 0.29S_4), Z(A_4) = (0.28S_3, 0.72S_4)$.

Ranking all the alternatives A_i $(i = 1,2,3,4)$ in accordance with the comprehensive evaluation value $Z(A_i)$: $A_4 \succ A_3 \succ A_1 \succ A_2$, and thus the most desirable IT

governance alternative is A_4.
(2) Ranking the alternatives: TOPSIS with proportional 2-tuple linguistic information

According to the group comprehensive evaluation matrix L, define the positive-ideal solution and negative-ideal solution as:

- the positive-ideal solution: $\{(S_5),(0.8S_3,0.2S_4),(0.73S_4,0.27S_5),(S_4),(0.56S_5,$ $0.44S_6)\}$.
- the negative-ideal solution: $\{(0.84S_0,0.16S_1),(0.04S_1,0.96S_2),(0.07S_2,0.93S_3),$ $(0.28S_1,0.72S_2),(0.37S_3,0.63S_4)\}$, utilizing the following equations:

$$d_i^+ = \sqrt{\sum_{j=1}^{5} (\mathrm{CCV}(l_{ij}) - \mathrm{CCV}(l_j^+))^2}, \; i = 1,2,3,4,$$

$$d_i^- = \sqrt{\sum_{j=1}^{5} (\mathrm{CCV}(l_{ij}) - \mathrm{CCV}(l_j^-))^2}, \; i = 1,2,3,4$$

to calculate the distances of each alternative from the positive-ideal solution and negative-ideal solution. We can obtain:

$$d_1^+ = 0.7990, \quad d_1^- = 0.4574, \quad d_2^+ = 0.8963, \quad d_2^- = 0.4829,$$
$$d_3^+ = 0.5956, \quad d_3^- = 0.6038, \quad d_4^+ = 0.6059, \quad d_4^- = 0.8341.$$

Calculating the relative closeness degree of each alternative from the positive-ideal solution by equation $\xi_i = \frac{d_i^-}{d_i^+ + d_i^-}$, and $\xi_1 = 0.364$, $\xi_2 = 0.3501$, $\xi_3 = 0.5033$, $\xi_4 = 0.5792$.

Then, rank all the alternatives A_i $(i = 1,2,3,4)$ in accordance with the relative closeness degree ξ_i, we can obtain $A_4 \succ A_3 \succ A_1 \succ A_2$, and obviously the most desirable alternative is A_4.

18.6 Conclusions

In the real decision-making environment, decision makers often prefer to use the linguistic term sets which are not uniformly and symmetrically to express their views. In order to deal with this type of linguistic term sets, this paper develops multi-attribute group decision making methods with linguistic assessments and linguistic weights, based on the proportional 2-tuple linguistic model. The main points presented are as follows:

- Some new operations in proportional 2-tuple linguistic model are defined, they are the weighted average aggregation operator with linguistic weights, ordered weighted average operator with linguistic weights and the distance between proportional linguistic 2-tuples.

- Two multi-attribute group decision making methods are presented. They are the method based on the proportional 2-tuple linguistic aggregation operator, Technique for order preference by similarity to ideal solution (TOPSIS) with proportional 2-tuple linguistic information.

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Chapter 19
Research of Information Dissemination's Public Risk Management in We-media Era

Shuai Xu

Abstract We-media which stands out among many network applications, has largely changed the form of information dissemination's public risk management. Through such a personalized network platform of information and dissemination, users can release the words, pictures, audio, videos and other multimedia information by the WBE, mobile phone and other developing client components. At present, our country is undergoing a special period of economic transition and social transformation which caused fierce social changes. In this paper, based on the analysis of We-media technology characteristics, forms and features of dissemination, the author will further analyze present state and problems of information dissemination's risk management in We-media era. And finally the author puts forward risk management measures of We-media information dissemination.

Keywords We-media · Information dissemination · Risk management

19.1 Preface

As a popular way of information dissemination, We-media such as microblog, represents the latest technology and information features of internet era. Microblog, the typical representative of We-media, was born abroad and revolved into new internet dissemination media after being introduced to China. According to the "Social Blue Book" issued in December 2009 by Chinese Academy of Social Science, microblog is called "the most destructive public opinion carrier" by researchers.

Some researchers think that based on web2.0 technology and its multi-media nature, We-media multiplies its dissemination stage and mode, and makes original

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form-classified group dissemination upgrade into mass transmission. The revolution from level one and two, to even higher dissemination levels, has enriched dissemination modes and channels, diversified and maximized dissemination effects [1].

Additionally, the emergence of the microblog is regarded as a symbol of the coming Web3.0 era. In 2006, American website Twitter firstly launched the microblog service which afterwards swept around the world. In 2009, with the strong cooperation with some domestic portal websites such as Sina, Netease, Phoenix and Tencent, the microblog has been surging forward vigorously. According to the investigation report of the Social Survey Center of China Youth Daily in February, 2010, among 2117 research objects, there were 69% involving in applying the microblog and 43.1% intending to utilize it. In January, 2011, Jack Rossi who was the president of Twitter Company revealed that the registered users globally of twitter had reached 200 million, of which many are celebrities.

19.2 Definition

19.2.1 Web2.0

Relative to Web1.0, Web2.0 refers to new kind of Internet application. The main feature of Web1.0 is that users can obtain information through the browser. Web2.0 pays more attention to the users' interaction, hence the user is both website visitor and content maker. Web2.0 technology has been applied in the digital archive personalized service website [2]. The so-called content maker means that every user is no longer just reader, but also the author; no longer just surfer, but also the wave maker. Using model has developed from simple reading to writing and even collaborative constructing, from passively receiving Internet information to actively creating Internet information. All have displayed its humanization quality.

Web2.0 technology, anything but just specific technology software, is much a concept, that takes individual and group users as centers, pays close attention to every user, advocates the information sharing, breaks unilateral information monopoly situation of portal website, and creates content by each user.

19.2.2 Public Risk

The definition of public risk is similar to that of public product. When the market (or individual behavior) cannot manage or effectively share risk cost, then the risk will gradually transit to "public". If there exists a high uncertainty, or the risk appears such features of externalities or non-speciality, then it is to be transformed into public risk. It will also take place when the risk can't be distributed to the responsible/the capable institutions with the help of private ownership system.

Public risk refers to the related risks of problems arising out of public interest maintenance. And public affairs mean the affairs relevant to protecting individual rights, balancing interest and ensuring justice of political process. Risk evaluation is complex, requiring the analysis of risk from the different perspectives of the public and private sector entities [3]. The government often manages public risk indirectly, that is to say, through policy-making or consigning to other departments, the government can manage the public risk that is publicity but not within the scope of direct intervention [4].

19.2.3 Risk Management

Risk management is a new management discipline that studies the regularity of risks and risk control technology. The risk management process is made up of several point-in-time assessments of risk that need to be re-evaluated as risks evolve [5]. Through the risk identification, estimation and evaluation, economic entities optimize and rearrange various risk management technology, so as to implement effective control upon risks, properly handle the consequence of loss caused. Thus the goal of "least expense, most security" can be achieved. Risk management is an important part of public affairs management, as the main responsible supervisor, the government inevitably undertakes the tasks of dealing with all kinds of disasters and crisis [6].

19.3 Research Subject-dissemination Mode of We-media

19.3.1 Dissemination Structure of Blog Information

Knowledge sharing means that an individual, team and organization share the knowledge with other members of the organization in the course of activities through the various ways [7]. We-media transmits information by individuality after the popularization of computers. Due to its fission-like spread, We-media effect is more and more close to mass dissemination. Mircroblog, for example, has complicated network as the social web. Through the connection of each node, information is able to diffuse and spread constantly. In this network platform, people are not always able to obtain information directly from the original source, but often transfer information by message forward. The whole structure of microblog is also a binary transmission structure formed by "the key node and common node". Thus the roles of users are naturally divided into key communicator and ordinary communicator. Its dissemination mode is shows in Fig. 19.1.

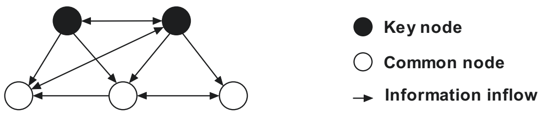

Fig. 19.1 Binary Dissemination Structure of Mircobloy Information Network

19.3.2 Realization of Content Polymerization Technology

The standardization and serialization of components production in the 19th century makes USA the leading role in machinery industry. And the same important role that Web2.0 takes to support the internet spreading its content proved that: only by certain standardized polymerization can micro content display its value. In this polymerization, the search engine holds a strong position, searching behavior is providing the appreciation value to the contents, thus strengthened the value chain of the information flow, integrated the scattered micro contents, and at the same time added their former value [8].

19.4 Dissemination System of Micro-content Information

Information dissemination is of increasing importance to our society. Existing work mainly focuses on delivering information from sources to sinks in a timely manner based on established subscriptions, with the assumption that those subscriptions are persistent [9]. A complete dissemination process is composed of five elements: dissemination subject, dissemination content, dissemination channels, audiences and dissemination effect. As for We-media, it has the following dissemination mechanism (1) dissemination subject: the "follow-up" interactive mode breaks the original classification of distributor and recipient (2) dissemination content: bears narrative characteristics of fragmented and private text; (3) dissemination mode: the diverse information release channel; (4) dissemination effect: construct social public discourse space. This dissemination mechanism makes the grassroots' discourse power get its regression, make it possible that grassroots opinions eventually become public opinions and at the same time have a profound impact upon the traditional pattern of public domain. To be specific, it is equipped with the following characteristics.

- One-multiple dissemination with multiple centers. Users are the center organizations and dissemination contents, which is a kind of one-multiple dissemination with many dissemination centers. From microscopic angle, a Netease user releases an essay which can be read by friends of A. Similarly, when the Sina microblog user B updates a message, all his fans will receive this message, which reflects the one-multiple fan-shaped spread. Macroscopically, there are people expressing their moods, issuing the logs and updating their messages in Netease and Sina microblog at every moment. Besides, each user has a group of his friends, which means that the message is disseminated in real-time through multiple centers. And, such dissemination is effective.

- Net-link fission spread. The multiple centers are spread through the link of the net structure. However, due to the existing difference in the dissemination process, the microblog will generate the fission spread while SNS is lack of the condition for such fission spread. Both microblog and SNS take the individual as the network nodes to form the network link through the connection with friends. The multiple centers participate in the network link to realize the spread and promotion of the messages. Such multi-center network link mode manifests the difference between the microblog and SNS in the dissemination course. Theoretically and technically, after the formation of one-time spread of the one-to-multiple mode, it will also produce the *N* times spread of many-to-many (till infinite) dissemination, finally shaping the many-to-many until to infinite fission spread.

This dissemination mode of the microblog is not only a kind of fission spread but also the multi-center network spread. As long as this microblog exists and is read by receivers, it may be spread. Theoretically, it is the process of infinite dissemination, which is far faster and more extensive than any previous media products in the dissemination speed and width. The fission mode and multi-center spread mode of the microblog make itself be a kind of rapid and popular dissemination media.

19.5 Present State and Problem of Information Dissemination Risk Management in We-media Era

The biggest problem of microblog information dissemination is information's authenticity and validity. Barrier-free dissemination is the characteristic of this dissemination mode. Therefore, how to guarantee the safety of information transmitted, how to regulate the safety of the dissemination vehicles, and how to supervise the information communicators to be self-disciplined have become a complicated and difficult problem.

19.5.1 Virus-like Fission Spread

This definition originates from nuclear fission, which according to Baidu encyclopedia, also called nuclear division, refers to the process of splitting from one atomic nucleus into many. Only large quality nucleases like uranium can develop into fission. After absorbing one neutron, two or more nucleases of smaller quality will be brought out, and two or three neutrons and great energy will be released. They cause other nuclear fissions and the process going on unremittingly is called chain reaction. Hence, huge energy is released in all.

In such areas as public welfare action, social assistance, supervision of public opinion, the spreading mode has displayed its strong social impetus and non-institutional rectifying power. However, false information, partial revealed event, and vicious rumor will even reverse the direction of the development of events. Abuses of or vent one's resentment through micro-blog often leads to unexpected consequences, or even may harm social justice, and influences well operation of social order.

19.5.2 The Dissemination of Network Information Conceals Risks

Openness, anonymity and immediate-sharing in the dissemination of information of we-media make it possible that information spreads at a low cost and a large scale in a short time and do not need authority, examination and modification from government. As companies and organizations have grown to rely on their computer systems and networks, the issue of information security management has become more significant. To maintain their competitiveness, enterprises should safeguard their information and try to eliminate the risk of information being compromised or reduce this risk to an acceptable level [10]. The publicity behavior of Netizen depends on their own value-orientation, political consciousness and interest expression to a great extent. Therefore, in fact, it is difficult for the government to control the content and result of microblog information dissemination effectively, which makes it more difficult for a nation to control public voice. Some information, values and political tendency that go against the government centralizing public opinions and public control have an influence on the orderly operation of political system.

19.5.3 We-media Triggers Social Collective Behavior

Nowadays our country is in the period of the so-called "risk society" by sociology and social group. It is likely to take shape in emotional value demand during the process of social transition. While with the massive emergence of socialized media, it is easy for people to abreact their dissatisfactions that it is difficult for them to get contented value appeal in real society and easily transfer to the internet. In the expression and description related to public events, it is inevitable to appear one phenomenon that regards civilian emotion, desire and demand as the only ending point and starting point. This happens to have the same view with populism's connotation in Political Science Encyclopedia written by David Miller, Vernon Bogdanor and Blackwell. It said, "a kind of group emotional expression stems from the excessive human's love desire to justice, equality, participation and simplicity and manifests rebellion and mania to current situation and system." [11].

19.6 The Countermeasure of Risk Management and Control in We-media Information Publicity

Out effective counter plan to answer the risk management and control in we-media information publicity is that we need highly value the influence of internet and other new media to public opinion, set up the management system combining legal norm, administrative supervision, self-regulation and technical support. Information security is a critical issue that many firms face these days. While increasing incidents of information security breaches have generated extensive publicity, previous studies repeatedly expose low levels of managerial awareness and commitment, a key obstacle to achieving a good information security posture [12].

19.6.1 National Macro Control

The nation should focus on speeding up the construction of modern risk management mechanism in order to handle global risks and system transition risks effectively. Risk management is the science and art of recognizing the existence of threats, determining their consequences on resources, and applying modifying factors in a cost-effective manner to keep adverse consequences within bounds [13]. In the process of transition, the weakened nation's management ability will lead to turbulence of transition and become the blasting fuse of the explosion of all social risks. To improve national management ability, reforming the nation's internal management structure and improving the nation's regulatory capacity of market and civil society are not enough, it is also necessary to adjust the relationship between government, market and civil society into a cooperated and complementary one so that social risk realization can be truly improved. Furthermore, risks don't belong to a certain country or region but commonly faced by all mankind. Many risks, ecological risks for example, are inter-regional or even global, therefore only governmental cooperation between regions and even international cooperation can really solve the problem. Linked together, organizations can exchange information and engage in transactions in ways unanticipated before, the emphasis being on information, which became core to most business activities and without which business will fail to operate [14]. Hence risk management is not the responsibility of a certain country or region but of the world. Under the precondition of considering fully the cultural differences, carrying out wide international and regional cooperation is the inevitable choice to achieve risk co-management.

19.6.2 Technical Specification and Perfection

Network technical regulation such as IP transfer protocol, domain rule system, firewall technology and data encryption technique adjust network construction behavior-network primary relationship on the basis of industry consensus and self-regulation which is the general regulation to guide network construction behavior. Seen form the range of application, it has the universality, forms the value orientation and it has the neutrality. Network technical regulation is a part and parcel of network construction, even it is the soul of that. If there are no uniform rules, global and embracive network will be unimaginable and therefore it can be only in a state of disunity (information isolated island), and can not form global virtual community absolutely. Specifically, at present the technique controlling of network media mainly has authentication technology, blocking, filtering and rating. Our country mainly adopts the first three methods. Nowadays the safeguard of network security in our country chiefly relies on the ceaseless technological upgrade and great majority emphasizes self-protection and demand users to establish password and install firewall in the process of practice.

19.6.3 Strengthen the Control to Risks

Risks are not usually likely to reveal their values continually after it has had the damage which has had influence and people have known, but for this reason as a boundary point, it will continue to give birth to risk factors which are new-style, potential and have no replicability or reiteration can be overcome after the failure results happened. The code of risk factors does not lie in today but in future. Therefore, it is important to control risks in the tolerable range of social system operation and development. Social development obviously exits risks. But it depends on the risks are big or small. The small risks must be assumed and high risks need to be controlled. Government somehow should estimate the risks about which bring from government self-behaviors, social interest group behaviors and even some individual behaviors. When the behaviors of a person or enterprise bring risks to others, government will protect and lighten the risks through controlling.

19.6.4 The Norm and Perfection in Law

The legal basis of administrative supervision to internet in our country is Management Method of Internet Information Services. The 18th rule of this law provides, “The State Council information industry competent department and the telecom administration of provinces, autonomous regions and municipality bring supervision and administration to internet information service into force according to the law. Related competent government department such as press, publisher, education, hygiene, supervision and management over drugs, industrial and commercial administration as well as public and national security implementation supervision and management in own scope of official duty." With the internet regulation formulated in succession by all ministries and commissions, administrative machineries become more and more participating into the control of internet media, which summarize into three types: access control department such as ministry of industry information technology; security control department such as public security department and national security department; content blocking department such as the central and local information offices, culture sectors and television and broadcasting departments.

19.6.5 Establish the Risk Management System

Promoting to establish the risk society based on the diversification of the risk subjects makes the relative subjects of each interest in society encounter with the challenge. They all need to improve their abilities against risks. Given there is a great deal of uncertainty in the process of information systems security risk assessment, the handling of uncertainty is of great significance for the effectiveness of risk assessment [15]. All subject cannot independently deal with the challenge of the risk society, which is required, the cooperation and compound management with the government, experts, civil society and citizen. In another world, the current Chinese social risk not only needs the public and private governance but also requires the cooperation of the public and private area. The government should establish the cooperation relationship with the society, which helps the government to achieve the risk information earlier so as to get the favorable opportunity of the risk management. It asks to change the previous control mode that regards the government or nation as the center, to build the risk management system including the social multiple subjects such as government, enterprise, non-profit organization, experts and the public and form the new pattern of the risk management that each side controls its own risk, government manages the public risk and the insurance takes part in the risk sharing.

19.6.6 Strengthen the Administrative Supervision

The management of our country on the news dissemination industry takes the administrative management as the dominant system. So does the network communication. The operational management of the network communication mainly includes the network communication security, network communication content and other managements. The general sense of the network security chiefly consists of two aspects: the operational security and information security. Management Method of Internet Information Services is the legal basis for us to conduct the administrative supervision on Internet [16]. The 18th rule of this law provides, "The State

Council information industry competent department and the telecom administration of provinces, autonomous regions and municipality bring supervision and administration to internet information service into force according to the law. Related competent government department such as press, publisher, education, hygiene, supervision and management over drugs, industrial and commercial administration as well as public and national security implementation supervision and management in own scope of official duty.” With the internet regulation formulated in succession by all ministries and commissions, administrative machineries become more and more participating into the control of internet media, which summarize into three types: access control department such as ministry of industry information technology; security control department such as public security department and national security department; content blocking department such as the central and local information offices, culture sectors and television and broadcasting departments.

19.6.7 Enhance the Self-discipline Consciousness of the Industry

It is the important component of the network dissemination management to establish the industry self-regulation system of the network media, play the role of the internal supervision of the industry and standardize the behavior of the practitioner. The largest organization of Chinese Internet industry is the Internet Society of China which is founded on May 25th, 2001. Now, it has more than 200 members, most of which are the corporate member. Its competent business unit is the Ministry of Information Industry. This Industry draws and publishes a series of self-discipline norms in succession such as Public Pledge on Self-Discipline for the Chinese Internet Industry, Illegal and Harmful Information Self-Discipline Including Forbidding the Spread of Pornography in Internet Website, Self-Discipline Norms against Malwares, Self-Discipline Norms about Blog Services, Public Pledge on Self-Discipline for Anti-Virus and Declaration on Self-Discipline of the Copyright of Chinese Internet Industry, to promote the healthy development of Internet. There are still some net citizens holding some self-discipline activities. For example, the “Net Civilization Engineer” was started in December, 2000; In September, 2011, before the coming of the 2562 anniversary of Confucius’ birthday, the domestic fans initiatively issued to set September 28th (Confucius’ birthday) of each year as “the Self-Discipline Day of Chinese Citizen” and initiated people to follow Public Pledge on Self-Discipline for Chinese Net Citizen. Besides, there are also other self-discipline norms aiming to the specific behavior of the network dissemination.

19.7 Conclusions

Upgrading and general diffusion of information technology have promoted the change of flow and distribution pattern of knowledge and information, which triggers the change of political power structure and then puts forward new challenges to national management ability. Since the political unrest after 2009's presidential election in Iran, from the end of 2010 to the start of 2011, Tunisia, Egypt, Libya, Bahrain, Syria and other countries in western Asia and northern Africa, even in the countries with different development levels, cultural backgrounds, political systems as well as citizen structures such as Norway and London appeared political or social unrests to various degrees. The root cause of such unrests is not the information technology revolution or the widespread of new media. The effect of cascade, mobilization, magnification and catalysis of new media has a fueled influence in the process of situation development without a doubt. How to cope with all public risk challenges produced by new media such as microblog in technology information publicity process, seek the management methods to adapt new situation and explore new media management mode to accommodate technical development demands is becoming a global common topic.

The influence of globalization and dramatic changes of technology is multi-dimensional and complicated. According to Fritz Derek Jameson, the forms can be summarized as five kinds: technological, political, cultural, economic, and social. Whether we realize or not, globalization has influenced every aspect of our lives, with no individuality or society that can be excluded from the influence. Since the 21st century, China has been developing in extremely complicated international environment, and especially in the critical period of economic and social transition, the risks of transition and globalization both made transiting circumstance of our country more complex with more complicated risks. From the overview of the paper, it can be seen that it is of realistic significance to acknowledge risk society correctly and establish efficient mechanism of risk management.

Formulating network ethics needs respect ethic tradition, and makes the best use and integrates traditional and modern ethic resources. Insisting on the basis of Chinese traditional ethics and noticing to introduce excellent achievements in traditional morality and effective operating mechanism is that internet and tradition morality coordinate and interact to constitute together a higher moral level in network ages. Regarding socialism with Chinese characteristics as the guidance reflects fully the advanced and epochal nature of socialist ethics. To enhance the microblog users' moral self-disciplined consciousness, quality education of public media should be reinforced and civil society and public spirit should be blossomed.

So long as risks are the unpredictable and non-discharged characteristic in the progress of modern economy and is distributed as same as wealth in different stratum, social performance of its principal contradiction and problem in fact is social justice problems. In the other words, in many aspects, with the inequity of class, status and wealth, social phenomenon reflected by those problems badly in need of social equity and justice solving brings about a kind of totally different allocation risks in society. Whether government and decision maker carry out value ideas of equity and justice in the whole society can directly influent social stability and harmony.

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Chapter 20
A Research on High and New Technology Enterprise Entrepreneurial Incubator Selection

Fangwei Ning, Junwen Feng and Ye Xu

Abstract Firstly, analyzing enterprise incubator function and incubation process. Then, by taking the multi-attribute decision property into account, a new incubator selection model is proposed based on TOPSIS (technique for order preference by similarity to ideal solution) and information entropy. The feasibility and effectiveness of the proposed method is validated by the case.

Keywords Incubator · TOPSIS · Information entropy · Selection decision

20.1 Introduction

The development of high-tech science industry is a key factor affecting national scientific and technological strength and the level of development, advancing the country's sustained rapid economic development booster. With the leadership of the high-tech industry development, it has dominance in the 21st century economic development and overall national strength. Between countries or regional the nature of economic competition is mainly in high-tech industry competition. The incubator system helps to promote the science and technology achievements industrialization, which has been highly concerned about being an effective tool to obtain competitive advantages of the high-tech industry. It plays a very important role in the development of high-tech industry, national and regional innovation system and economic prosperity. Current research on incubators of high and new technology enterprises in China are still in the initial stage of exploration, immature. But due to the needs

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of high-tech industrial development and the strong support from the national Governments, a variety of technology enterprises incubator has a rapid development [1, 2].

How to select enterprise incubators from the perspective of strategic decisions will become particularly important. In this article, an incubator selection method is proposed which is based on the information entropy and TOPSIS, by analyzing the basic theory of the information entropy, TOPSIS (Technique for Order Preference by Similarity to Ideal Solution) as a relatively simple logical meeting the specifications optimal selection method, the main use of information entropy indicators to determine the classification of each index weight, by means of the problem, “the best solution” and “most unsatisfactory solution”, sort the indicators attribute value of merit, and to provide a more scientific basis for selecting the optimal incubator.

20.2 The Basic Theory of Information Entropy

20.2.1 The Importance of Information

Information on the impact of role in the modern economic life gradually shows up, and became one of the principal means of market competition. The importance of information on the development of each enterprise is very significant. If an enterprise is the lack of information, even if it has sufficient funds, spacious workshop, a wealth of resources and manpower, it is difficult for enterprises to grow and develop, because the information is the enterprise’s vitality. Information on each of the enterprise is the most important resource of enterprises, who obtain more information, master the information accurately, who will be able to have a win in the market competition opportunities.

With the rapid development of science and technology, electronics technology, there are more and more ways for people to obtain information, getting more and more abundant information. In addition to daily television, newspapers and other traditional means of dissemination of information, networks, mobile phones and other advanced and convenient way, making access to information is no longer monotone, single. Breaking the previous forms of information especially advanced information monopoly, people can get a lot of information. However, access to information on how to use, especially with how people themselves or their own characteristics into useful information. Reality, some people can make good use of information obtained good development, while others are just the opposite. The reason why there will be two opposite results, mainly due to one of the greatest features of information: first information, then the judgment. Even if the same information, everyone has its own judgment standard and different. Some people through screening information, organizing information, analyzing information discover an adversity to make it survive go on the way to be able to get rid of, some people may be drawn pessimistic conclusion from the analysis. However, the reality of the experience and practice of warned us that only by adhering to the basis of factual information in order to come up with accurate information to determine the results. Especially in today's economic situation changing times, accurate judgment, extensive collection of information, summarizing the essence, kicked out of the dregs, the implementation of effective analysis, enterprises will have the basis and guarantees correct value judgment to the development of the situation, enterprises can take initiative in a competitive market, gain a competitive advantage.

20.2.2 The Basic Concepts of Information Entropy

Claude E. Shannon, the founder of information theory, defining information entropy as discrete random event probability of occurrence. Information entropy is mathematically a abstract concept, we can understand the information entropy into the probability of occurrence of certain information. When the higher degree of order of a system, the information entropy rather than lower. But the lower the degree of ordering is, the higher the information entropy. From this it can be seen that the information entropy is a measure of the degree of ordering a tool. In most cases, the higher the probability that a message appears, indicating that the information to be widely spread or widely referenced. Thus can be considered from the perspective of the spread, the value of the information can be represented by information entropy [4–6].

Program to calculate the information entropy is too much trouble, especially impossibly calculating entropy with multiple precondition information. Therefore, lots of information in the real social value cannot be calculated. Because information entropy and thermodynamic entropy has a close correlation, the decay process in the determination of information can determine the value of the information entropy. Therefore the value of the information can be reflected by the transmission of information. In the absence of external circumstances, information is more widely spread, longer time to process, so the higher the value of the information [7, 8].

20.2.3 Basic Properties of Information Entropy

In information theory, entropy is a very important concept, which can measure the uncertainty of a discrete random variable taking values of probability. The number of sets, entropy can be used to measure the degree of the order of the number of sets, where the degree of ordering is the high and low of the degree of correlation between the indexed concentrated around the connected data. Therefore, you can use the information entropy measure concrete collection, determining whether a collection of the things orderly according to the level of information entropy, are you sure, are diverse.

(1) Symmetry

The probability of occurrence of the system of the information, reversing where certain information to appear, although this system information appears in the order is changed, the entropy of the system of this information probability value does not change, which means that the entropy of the system does not change with the change of the information sequence.

(2) Non-negative

Information entropy is based on probabilities, while probability of knowledge knowable probability is negative, thus entropy values are non-negative.

(3) Certainty

In probability theory, if it is an inevitable event, the event's probability is 1, other events occur with a probability of 0. Similarly, a system, if the probability of a message's apparition is 1, the other information the probability is 0, so the information entropy of the entire information system is 0.

(4) Additivity

In probability theory, if an event can be decomposed into two events, the decomposition of the probability of the event is equal to the sum of the probability of two events occurring.

Similarly,in the information system, if an information broken down into two, the information entropy is equal to the entropy and the decomposition of the two pieces of information.

(5) Expansibility

In the information system, the probability of a message appears in a small or even negligible, the impact of this information is the entropy value of the entire system can be ignored. Accordingly, it can be drawn that add a very small probability of an information system, the entropy of the new information system will not change.

(6) Extremity

When information systems such as the probability of the same information in the probability appears, the entropy of information system reached maximum, more information and the system, the greater the entropy.

20.3 Incubation Process of Business Incubator

Due to the different stage of development of incubated enterprises, the hatching service Provided by incubator is different. Different characteristics have different hatching patterns. In this paper, business incubator hatching process is divided into five parts, they are Application for incubation, Examination and approval, Signed an agreement, Hatchery management and Final assessment [3]. Each part has a corresponding management specification, The specific process is shown in Fig. 20.1.

As can be seen from Fig. 20.1, These steps, selecting incubating enterprises, finding out the Requirements of the enterprises, allocating resources and assessment, which determines the success or failure of the incubation, are very important in the entire hatching process of business incubator. Besides, In order to provide

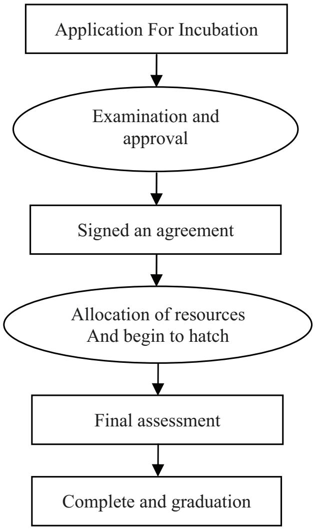

Fig. 20.1 Hatching process of business incubator

incubation space for more enterprises, the incubated enterprises will be regularly evaluated, Some poorly run enterprises will be eliminated, so that we can have more incubation space and optimize the incubator structure as well. The newly established enterprises incubating period based primarily on housing lease period, it's also one of the graduation period of enterprises. At the same time, period of the agreement is also a restriction of graduation. If it expires, we should review whether the incubating company is qualified for graduation. or continue incubating. Generally, graduation standards of incubated enterprise based on hours of operation, production scale, annual income and operating conditions. Once met the graduation standards, incubating enterprises need to submit an application, After reviewing and approving by the Incubator, the incubating enterprises can be awarded the diploma.

20.4 Incubator Selection Analysis Based on Information Entropy and TOPSIS Method

Choose the best business incubator is a typical multi-objective optimized decision-making problem [9–11]. TOPSIS method is a logical and simple optimal selection method to solve such problems. The evaluation procedure is as follows:
(1) Construct the initial index evaluation matrix

If the alternative business incubator is m, evaluation is n, evaluation value of business incubator is x_{ij}, then Evaluation matrix for all indicators of business incubators is:

$$X = \begin{pmatrix} x_{11} & \cdots & x_{1n} \\ \vdots & \ddots & \vdots \\ x_{m1} & \cdots & x_{mn} \end{pmatrix}. \tag{20.1}$$

In order to solve different dimension, Normalize the indexes as the following method:

$$r_{ij} = x_{ij} \Big/ \sum_{i=1}^{m} x_{ij}, i = 1,2,\cdots,m; j = 1,2,\cdots,n. \tag{20.2}$$

(2) The establishment of information entropy and entropy weight

During the selection of business incubators, Due to the different needs of each enterprise, Evaluation of the degree of importance of each index different. In determine weight factor of the evaluation index, the traditional TOPSIS method basically based on expert scoring, which is very subjective. In order to avoid the subjectivity, the author use information entropy to determine the weights in this paper.

Information entropy method uses probability theory to measure uncertain data, the distribution of the data is more scattered, the worse the stability. Made entropy e_j as decision-making information of Various indicators:

$$e_j = -k * \sum_{i=1}^{m} r_{ij} \ln r_{ij}, j = 1,2,\cdots,n. \tag{20.3}$$

In this formula, $r_{ij}(j = 1,2,\cdots,n.)$ represents the value indicator j; $k = 1/\ln m$, If the number of business incubators is certain, then k is a constant, to ensure $0 \leq e_j \leq 1$. The degree of dispersion d_j of the evaluation value data of indicator j can be expressed as:

$$d_j = 1 - e_j, j = 1,2,\cdots,n. \tag{20.4}$$

If more scattered the distribution r_{ij}, the greater the degree of dispersion d_j,then the degree of importance of indicator j is also higher; Distribution r_{ij} is relatively concentrated, the lower the degree of importance; If all of the r_{ij} values are equal distribution of absolute concentration, shows that the indicators had no effect.

$$w_j = d_j \Big/ \sum_{j=1}^{n} d_j = (1 - e_j) \Big/ \sum_{j=1}^{n} (1 - e_j). \tag{20.5}$$

(3) Index value weighted matrix

Weighting factor of each index w_j which is got by information entropy method, and standardized evaluation matrix is index value weighting matrix to value business incubators:

$$v = \begin{pmatrix} w_1 r_{11} & \cdots & w_n r_{1n} \\ \vdots & \ddots & \vdots \\ w_1 r_{m1} & \cdots & w_n r_{mn} \end{pmatrix} = \begin{pmatrix} v_{11} & \cdots & v_{1n} \\ \vdots & \ddots & \vdots \\ v_{m1} & \cdots & v_{mn} \end{pmatrix}. \tag{20.6}$$

(4) According to weighting matrix of the index value, calculate the set of indicators weighted evaluation values:

$$\begin{aligned} V^+ &= (v_1^+, v_2^+, \cdots, v_n^+) \\ &= \{(\max v_{ij} | j \in J_1), (\min v_{ij} | j \in J_2) | i = 1, 2, \cdots, m\}, \end{aligned} \tag{20.7}$$

$$\begin{aligned} V^- &= (v_1^-, v_2^-, \cdots, v_n^-) \\ &= \{(\min v_{ij} | j \in J_1), (\max v_{ij} | j \in J_2) | i = 1, 2, \cdots, m\}. \end{aligned} \tag{20.8}$$

In this formula, V^+ represents the most ideal (upper bound), V^- represents the most undesirable (lower bound), J_1 represents the indicators set, the bigger the Index value, the better it is; J_2 represents the indicators set, the smaller the Index value, the better it is.

(5) Calculated the distance of the upper and lower bounds

Calculate the actual evaluation value and distance of t of the upper and lower bounds based on n -dimensional Euclidean formula:

$$L_i^+ = \sqrt{\sum_{i=1}^{n} (v_{ij} - v_j^+)}, i = 1, 2, \cdots, m, \tag{20.9}$$

$$L_i^- = \sqrt{\sum_{i=1}^{n} (v_{ij} - v_j^-)}, i = 1, 2, \cdots, m. \tag{20.10}$$

(6) Calculated TOPSIS evaluation value

Sorted according to the size of the value, then select the top as the ideal incubator, The formula is:

$$Y_i = L_i^- / (L_i^+ + L_i^-). \tag{20.11}$$

20.5 Case Study

After market research and study, A high-tech enterprise decided to choose one from $S_1, S_2, S_3, S_4, S_5, S_6$ business incubators as Incubation of the enterprise entrepreneurship. Select the incubating space area, investment in fixed assets, the number of incubating companies and the total income of incubating companies as evaluation indicators. Evaluation values of the four indicators of those 6 business incubator are shown in Table 20.1.

Table 20.1 Evaluation values of 6 incubators

Business incubator	Incubating space area	Investment in fixed assets	Total income of incubating companies (Ten thousands)	Number of incubating companies
S_1	95000	2350	20	95
S_2	94000	2200	15	98
S_3	93000	2120	22	100
S_4	96000	2060	19	95
S_5	92000	2300	18	96
S_6	91000	2100	22	97

Those 6 business incubator constitute an indicator evaluation collection (it is called the sample space in probability theory), $S = \{S_1, S_2, S_3, S_4, S_5, S_6\}$. The candidate incubator which has Selected the incubating space area, investment in fixed assets, the number of incubating companies and the total income of incubating companies as evaluation indicators, constitute the index space $U = \{u_1, u_2, u_3, u_4\}$, then decision-making initial evaluation value matrix X is:

$$X = \begin{pmatrix} 95000 & 2350 & 20 & 95 \\ 94000 & 2200 & 15 & 98 \\ 93000 & 2120 & 22 & 100 \\ 96000 & 2060 & 19 & 95 \\ 92000 & 2300 & 18 & 96 \\ 91000 & 2100 & 22 & 97 \end{pmatrix}. \tag{20.12}$$

Inconsistent of dimension of various indicators requires it to be Normalized by formula (20.2) and got standardized average matrix, Calculate the weighting factor and give weight based on the establishment process of information entropy and entropy weight. In another words, first, put the normalized data into entropy formula: $e_j = -k * \sum_{i=1}^{m} r_{ij} \ln r_{ij}, j = 1, 2, \cdots, n$, got decision-making Information of the various indicators, then use Entropy measure formula:

$$w_j = d_j \Big/ \sum_{j=1}^{n} d_j = (1 - e_j) \Big/ \sum_{j=1}^{n} (1 - e_j)$$

to calculate the entropy weight of each indicator based on Weighting factor of index, got a standardized weighted evaluation value matrix:

$$W = \quad (0.0174\ 0.1220\ \ 0.8433\ \ 0.0174), \tag{20.13}$$

$$v = \begin{pmatrix} 0.0029 & 0.0218 & 0.1454 & 0.0028 \\ 0.0029 & 0.0204 & 0.1454 & 0.0029 \\ 0.0029 & 0.0197 & 0.1599 & 0.0030 \\ 0.0030 & 0.0191 & 0.1381 & 0.0028 \\ 0.0028 & 0.0214 & 0.1309 & 0.0029 \\ 0.0028 & 0.0195 & 0.1599 & 0.0029 \end{pmatrix}. \tag{20.14}$$

Calculate V^+ and V^-:

$$V^+ = (0.0028\ \ 0.0191\ \ 0.1090\ \ 0.0030), \tag{20.15}$$

$$V^- = (0.0030\ \ 0.0218\ \ 0.1599\ \ 0.0028). \tag{20.16}$$

Calculated the distance of the upper and lower bounds by (20.9) and (20.10):

$$L^+ = (0.0145\ \ 0.0509\ \ 0.0021\ \ 0.0219\ \ 0.0290\ \ 0.0023), \tag{20.17}$$

$$L^- = (0.0429\ \ 0.0013\ \ 0.0509\ \ 0.0291\ \ 0.0220\ \ 0.0509). \tag{20.18}$$

Calculate TOPSIS evaluation value by Equation (20.11):

$$Y = (0.7473 \ \ 0.0249 \ \ 0.9603 \ \ 0.5820 \ \ 0.4313 \ \ 0.9568). \tag{20.19}$$

So the order of six business incubators is:

$$S_3 > S_6 > S_1 > S_4 > S_5 > S_2. \tag{20.20}$$

This shows that incubator S_3 is the best choice for the enterprise.

20.6 Conclusion

With the rapid development, China is becoming the center of the global high-tech industry. The decision-problem of choosing enterprise entrepreneurial Incubator is becoming more and more important. In this paper, the author transports and sort the evaluation indexes Firstly, Calculate the weight with information entropy measure, calculate standardized weighted evaluation value matrix and the distance of the upper and lower bounds, then got TOPSIS evaluation value. By sorting and optimizing the evaluation value, build multi-attribute decision model based on probability theory and information entropy theory, to provide the basis for the selection of corporate entrepreneurship incubator. This method, which effectively solved the subjectivity in determining the weight by traditional methods, combined the quality and quantity effectively and made Subjective and objective evaluation complement each other, puts more evaluation information into the evaluation results, is consistent with the needs of corporate decision-making.

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Chapter 21
The Research of Information Disseminating System Management in New Media Age

He Liu

Abstract With the advent of new media age, the tendency of individualization is more and more distinct. It is the reflection of society diversification and individualized needs in the field of media, the fruit of technological development and application in modern media, the representation of mass information and society informatization, and the outcome of dissemination media's development in a certain phase. Especially the We-media forms such as Microblog, have put forward new issues to the management and control of information dissemination system, thus come up with suggestions that we should face up and follow the trend, set management target of harmonized development, establish distributed management model and a coordinated system in the computer network environment which is mainly under technological and legal management.

Keywords New media · Information dissemination · Information management

21.1 Introduction

In recent years, the rapid development of information technology and science has generated new media as web portals, academic website, BBS, blog, Microblog, and Kik. The new media which are preeminent due to their online mutual interaction, or hypertext links and dynamic update record and release thoughts and personal argument of media users, connecting relevant and valuable information and resources of the website. As a new style of living, working, learning, and communicating, these new media have been accepted and applied more and more popularly [1]. For example, Microblog, a system similar to blog used to release immediate information, is

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generally used by users who release information through mobile and IM (Immediate Mobile) software such as gtalk, MSN, QQ etc or API interfaces. "Micro" besides the letter "blog" has straightforward shown the difference between "Microblog" and "blog". Due to its innate relation with mobile notes, the word count required of a Micoblog is the same to that of a note, both less than 140 words. Microblog has been gradually applied in organizations and institutes as government, enterprises, and public areas and its development has a more and more obvious effect on the developing mode, the management and control of media [2].

21.2 Definitions

(1) New media

New media can be defined in two ways, both in technology and in information dissemination. Technologically, new media refers to the forms of new media based and influenced by IT technology. Wireless mobile web, the wider extension of website basis nowadays, and other new forms of media relevant to computer and website can all be called new media [3]. On the other hand, from the perspective of media, new media is the fourth and fifth media concretely. According to the materials from Stanley International BBS, UNESCO has made a more brief and concise definition of new media: new media is internet media, which is relative to traditional media forms. People absorb visual information unilaterally from pictures and words in newspaper and publications, acquire audible information from sound wave of broadcast, and accept both visual and audible information from motional pictures and sounds in TV. The first three media are all unilaterally disseminating information, with audience unilaterally receiving information. Thus the choice of receiving or not put the audience in a negative position. However, from the perspective of the fourth media, the internet, receivers have been transferred to the active side. They can select freely which part of information, choose to receive the information or not, and this transformation from unilateral output to mutual interaction is the biggest difference between new media and traditional media [4]. In brief, new media is a specific definition in a certain time or an age. It is likely that new media will become more and more digitalized, virtualized or even inexistent in the future. Although it will become a history like other things, it is a symbolized pronoun of this period and remains to refer to the many changes and progression as technology develops. It is certain that new media won't end up in such a platform of digital and online media, but will further develop on the contrary.

(2) Information management

Information Management (IM) refers to the management activities which take IT as the carrier and the internet information and information service as the basic objects. Through the distribution, constitution, storage, utilization and service of computer network information, it can ensure normal operation of the service and application of computer network information. The computer network information management of new age is composed of four parts: organization of information resources, platform coordination, terminal user access control and safeguarding [5]. If the total computer network information management is regarded as an entirety, then the organization of information resources is the premise, information platform coordination is like the carrier, terminal user access control is the basis, safeguarding is the kernel, and the last has shown its the important position among the four. This classification can help us to make safeguarding measures pertinently, so that security and integrity of the whole computer network information can be achieved. Specifically, computer network information management can be divided into four basic types [6]:

(a) Basic Running Information

Basic running information is the basis of the entire computer network information, the basic managing object, and the essential premise of all kinds of diversification development of computer network information. Generally speaking, it consists of IP address, domain name, and AS.

(b) Server Information

Theoretically, server information is the joint name of all the information closely related to the server's normal performance during the process of supplying network information service of computers. It is the most crucial indicator for related technicians to judge the performing quality and efficiency of the whole computer server. Generally, server information includes the basic configuration parameters, load balance index, access index and information service integrity index.

(c) User Information

Simply, user information of computer network information consist the relevant materials and data of users' name, department, posts, rights and liabilities, and it is the certification of users' identities.

(d) Network Information Resources

Network information resources refer to the information resources generated during the process of supplying network information service to terminal users by the computers. To the network structure of tree topology form, network information resources of servers are scattered and nonlinear, and the transmission and release of network information resource are nonsynchronous producing many potential safety hazards such as intervention of unsafe information, and leaking of network information, which needs special care from relevant technicians.

21.3 Information Dissemination System in New Media Age

Nowadays, new media which appear mainly in the forms of social network websites (Online Social Networks abbreviated as OSNs) such as Sina blog, Renren, Facebook, Flickr, have become one of the main platforms for people to communicate, enquire and release information online. Through unilateral or two-way communication and sharing information among friends, users of OSNs are no longer the negative media receivers but the makers, sharers and spreaders who are able to get involved in online activities actively. Due to its large base number, good time-effectiveness, relatively free disseminating system and low cost of use, OSNs has become a very good socialization and business (viral marketing) platform for sharing and disseminating information [7].

21.3.1 Information Dissemination Model of Microblog

The continual improvement of development and disseminating model of computer network has shown that the fusion of the two in the progress. The greater refinement of computer network function, stronger instantaneity of website, and wider coverage have provided the objective basis to produce more refined and diverse new media models with more disseminating channels. New IT and disseminating model complement, coordinate and develop mutually. This paper will take Microblog which can represent technical thoughts of a new generation for example, and illustrate the dissemination model in five parts: disseminator, information, media, receiver and feedback.

This classification is similar to Maletzke model. In 1963, the German scholar Maletzke put forward a mass communication model in "The Philosophy of Mass Communication". Based on models of predecessors and through meticulous consideration, this model was illustrated in five parts: disseminator, information, media, receiver and feedback. And each part was illustrated in full details. It is emphasized by this model that the self-image, personality, organization situated, dissemination content, pressure from the public, working and social environment of disseminator are all influencing and restricting factors of dissemination. While factors that affect receivers are: the self-image, personality, group and social environment of receivers, the effect and influence of information, and restricting power of media, etc. There are mainly two aspects in the factors that influence and restrict media and information. First, the selection and processing of information content by disseminator. Second is the contact and selection of media content by receivers. Through the analysis of this model, it can be concluded that this model not only shows the conditionality of society in the process of dissemination but also the psychological variable in it. Compared with previous models, this model is more reasonable in the analysis and research of actual dissemination process [8]. Fig. 21.1 has illustrated the dissemination Maletzke model of communication.

Microblog has achieved complete fusion from dissemination platform to dissemination content in its unique way. Briefly, Microblog is both dissemination path and dissemination effect. Thus, the dissemination model of Microblog manifests itself as the fusion of M and media in Maletzke model, here called M. Fig. 21.2 has illustrated the dissemination model of Microblog:

The disseminator of Microcblog edits and releases information, while receivers contact and select media content. The fusion of M and media become the key point between disseminator and receiver. After transmission from Ms to R, preliminary dissemination will go on among receivers, which features in fast and shotcut point-to-point note dissemination. Due to different hotspots' scattered followers, the dif-

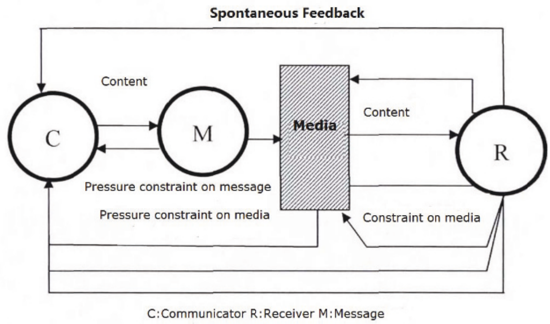

Fig. 21.1 Maletzke model of communication

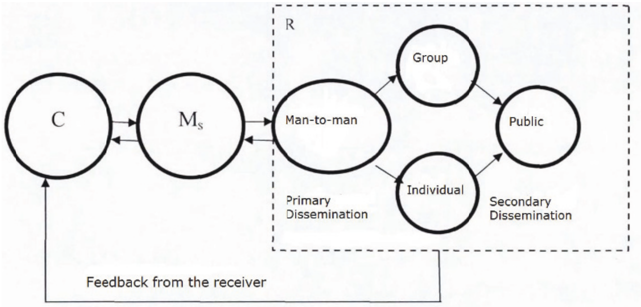

Fig. 21.2 The dissemination model of Microblog

ferentiated dissemination of receiver division, pertinence, and in-time content update can be achieved, so that followers of a same blog or subject turn into a circle or a group [9].

The fission dissemination of Microblog equipped itself a feature of re-amplifying dissemination. When a hotspot is being disseminated through Microblog, the disseminator will state and spread his opinion of the issue briefly, and the receiver will transmit and feedback the information afterwards in the process of information dissemination, then the disseminator will continue to come up with new information according to the feedback from receivers in order to reply the receivers' feedback and explain. To make the information more complete and persuasive, the disseminator or receiver will extend the topic from the platform of Microblog to other internet dissemination platforms, even to traditional platforms such as newspapers, broadcasts and TV. Hence disseminator and receivers' preliminary dissemination that spreads in multi-levels from Microblog has enlarged into mass communication. Mass communication deepens and enlarges the hotspot, and finally transmits the more complete and diverse feedback of receivers to the preliminary information disseminator [10].

21.3.2 Dissemination Features of Information in Microblog

(1) Differentiated dissemination

This dissemination refers to a subdividing dissemination to a receiver group of distinct characteristic. It features in differentiated receiver group, dynamic adjustment and content update. There is noticeable dissemination in the preliminary dissemination, when disseminator owning indefinite number of followers turns into differentiated dissemination. The receiver are directional with little characteristic of mass communication [11].

(2) Mass communication

Microblog dissemination has experienced the process from preliminary differentiated dissemination of small groups to mass communication, and finished update of differentiated dissemination's influence to that of mass communication in the process. However, this effect brought out by the update makes a much stronger effect in dissemination scope. The function of a key forward becomes the tunnel of finishing this update so that the receiver of preliminary dissemination transferred to the producer of re-dissemination and the server of valued information. Thus there will be the geometric increase of receiver group and wider dissemination scope. The rapid growing from individual and small group into mass has achieved secondary dissemination and update of dissemination status [12].

(3) Multi-level dissemination

Different from traditional dissemination model, the dissemination of Microblog is very complicated, not single or linear but multi-level. This non-linear dissemination process doesn't end in first time. It performs preliminary dissemination through the function of focus, continues secondary mass communication in the face-to-face way, and more multi-level dissemination of larger influence. The effect brought out by the dissemination mechanism of large and geometric multi-level scope is unpredictable. During the process of preliminary Microblog dissemination, content and information loaded is transmitted to receivers through differentiated dissemination, and secondary dissemination will start or not depending on the selection of contents by receivers who added their own information. Secondary dissemination extends to mass communication, and then turns into multi-level dissemination with the help of traditional mass communication platforms. The geometric increase of contents and scope of information, depth and width of negotiation and effect of mass communication will bring larger disseminating effect and influence of Microblog dissemination mechanism [13].

21.3.3 The Current Status and Problem of New Media's Information Dissemination Management

In the new media age, there are great changes in the characteristics and scope of dissemination, especially after the existence of Microblog. However, there are many problems as bulk, fake, disordered and incontrollable information. Thus how to improve these situations and lower the negative impact brought out by internet has become an urgent problem.

(1) Severe information pollution

The illegal and hazardous information mainly include: the information that hazards the country's security such as those relevant to political demagoguery, terrorism, producing bombs, and drug abuse; the information that harm the benefit and health of juveniles, like seducing juvenile marketing, violence and eroticism; the information hurting the dignity of others, inciting national and racial hatred; the information that threatens the security of economic performance; the information destroying others' privacy such as filching others' data, harassing people by electrical vehicles and ruining others' reputation; the information that destroy intellectual property rights and so on [14]. Nowadays, the phenomenon that the users of Microblog can express their own opinions through Microblog' client-side can be regarded as they boast the right of making speech freely. However, there lacks specific regulation on such freedom of speech, leading some comments severely hurting others' benefit but without accusation or correction from government, and make the freedom of speech of the public magnify accordingly.

(2) Severe offence of privacy

Meanwhile, some citizens put forward the exposure of their privacy. The users of Microblog not only express their own opinions, but also have the freedom of sharing photos, part of which involves others' privacy and yet this kind of performer's behavior won't be prevented [15].

(3) Security of information

The government has the duties to protect citizens' legal rights from being violated, but on the problem of information security of Microblog, they can't come up with specific measurement like turning off Microblog client, hence the solution of information security of Microblog is urgent. The open and sharing computer internet offers convenient service to terminal users, but also brings out certain security problems to the whole computer network.

21.3.4 Some Countermeasures

The rapid development and wide application of internet technology of computer, global communication and internet have made profound changes take place in science, economy, culture and society. Since the 1990s when we have entered a new age featuring in informationized, networking and globalized economic development, information has become another crucial resource after material and energy to support the social and economic development, transforming the allocation of social resources, and changing people's value, and styles of living and working. Therefore, in order to solve the problem above, some countermeasures of information management and control in the new media age are presented as follows [16]:

Firstly, we should face up to this trend, improve our opinions, evaluate the basic environment and tendency of new media scientifically and set information management target in accordance to the tendency. Since the individualization of new media delegated by Microblog is the reflection of social, economic and technological developing trend in the area of media, this tendency should be guided but not restrained. The aim of information management and control is to trigger healthy development of individualization of new media, to widen the influence of new media, to balance and coordinate new and traditional media, and achieve mutual development of both media and society.

Secondly, traditional information management model in the new media ago should be reformed. New media relies on the internet, which has basic functions as information storage and dissemination service. Currently, due to the magnitude of information, the total amount of information is hard to control and even harder in dissemination channels because of interactional links. Especially such individualized applications like Microblog, whose privacy and communicating features make it harder to examine each product one by one. In the face of these challenges, management models must be reformed to achieve renovation. For example, establish classified management model, control links in private blog, both to prevent leaking of privacy but also arbitrary spreading of speeches and forming of bad organizations.

Thirdly, according to distributed and individualized internet media, establish the technical system of new media management and control. Internet platform is the basic operational social platform and foundation of efficient performance of social, economic, political and cultural activities in modern society. But at the same time, this platform is also a highly distributed IT system. To a large extent, the individualization and personalization of new media which fundamentally changes the organization, production and dissemination of information, is produced due to the application of these technology. Hence, a distributed media management platform can be established according to the characteristic of distribution media platform of the internet. Fourthly, since such media as Microblog, BBS, blog are noticeably individualized, numerous, and unsystematic, a system used for blog links' collecting, searching and filtering can be designed so that information can be guided and filtered and the mechanism that selects the superior and eliminates the inferior can be formed. For example, the topic Microblog research and engine system which gathers information, selects and recommends better information, can guide the new media of good credibility to develop healthily.

Fifthly, improve the legal environment of media management. In China, we already have the basic regulations and policy system and it has laid standardized regulation on the management of domain name, BBS, internet news, and online publication. However, we should further make united and legal definition of new media, solve the problem brought out by the great difference of technical division and administration classification, and eliminate the severe separation and overlapping in the division of media, so that the present stat of overlapping management can be transformed [17].

Sixth, follow the principles of prevention, dynamics, and balanced safeguarding. The principle of prevention means that we should mainly prevent in Microblog information security management, with certain forward thinking. Dynamic principle refers to the improvement of protecting ability of Microblog system according to current changes of conditions and progress in technology. While the principle of balanced safeguarding comes from “cask theory”, it means that the security level of the whole Microblog system depends its weak points, thus to improve the intensity of security in a certain part is not practical to the whole system.

Seventh, enforce the safeguarding of visit control. In current condition of being supported by existent technology, the strategies to control visits in information security management of computer network can be divided into two types: one based on rules and the other based on roles. Due to the support of this safeguarding strategy, the terminal users accept roles and are blessed with according rights. In nature, user s role is the fundamental semantic structure of forming access control strategies, and able to make equal quantity of transformation as rights and liabilities of users change. And finally, strengthen the safeguarding of access control. For the structure of computer network, I suggest that X.509 certificate promulgated under the environment of PKI system should be used as the safety certificate of access control in the whole computer network information management. After the submission of X.509 certificate by the user, the access control system in computer network will read the relevant information of the certificated submitted, reads and inquires corresponding information in the directory server, then inquires the roles of users of submission, and on the basis defines the accessing right of access resources required by users [18].

21.3.5 Conclusion

With the increasing development of science, technology in modern society and improvement in society and economy, the material and spiritual needs of public grow and meanwhile it put forward more overall and systematic demands of development to the application of computer network and technology of the system in new media age. Information management in the new media age is boasting itself more diverse, integrated and systematic development. And information security problems brought out by it is especially obvious, thus in need of our wide attention. This paper has analyzed and illustrated briefly some problems in the information management of new media which needs special focus, and the countermeasures designed to protect, in the expectation of offering some reference and help for related research and practice afterwards.

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Chapter 22
A Classifier Ensemble Model Based on GMDH-type Neural Network for Customer Targeting

Jin Xiao, Changzheng He and Shouyang Wang

Abstract With the speedy development of information technology, database marketing has become a hot topic for both marketing practitioners and scholars, and customer targeting modeling is a top priority in database marketing. To overcome the limitations of the existing models, this study proposes a classifier ensemble model based on group method of data handling (GMDH) type neural network for customer targeting. It first utilizes GMDH-type neural network to select the key explanatory variables, trains a series of base classification models, and then conducts the classifier ensemble selection based on the forecasting results of the base models by GMDH-type neural network again to get the final ensemble model. The empirical analysis results show that the hit rate of the proposed model is better than that of some existing models, and it can bring more profits for the enterprise.

Keywords Customer targeting model · GMDH-type neural network · Multiple classifiers ensemble · Database marketing

22.1 Introduction

Nowadays, the massive amounts of data are changing our world. In many industries, especially telecommunication, finance, and so on, the data are almost the operation itself. According to the estimation of McKinsey Global Institute (MGI), the new data of the enterprises in the global are more than 7 EB (1 EB equals to 10 billion GB) in 2010. At the same time, the consumers store more than 6 EB new data in PC, laptop computers, and other equipments. It is obvious that big data has been a trend,

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and the use of the massive amounts of data will become the base of the enterprises' future competitiveness, and it will indicate the advent of a new wave of productivity increase and consumer surplus. However, with the geometric growth of the customer data, the value density of data decreases gradually. How to mine the valuable information from the data ocean, allocate the limited source more reasonably and maximize its profits is an urgent issue for all enterprises.

To solve the above issue, the database marketing emerged in 1990s provides a powerful tool. Database marketing is to utilize the customer databases to enhance marketing productivity through more effective acquisition, retention, and development of customers [1]. The customer here can be either the current customers or the potential customers. The enterprises have the data on the current customers' purchase behavior, demographic and psychographic information, as well as the firm's previous marketing efforts extended to these customers and their response to them. While for potential customers, the enterprises may be able to obtain data on customer demographics and psychographics, as well as purchase history data, although not in the same depth as available for their current customers. The aim of the database marketing is to identify which part of the enterprise's marketing efforts is effective, and enable the enterprise to focus on those valuable customers.

In database marketing, it is vital to build an efficient customer targeting model. It uses the data of the current customers to learn model, and adopts the learned model to predict which customers will respond to mailings and other forms of direct marketing promotions (including e-mail and targeted Internet) [2], and these customers are just the target ones of the enterprise. At present, the commonly used customer targeting model is linear statistic method, and the typical model is Logistic regression. There are no assumptions about the distributions of the explanatory variables in Logistic regression. However, the explanatory variables should not be highly correlated with one another because it may cause problems with estimation [3]. Logistic regression does not need to presume the distribution of the explanatory variable, but there is no high correlation among them, or it will bring the error of the model estimation. At the same time, samples with large size are required for logistic regression to provide sufficient numbers in both categories of the response variable. The more the explanatory variables are, the larger the sample size requires [3]. In order to overcome the limitations of Logistic regression, other methods such as ridge regression, stochastic RFM (Recency, Frequency, Monentary) response models are applied to customer targeting.

As a non-linear model that can simulate the brain function, the neural networks have also been applied to customer targeting in many industries such as retailing, banking, telecommunication, and have shown good forecasting performance [4]. While, some scholars found that the customer targeting performance of neural networks is no better than that of the simpler Logistic regression. In fact, there are many merits to customer targeting with neural network, while there are also shortcomings, such as the difficulty in confirming the optimum training parameters, easily leading to over-fitting to noise data [5]. The "over-fitted" neural network model will fit the training data (even containing noise) perfectly, but its performance in the dataset which is not used to model is poor.

On the other hand, for a large number of forecasting variables describing the customers' features, data dimension reduction is an important factor in building a predictive model that is easy to interpret, cost effective, and generalize well to unseen cases. The commonly used method is principal component analysis (PCA) which is used to generate new variables as predictors [6]. While this method has some drawbacks: first, in the process of data reduction, it does not consider the relationship between the dependent and independent variables; second, the resulting principal components from PCA can be difficult to be interpreted when the space of input variables is huge. Different from the idea of PCA, the variable selection method can directly select some key variables with strong interpretability from the independent variable set. However, how to select an optimal variable subset is still an issue to be resolved. At the same time, most of the existing researches adopt single predicting model. To improve the performance of customer targeting, some scholars attempted to utilize multiple classifiers ensemble technology [5], for instance, Ha et al [2] proposed Bagging based customer targeting model. While these researches just combine all base classifiers. In fact, redundancy may exist among the base classifiers because each classifier provides a solution to the same task. Thus, Zhou et al [7] proposed that integrating a classifier subset selected from the base classifier pool (BCP) may be better than integrating all classifiers. But it is scare to use ensemble selection strategy in customer targeting area.

To solve the new problem in practice, we must look for new method. Group method of data handling (GMDH) based multi-layer neural network proposed by Ivakhnenko [6] is a heuristic self organizing modeling technology. GMDH neural networks can find the optimal complexity model through the external criteria and termination principle, and finish the modeling process automatically, including the selection of the important variables, the calculation of the parameters of the middle candidate models, the confirmation of the number of layers of multi-layer network structure. It can avoid the problems of traditional neural network such as confirming the parameters and over-fitting.

This study proposes a multiple GMDH-type neural networks ensemble (MGNNE) model for customer targeting. First, it utilizes GMDH-type neural network to select the key independent variables, and constructs a series of base customer targeting model. Further, it conducts the classifier ensemble selection based on the forecasting results of the basic models by GMDH-type neural network again to get the final customer targeting model.

The remainder of this paper is organized as follows. Firstly, it gives an outline of GMDH theory in Sect. 22.2, describes the MGNNE model in detail in Sect. 22.3. Secondly, to evaluate the performance of the proposed model, it shows the experimental setup and experimental results analysis in Sect. 22.4. Finally, conclusion remarks are given in Sect. 22.5.

22.2 GMDH-type Neural Network

The basic idea of GMDH-type neural network is to build a multi-layer feedforward network structure. It starts from the input layer, generates new candidate models in every layer through combining two models of previous layer, then utilizes some external criteria [8, 9] to evaluate and select the middle candidate models in a multiple-input single-output dataset, finally gets the optimal complexity model by termination principle. In recent years, GMDH-type neural network has been applied in a broad range of areas such as engineer, science and economics successfully [10–13].

In GMDH-type neural network, the general relationship between the output and input variables is described in the form of mathematical description, which is also called reference function. Usually the description is considered as a discrete form of the Volterra functional series or Kolmogorov-Gabor polynomial:

$$y = f(x_1, x_2, \cdots, x_n) = a_0 + \sum_{i=1}^{n} a_i x_i + \sum_{i=1}^{n}\sum_{j=1}^{n} a_{ij} x_i x_j + \sum_{i=1}^{n}\sum_{j=1}^{n}\sum_{k=1}^{n} a_{ijk} x_i x_j x_k + \cdots \tag{22.1}$$

which is known as K-G polynomial [8]. Here, y is the model output (in customer targeting, y is the response variable), and a is the vector of coefficients or weights. In particular, the form of the first order (linear) K-G polynomial including n variables (neurons) is as follows:

$$f(x_1, x_1, \cdots, x_n) = a_0 + a_1 x_1 + a_2 x_2 + \cdots + a_n x_n. \tag{22.2}$$

If the reference function is linear, then when we model by GMDH-type neural network, we regard all sub-items of Equation (22.2) as $n+1$ initial input models of the network: $v_1 = a_0, v_2 = a_1 x_1, \cdots, v_{n+1} = a_n x_n$. Its specific modeling process is as follows.

Compose every two random initial models as one unit according to the transfer function $y = f(v_i, v_j) = a_1 + a_2 v_i + a_3 v_j$, and then there are $n_1 = C_{n_0}^2 (n_0 = n+1)$ middle candidate models in the first layer:

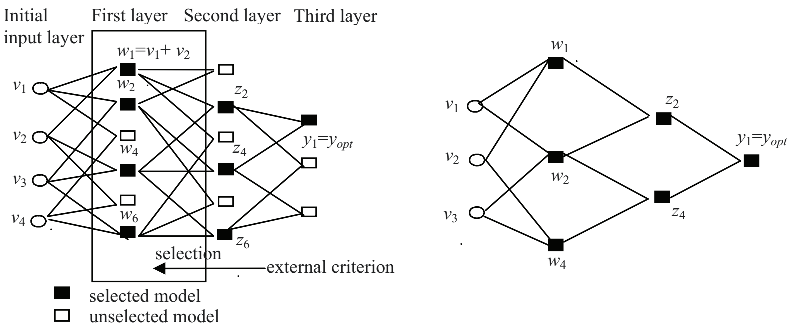
$$y_k^1 = a_1^k + a_2^k v_i + a_3^k v_j,\ i, j = 1, 2, \cdots, n_0,\ i \neq j,\ k = 1, 2, \cdots, n_1, \tag{22.3}$$

where, y_k^1 is the estimation output, the coefficients a_1^k, a_2^k, a_3^k $(k = 1, 2, \cdots, n_1)$ are gotten by least squares (LS) in training set. By threshold measurement, $F_1 (\leq n_1)$ candidate models are selected, and they are regarded as the inputs of the next layer by pairwise coupling. Then, $n_2 = C_{F_1}^2$ middle candidate models are gotten in the second layer:

$$y_k^2 = b_1^k + b_2^k y_i^1 + b_3^k y_j^1,\ i, j = 1, 2, \cdots, F_1,\ i \neq j,\ k = 1, 2, \cdots, n_2. \tag{22.4}$$

The process continues and stops after finding the optimal complexity model by the termination principle (see Fig. 22.1), which is presented by the theory of optimal complexity: along with the increase of model complexity, the value of external criterion will increase first and then decrease, and the global extreme value corresponds to the optimal complexity model [14]. In this way, algorithm can confirm the input variables, structure and parameters of final model automatically, accomplish the process of self-organizing modeling, and also avoid over-fitting [11]. Finally, the parameters of the optimal complexity model are retrieved through connecting units from the preceding layers.

Usually, GMDH-type neural network randomly divides the training data set into model learning set and model selecting set. When we utilize GMDH-type neural network to model, start from the initial model set composed by reference function, carry on parameter estimating by internal criteria (least squares), get middle candidate models (inherit, mutation) in model learning set, choose middle candidate models in selecting set by external criteria, until find the optimal complexity model by the termination principle. Fig. 22.1(a) shows the process of looking for the optimal complexity model y_{opt}. Fig. 22.1(b) demonstrates how to find the initial models contained in y_{opt}. After finding y_{opt}, we only need to reverse from the first layer to the input layer. We can see that it contains three initial models: v_1, v_2, v_3, i.e., variables x_1, x_2, x_3, and the variable x_4 is eliminated in the self modeling process.



(a) process of finding y_{opt} (b) find the initial models contained in y_{opt}

Fig. 22.1 The modeling process of GMDH-type neural network

22.3 Multiple GMDH-type Neural Networks Ensemble

Let D be the whole customer targeting dataset, T_r and T_e be the training set and test set respectively. Fig. 22.2 shows the flow of GMDH-type neural networks ensemble model for customer targeting. The model contains 3 phases primarily: (1) Generate a series of training subsets with balanced class distribution; (2) Select key explanatory variables and train some basic prediction models; (3) Construct the multiple classifiers ensemble selection model.

22.3.1 Generate a Series of Training Subsets with Balanced Class Distribution

When we construct a customer targeting model, the response variable y is a binary variable: if a customer responds to the promotion of enterprise, then $y = 1$, otherwise $y = 0$. We usually face a serious problem that the number of two classes customer is different largely, i.e., the class distribution of the training set is imbalanced. Under this condition, the traditional customer targeting models, such as Logistic regression and neural network, are prone to predicting all customers as the non-response customers, and the prediction accuracy of the response customers will be very low. While the response customers just are the target customers.

In order to solve this issue, the commonly used method adopts re-sampling technology, such as random over-sampling (randomly select some samples with replacement from the response customers, till the number of two classes customer sample are equal) and random under-sampling (select samples equal to the response customers randomly from non-response customers without replacement) to balance the class distribution. In multiple classifiers ensemble, the diversity among the classification results of all base classifiers is the important guarantee for the performance of ensemble model. Thus, it requires the diversity among the training subsets for GMDH-type neural network modeling. This study proposes a mixed sampling method combining over-sampling with under-sampling: suppose that there are m_1 response customers and m_2 non-response customers in the training set, over-sample ceil $(\frac{m_1+m_2}{2})$ response customers, under-sample ceil $(\frac{m_1+m_2}{2})$ non-response customers, here, ceil$(\cdot)$ is the rounded up function, and then we can get a training subset with balanced class distribution. Repeat the process L times, and L balanced training subsets are obtained. Therefore, in all training subsets, the samples of each class are not completely the same, which assures the diversity of the samples.

22.3.2 Construct the Multiple Classifiers Ensemble Selection Model and Forecast the Class Labels of Customers in Test Set

In fact, the modeling mechanism of GMDH-type neural networks is very flexible, for the variables of initial input layer can be some simple variables, and also some elementary models. Because GMDH-type neural networks can select some key units which have important influence on the research object from all of the input units, it is utilized to construct multiple classifiers ensemble selection model in this paper. Here, the L input units of GMDH-type neural network are the forecasting results $R1, R2, \cdots, R_L$ of the above L base customer targeting models for the customers in the whole training set, and the model output y is the real response variable of these customers. Next, the process of GMDH based ensemble selection is the same as that of general GMDH-type neural network, till we get the optimal complexity

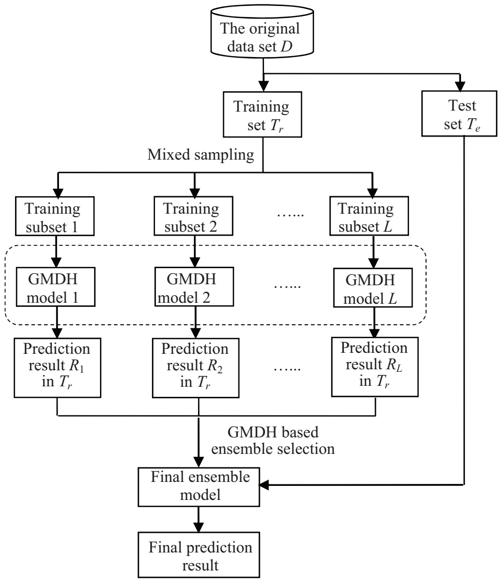


Fig. 22.2 The flow of multiple GMDH-type neural networks ensemble

multiple classifiers ensemble model. In the modeling process, those base customer targeting models whose forecasting results (the initial input units) are not important for the prediction of the final customer response will be washed out, and finally one classifier subset is obtained. Suppose that the subset contains $M(M \leq L)$ base models, the final ensemble model can be expressed: $y = a_0 + a_1R_{t1} + a_2R_{t2} + \cdots + a_MR_{tM}$.

The main aim of constructing customer targeting model is to forecast the response (class label) of customers in test set, therefore, after getting the optimal complexity ensemble model, we just need to use the final selected base models to predict the customers in test set, take their forecasting results into the final ensemble model, and then get the final forecasting results of their response to the enterprise's marketing strategy.

22.4 Experimental Analysis

22.4.1 Data Description and Experimental Setup

To evaluate the performance of the customer targeting model MGNNE proposed in this paper, the dataset for the experimental analysis is from the CoIL forecasting competition in 2000 [4]. It is a solicitation of 9,822 European households to buy insurance for a RV. There are 85 forecasting variables and one response variable. These customer samples are divided into two datasets: the training set with 5822 households, and the testing set with 4000 households. The training set is used to construct customer targeting model, and forecast the response of the customer in the test set. Further, in the training set, 348 families buy the insurance, and the hit rate is $348/5822 = 5.97\%$. From the perspective of database marketing manager, if we select customers randomly to promote insurance, the hit rate is 5.97%.

Meanwhile, we compare the performance of MGNNE with that of three commonly used customer targeting models, Logistic regression, neural network, and the Bagging based ensemble model [2]. For the neural network, it utilizes multilayer perceptron (MLP) in this paper. While, for the two multiple classifier ensemble models, we let the number of base classifiers be 25, and the base classifier of Bagging based ensemble model is also MLP. At the same time, the selection of input variables is very important for customer targeting model, no matter how good the forecasting model is, the unrelated input variables will result in poor forecasting performance. Therefore, to ensure the fairness of comparison, in this paper it first adopts PCA to reduce the dimension for other three models, and then trains the corresponding models. We record them as PCA-Logistic, PCA-MLP, PCA-Bagging in turn. Finally, all the experiments in this paper are implemented in Matlab 7.0.

22.4.2 Experimental Setup and Evaluation Criterion

In order to validate the performance of a customer targeting model, we adopt the model to forecast first, get the probability of buying the insurance for all customers in test set, and then sort them according to the probabilities in descending order, finally select the front $x\%$ customers as our target customers. The hit rate of the model is regarded as the criterion of evaluating the forecasting performance, and its definition is as follows:

$$\text{Hit rate} = \frac{N(y-1)}{N} \times 100\%, \tag{22.5}$$

where $N(y-1)$ denotes the number of target customers who will response to the promotion of the enterprise, and N is the total selected target customers.

22.4.3 Experimental Result Analysis

Table 22.1 shows the performance comparison among the four models referred in this paper in different ratios of the target customers. It can be seen that: (1) For the two single models, when the selected target customer ratio is no more than 10%, the hit rate of PCA-Logistic is higher than that of PCA-MLP, but when the ratio is more than 10%, the hit rate of PCA-Logistic is poorer than that of PCA-MLP; (2) For the two ensemble models, their forecasting performance is better than that of two single models as a whole; (3) For the MGNNE model proposed in this paper, when the ratio of selected target customers is less than 35%, its hit rate is always higher than that of other three models. Therefore, we can conclude that the whole customer targeting performance of MGNNE is the best.

Table 22.1 The hit rate of 4 customer targeting models in different conditions (unit: %)

Model	Selected x% customers									
	5	10	15	20	25	30	35	40	45	50
PCA-Logistic	21.32	17.86	14.33	13.00	12.20	11.83	10.86	10.19	9.61	9.35
PCA-MLP	19.88	16.95	16.26	14.02	13.19	11.76	10.87	10.34	9.74	9.64
PCA-Bagging	22.54	18.19	15.72	14.39	12.83	12.14	10.93	10.44	9.93	9.51
MGNNE	24.00	19.00	17.33	14.63	13.90	12.50	11.00	10.63	9.86	9.45

On the other hand, as it is shown in Table 22.1, although MGNNE model has the highest customer selection performance as a whole, its absolute value of hit rate is not much higher than that of other three models. However, in database marketing a little improvement in customer targeting performance may bring big change in the enterprise's marketing strategy and profits. In real database marketing, the marketing manager's most concerned issue is what ratio of selecting target customers is suitable according to the model's forecasting result, and what the largest expected profits are. Therefore, we suppose that the enterprise implements its promotion through posting beautiful pamphlet, and the promotion cost of each customer is \$7. If a customer responds to the enterprise's promotion, i.e., he or she will buy the insurance, the marginal income is \$70. Finally, there are one million potential customers.

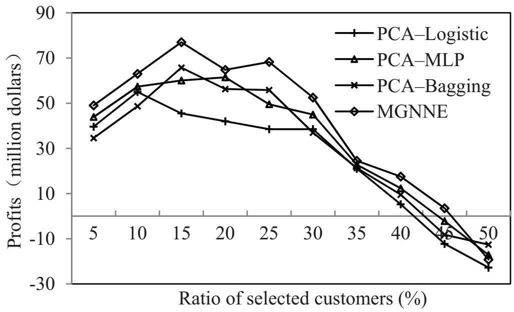


Fig. 22.3 The expected profits of 4 target customer selection models

The expected profits of 4 models by selecting the customers with different ratios as the target customers are shown in Fig. 22.3. For example, for MGNNE model, when selecting the top 15% customers as the target ones, its expected profits are $\$1000000 * 15\% * (70 * 17.33\% - 7) = \$770000$. As it is shown in Fig. 22.3, the best marketing strategy of marketing manager is to post pamphlet to the top 15%

customers in MGNNE model, because the largest expected profit of the enterprise are \$770 thousand. For PCA-Bagging model, its best marketing strategy is still to select the top 15% customer as the target ones, but its biggest expected profits are only \$657.3 thousand. Especially, when selecting the top 50% customer, the expected profits of 4 models are the minus value, which demonstrates the significance of building target customer selection model. If we select all customers as the target ones, the profits at most time will be very low, even in a deficit.

22.5 Conclusions

In this paper, we propose GMDH-type neural networks ensemble model MGNNE for customer targeting. The experimental results show the hit rate of MGNNE is higher than that of some existing customer targeting models, and brings more profits for the enterprise. MGNNE model does not need any prior knowledge or hypothesis about the distribution, and both the key forecasting variable selected and the final ensemble model trained can progress at the same time. In addition, it is a model of white information box, each base GMDH customer selection model and the final ensemble model are linear model and easy to explain. Therefore, it is expected to use the model in the database marketing of Chinese enterprise and improve their core competition.

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Chapter 23
Consumer Demand, Investment Demand and Housing Price Volatility

Jiejing Shen, Xuedong Liang and Cheng Luo

Abstract Considering the two characters of real estate: consumer attribute and investment attribute, the aggregate demand of real estate could be subdivided into consumer demand and investment demand. And in this paper, psychology expectation is quantified by gray prediction method, and then the real estate price model is established. Based on the theoretical model, using national quarterly data-from January 1999 to June 2011, we empirically analyze the effect of demand on housing price. The results demonstrate that investment demand can be used to explain housing price volatility better than consumer demand nowadays. Compared with the other factors, psychology expectation and down payment policy have much greater influence on housing price. In the end, some reasonable policy proposals on controlling price will be given on the stage.

Keywords Consumer demand · Investment demand · Gray prediction · Housing price management

23.1 Introduction

Since the reform of housing market system, Chinese property market has been undergone a period of high-speed change and growth. At the present, the real estate sector is important to the national economy and GDP (For the past several years, contribution to GDP in real estate was about 2%) of the local government, so it catches attention of the society. Nevertheless, with the rise in housing price, a series of economic and social problems have appeared. Maintaining price stability is

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one of the most important targets of China's macroeconomic adjustments. Unfortunately, the effect seemingly did not respond to the policy very well in the last several years. We can find it by the following facts: national commercial housing average price fold for 4572.3 per square meter in the first quarter of 2009, to the first quarter of 2011, the price rose to 6095.6 per square meter, with an increase of 33.3% in the two years. Although the price once had dropped, the duration of dropping was rather short, and then started to rise rapidly.

Now, non-market "restriction" policy has come into play. We have to think about why previous monetary policy, land policy and so on do not work, however, non-market "restriction" policy plays a part, and when "restriction" policy would exit from the market. The two pressing problems remain to be answered. The related study results of this paper will try to solve those issues, after that, some reasonable policy proposal for controlling price will be given on the stage. These are the purposes and significance of the research.

So we need to prudently choose an appropriate angle to answer the above two questions. In the housing market of China, land supply is controlled by the government and the control measures of estate enterprises can be formulated through the financial and tax policies. Therefore, we cannot get the satisfactory answer from the point of market supply. From the perspective of demand, real estate, the special commodity, has two characters: consumer attribute and investment attribute. The housing price will continue to rise, if the market is flooded with too many investment components, and the benefit of this rise will be higher than the cost (such as the smaller cost arising from interest-rate increase). Thus the relevant non-market measures cannot be withdrawn from the market at this stage. If the real estate market is flooded with consumer components, related market-oriented means will be needed in the future period. Therefore, how to measure investment and consumer demand, which appear in the market of China, is the key issue to resolve the two problems provided above. From this guide, we analyze consumer and investment demand on housing price fluctuation by using gray prediction and metering method.

Compared with the previous literature, the paper adds the psychology expectation factor to the model, because the government's strategies on housing price, developers' respond to these policies and the trend of price affect the psychology expectation of public, especially, investors (including speculators). Experience shows that, to a great extent, the real estate market is similar to the financial market, and public's psychological expectation has an important impact on market volatility [1]. In the expansion stage of real estate market, people's excessive optimism may further stimulate the real estate price to increase sharply; in the downturn stage of real estate market, pessimistic expectations will aggravate the housing market's depression.

Given the above analysis, the aggregate demand of real estate could be subdivided into consumer demand and investment demand, and then the price model is established, which is co-led by the two demands. Meanwhile, psychological expectation variable is added into the model and quantified by gray prediction method. The results of the research demonstrate that investment demand can be used to explain housing price fluctuation better than consumer demand nowadays, meanwhile, compared with the other factors, psychology expectation and down-payment policy have much greater influence on housing price.

The structure of the paper is arranged as following: the second part combs the domestic related literature about volatility factors of housing price; the third part is about the research design and data processing, specifically expounding the choice of variables and data; the fourth part is empirical analysis, through the econometric software to obtain the empirical results; the fifth part is the conclusion of this paper.

23.2 Literature Review

Housing price has been one of the hottest topics in the academic community, and lots of attentions are focused on analysis of the factors affecting China's real estate price fluctuations. In past, scholars took a variety of influence factors into account. For example, Shi [2] got supply, demand, interest rate and other factors together in MTV model. He believed that the availability of capital and changes in demand within the sample interval have a strong impact on the fluctuation of housing prices, while the supply is a weaker factor. Tong and Yang [3] theoretically analyzed the factors affecting real estate price, they argued that each factor worked by changing the relationship between supply and demand. Jiang and Zhang [4] empirically proved that second-hand housing price, mortgage interest rate, resident's income were major factors affecting the sales price of new houses.

There are some researches focusing on single influence factor: (1) On the psychological expectation, Zhou [5] analyzed the strategic choices of developers and properties, during the period of boom and irrational exuberance market, under the framework of asymmetric information. He got that only when properties believed the market was irrationally exuberant, the real estate price would be inhibited. Gao and Liu [6] pointed out that China's real estate market had the typical expectation characteristics. The expectation mechanism enabled the real estate market participants offset the impact of governmental regulation and control through their own special behaviors. Meanwhile, they built the model of real estate on rational expectation, adaptive expectation and quasi-rational expectation. Jiang and Yan [7] studied the linear model on psychological expectation and rates, and came to that public psychological expectations had greater efficiency of effecting on housing prices after the financial crisis than before. (2) On income, Tu and Zhang [8] empirically found that the per-capita disposable income was an important factor to promote housing price. Hu [9], starting from the fact that real estate possesses both consumer property and asset attribute, through empirical analysis of China's data on the basis of the theoretical model, illustrated that the larger income inequality in current China was an important factor that make real estate price rise. (3) On finance, Cui [10] built a general equilibrium model with financial accelerator, and pointed out that the rise in house prices would lead to increase in the number of credit with the mortgage of the real estate, and credit increase in turn had an impact on demand for housing which would lead to real estate price rise. Liu [11] empirically verified the reverse correlation between the interest rate adjustments of central bank and the housing price.

Overall, the documents about effect factors of housing prices are far from plentiful, and with various ways in China. However, the empirical research, from the dual nature of the real estate perspective, is seldom seen, or not so perfect, moreover, quantitative research of psychological expectation factor is extremely rare simultaneously. This paper starts the research from the dual nature of the real estate, makes psychology expectation be quantified by gray prediction method, and then establishes the real estate price model. Based on the theoretical model, using national quarterly data-from January 1999 to June 2011, we empirically analyze the effect of demand on housing price. The inclusions demonstrate that the influence degree of housing price from the consumer demand and investment demand respectively. Finally, some reasonable policy proposals on controlling price will be given on the stage.

23.3 Research Design and Data Processing

In the empirical part of this article, quarterly average price of commercial housing is choose as explained variable, and explanatory variables are divided into consumer demand and investment demand variables. Based on the theoretical model, we use national quarterly data-from January 1999 to June 2011, but the data can be obtained generally monthly or annually, so we have to compose data by appropriate means.

23.3.1 Consumer Demand of the Real Estate

According to the law of demand, in the case of other conditions remain unchanged, the increase of demand on the market will led to the equilibrium prices soar. There are many factors, which have impact on consumer demand, including people's income level, prices of related items, preference, expectation and so on. But the fundamental factors only contain: urban additional population and the income of urban additional population. The former implies the potential demand of the real estate; the latter decides the possibility that the potential demand converts into reality, which both dominate the demand changes.

Urban additional population. In this paper, we need to change the annually urban population into quarterly. Since most of systems are generalized energy system, we can assume that the monthly urban population quantity follows homogeneously exponential growth in these years (1999 $\sim$ 2011). So an equation for monthly urban population can be written as follows:

$$E_t^i = E_t^0 * \left(\frac{E_{t+1}^0}{E_t^0}\right)^{\frac{i}{12}},\ i = 1,2,3,\cdots,12, \tag{23.1}$$

where i is a superscript for months $(i = 1,2,3,\cdots,12)$, t is for different years, E_t^i is the expected number of the urban population in the ith of t, E_t^0 is the urban population in the early of t, E_{t+1}^0 is the urban population in the early of $(t+1)$. So, the population of every month can be calculated. Then average the monthly data to get the quarterly.

Income of urban additional population. With the increasing income of the residents, the potential purchase power and the requirement of living space will rise accordingly. Consequently, the housing price will increase simultaneously. But we cannot obtain this statistical data at present. In theory, the per-capita disposable income of urban residents can reflect the income level of urban additional population in a way. Therefore, the income of urban additional population can be converted into the per-capita disposable income.

23.3.2 Investment Demand of the Real Estate

As an investment product, the real estate follows the capitalization pricing model and its price, which has a big undulation, is influenced by market expectation and market liquidity. Investors invest in real estate for earning extra money by renting or selling houses, which makes profits in the future time. We believe that the main factors that affect investor's or speculator's decision include: psychology expectation; down-payment proportion of housing loan; interest rate.

Psychology expectation. In this paper, psychological expectation particularly stands for price expectation-"reasonable person" expects the future housing price level through the analysis of the characteristics of past house prices. Information system of real estate is imperfect because of the underdevelopment in China's real estate market. Hence fluctuations in real estate prices are vulnerable to the impact of people's psychological expectations. In addition, in the condition of incomplete information, the developers hype up the information about housing price, which strengthen the consumer expectations, causing the herding effect of market and exacerbate the fluctuations of housing price. Likewise, a series of government policies can also affect people's psychological expectations. Therefore, we have to assume that others factors do not change in the particular period, when price expectation is quantified.

Rational investors who predict the current real estate price would make reference to the top of the price indices. If the prediction of current housing price index is conducive to investment, they tend to take action; if the prediction is bad for investment, investors tend to stay on the sidelines. In psychology, the recent events have greatest impact on people's psychological [1]. So we choose the last four price indices to predict the current one, and give them different weights-the closer of the current, the greater of the weight. Price indices obtained and used by rational people are discrete and small sample data generally. Therefore, we study the expectation by gray prediction model, which has unique advantages over other means in analyzing discrete and small sample data.

Suppose that housing price index in the kth quarter is $X(k)$. Reference time series of price index can be written as follow:

$$X^{(0)} = \{X^{(0)}(1), X^{(0)}(2), \cdots, X^{(0)}(n)\}. \tag{23.2}$$

There are $n(n=4)$ observations. Firstly, we need to examine this data series in order to ensure the feasibility of the modeling method. Series level ratio is given by:

$$\lambda(k) = \frac{X^{(0)}(k-1)}{X^{(0)}(k)},\ k = 2,3,4. \tag{23.3}$$

If all of the series level ratio fall in the range $\left(e^{-\frac{2}{n+1}}, e^{\frac{2}{n+2}}\right)$, data series $X^{(0)}$ can be used in the model $GM(1,1)$. We can accumulate the time sequence to develop a new sequence to abate the random and wave property of original time sequence. New sequence $X^{(1)}$ can be generated by accumulating $X^{(0)}$.

$$X^{(1)} = \{X^{(1)}(1), X^{(1)}(2), \cdots, X^{(1)}(n)\}. \tag{23.4}$$

The corresponding differential equation of model $GM(1,1)$ can be written as:

$$\frac{dX^{(1)}}{dt} + aX^{(1)} = \mu, \tag{23.5}$$

where a is gray number of development, μ is gray number of endogenous control. Matrix B and vector Y are given by:

$$B = \begin{bmatrix} -\frac{1}{2}(X^{(1)}(2)+X^{(1)}(1)), & 1 \\ -\frac{1}{2}(X^{(1)}(3)+X^{(1)}(2)), & 1 \\ \vdots & \\ -\frac{1}{2}(X^{(1)}(n)+X^{(1)}(n-1)), & 1 \end{bmatrix}, \quad Y = \begin{bmatrix} X^{(0)}(2) \\ X^{(0)}(3) \\ \vdots \\ X^{(0)}(n) \end{bmatrix}. \tag{23.6}$$

So that we have differential equation $Y = B\hat{\alpha}$, where $\hat{\alpha} = (a,\mu)^T$ is parameter vector. Using the least squares method we can get:

$$\hat{\alpha} = \left(B^T B\right)^{-1} B^T Y. \tag{23.7}$$

From the differential equation, we can get the accumulate time sequences forecast model:

$$\hat{X}^{(1)}(k+1) = \left[X^{(0)}(1) - \frac{\mu}{a}\right] e^{-ak} + \frac{\mu}{a},\ k = 0,1,2,3,4. \tag{23.8}$$

With regressive calculation, the gray prediction method of original series can be written as follow:

$$\hat{X}^{(0)}(k) = \left[X^{(0)}(1) - \frac{\mu}{a}\right] [1-e^{a}] e^{-ak},\ k = 1,2,3,4. \tag{23.9}$$

From Equation (23.8) and Equation (23.9), we can get expected price indices. Fig. 23.1 reveals the comparison between the actual house price indices (PR) and expected house price indices (PER).

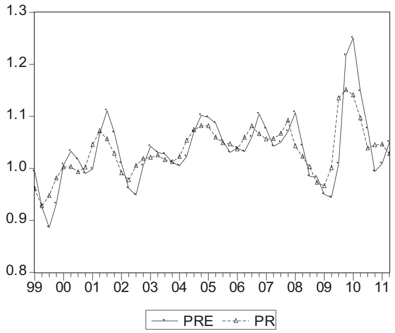

Fig. 23.1 Actual house price indices and expected house price indices

According to the past housing prices, people predict current situation, so that housing price have a tendency to maintain the original trend. From Fig. 23.1, we can see that the expected price volatility is greater than the actual one, which reflects the inertia of people's expectations. Psychological expectation is easy to produce the expected error, which affects the trend of prices. Hence, it is desirable to symbolize psychological expectation as expected deviation of house price index ($PREB = PER - PR$), which may be positive or negative.

Down-payment proportion of housing loan. The majority of buyers try to get bank loans. Especially, investors hope to get more revenue by using financial leverage. A lot of money swarm into the market, when down-payment proportion is lower, which causes higher house prices, even bubbles. Down-payment ratio has different values at different time because of various policies. Based on the analysis in this paper, we introduce dummy variable: high proportion is set to 1 and low proportion is set to 0.

Interest rate. Interest rate, as the opportunity cost of investment, affects the housing price by influencing the capital flow of the market. The higher interest rate, the higher investment cost. Real estate investment is generally a long-term investment, so we select five-year lending rate as an explanatory variable of the model.

23.4 Empirical Analysis

In the paper, data from January 1999 to June 2011, comes from China Statistical Yearbook and the CEInet Statistical database. All of them have been adjusted to quarterly data.

Bases on the above analysis, the estimation equation can be written as follow:

$$\mathrm{AP}_t = F\{f_1(\mathrm{NUP}Q_t, DI_t) + f_2(\mathrm{PREB}_t, \mathrm{FR}_t, \mathrm{R}_t)\} + \mathrm{U}_t. \tag{23.10}$$

We can transform the estimation equation into the regression model:

$$\begin{aligned} Ln(\mathrm{AP}_t) = \; & \alpha_0 + \alpha_1 * Ln(\mathrm{NUPQ}_t) + \alpha_2 * Ln(\mathrm{DI}_t) + \alpha_3 * \mathrm{PREB}_t + \alpha_4 * \mathrm{FR}_t \\ & + \alpha_5 * Ln(\mathrm{R}_t) + \mu_t, \end{aligned} \tag{23.11}$$

where $Ln(\mathrm{AP}_t)$ is log average housing price, $Ln(\mathrm{NUPQ}_t)$ is log urban additional population, $Ln(\mathrm{DI}_t)$ is log per-capita disposable income, PREB_t is expected deviation of house price index, FR_t is down-payment proportion of housing loan, $Ln(\mathrm{R}_t)$ is log interest rate, is an error term.

Most of the time series is non-stationary. If we just regard non-stationary time series as stationary, the course of study will finally lead to spurious regression-meaningful relationships between variables do not exist, but the result of the regression draw a wrong conclusion that there is a meaningful relationship. So, we have to examine the stationary of time series by using ADF (Augmented Dickey-Fuller) test method, which contains constant term but no trend term. Specific test results are showed as Table 23.1.

Table 23.1 Unit root test

Variables	ADF test statistic	1% Critical value	DW	Conclusion
LNAP_t	−8.616762	−3.5778	1.489241	1^{st} Difference stationary
LNNUPQ_t	−3.361088	−3.5778	1.957145	1^{st} Difference stationary
LNDI_t	−80.73770	−3.5778	0.834118	1^{st} Difference stationary
PREB_t	−5.970283	−3.5745	2.168130	stationary sequence
FR_t	−4.685568	−3.5778	2.004240	1^{st} Difference stationary
LNR_t	−6.055924	−3.5814	2.044833	1^{st} Difference stationary

From the Table 23.1, we can see that variables' stationary are not the same. Consequently, we need to verify the existence of cointegration relationship between the variables, which makes linear combination of these variables smooth and steady, by using Johansen cointegration test method in order to eliminate the spurious regression. Test results are showed as Table 23.2.

Table 23.2 Cointegration test

Variables	Eigenvalue	Trace statistic	5% Critical value	Cointegration test
LNNUPQ_t	0.631	109.990	68.52	None**
LNDI_t	0.545	62.161	47.21	At most 1**
PREB_t	0.218	24.414	29.68	At most 2
FR_t	0.175	12.591	15.41	At most 3
LNR_t	0.068	3.374	3.76	At most 4

Notes: ***, ** and * are 1%, 5% and 10% of significant levels, respectively.

The results of test reveal that the cointegration relationship between the six variables does exist. Consequently, OLS (Ordinary Least Squares) can be used for regression analysis. The result is showed as follow:

$$
\begin{aligned}
Ln(\mathrm{AP}_t) = {} & 7.0108 + 0.0726 * Ln(\mathrm{NUPQ}_t) + 0.1098 * Ln(\mathrm{DI}_t) + 0.2552 * \mathrm{PREB}_t, \\
t = {} & (6.2106) \qquad (0.7057) \qquad\qquad (2.6249) \qquad\qquad (2.8615) \\
& +0.4770 * \mathrm{FR}_t - 0.3278 * Ln(\mathrm{R}_t) \\
& \quad (7.0981) \qquad\quad (-0.9153) \\
R^2 = {} & (0.8126),\ F = (21.8176),\ DW = (2.9361),\ df = 44.
\end{aligned}
$$

The value of R^2 is 0.8126 suggesting that the model fits the data reasonably well. The values of F and t reveal that the overall linear relationship of model is marked and dependent variables are influenced greatly by most of independent variables, respectively.

The regression equation indicates that housing price will change 18.24% (18.24% = 7.26% + 10.98%), when consumer demand changes 1%. The additional urban population has less impact on housing price, mainly because that most of the urban population are young, who are lack of purchasing power. Nevertheless, investment demand has more complex impact on housing price: the price will rise 0.2552 units, if expected price is higher than a unit of actual price, meanwhile, the price will reduce 0.2552 units, if expected price is lower than actual price of one unit; the housing price changes 0.4770 units, when down-payment proportion changes 1 unit; while five-year interest rate has less effect on housing price, mainly due to the market of China's real estate remains a buyer's market, rather than a seller's, which is full with investment demand, leading to higher interest rate cannot curb housing price.

23.5 Conclusions

Using the nationwide quarterly data from January 1999 to June 2011, we empirically examine the impact of demand on the real estate price. The aggregate demand for real estate could be divided into consumer demand and investment demand. Consumer demand derives from additional urban population and per capita disposable income, the increase of which will both lead the rise in the real estate prices. And investment demand derives from China's policies and investors' psychological expectations, in which, the lenient policy and optimistic investment expectations both conduce to the rise in housing prices. We empirically find that investment demand for real estate plays an increasingly important role in pushing up housing prices. In addition, down-payment ratio affects housing prices heavily, which is the reason for the government more than once to adjust the down-payment proportion against the economic trend. Meanwhile, the psychological expectations of the public guide the investment decision-making significantly, and the "herding" caused by psychological expectations sometimes is a key factor that affects housing price.

These days, China's housing prices have slightly dropped, but the government should be more careful to formulate policies. On the one hand, attentions should be paid to prevent housing prices from rising sharply again. On the other hand, the government should be alert to the rapid fall of housing price, for the shock of the real estate will affect the healthy development of entire national economy. Houses have a close relationship with livelihood issues, if handled improperly, it will seriously affect the happiness of the residents.

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The above conclusions are largely obtained undergoing rigorous theoretical proofs and empirical research, which reveal that the demand, especially the investment demand, affects the real estate prices significantly. Five basic factors are chosen for modeling in this paper, while there are still many other factors that influence consumer demand and investment demand which are not taken into account. Further improvement of the model is to be studied.

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Chapter 24
Study on Corporate Social Responsibility (CSR) Affect on Brand Trust and Purchase Intention after Brand Scandal

Chunya Wang and Weiping Yu

Abstract This thesis, through a questionnaire research methods, explored repair effects of corporate social responsibility activities after the brand scandal, such as improving product quality, philanthropy and donation money or equipments to students in remote regions and environmental protection in order to repair brand trust and consumption intention. Authors found that CSR activities had positive integrated effects on renewal brand trust and consumption intention.

Keywords Brand scandal · Corporate Social Responsibility (CSR) · Brand trust · Consumer purchase intention

24.1 Introduction

In recent years, the worldwide brand scandals are often seen, domestic and foreign scholars mainly focusing on how to restore consumer confidence and repair damaged brand image in the perspective of a short-term crisis management. However, scandal negative effect cannot be eliminated by emergency management because the root cause of majority brand scandals is that enterprises seek nothing but profits, neglect social responsibilities, enterprises must take long continual repair in the perspective of social responsibility. Although many scholars have researched the effect of corporate social responsibility, confirmed that it will help to improve the financial performance, improve the consumption intention, enhance the brand image and resist the negative effect of scandal etc., vast studies did not involve scandals situation, and have not been explored if social responsibility activities in scandal

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situations can rebuild the brand trust and regain purchase intention. Jiang and Chen [1] explored charitable donation after the scandal have insurance effect on brand reputation, but did not consider mainly CSR behaviors' comprehensive repair effect on brand trust and consumption intention in the scandal in China, these commonly used CSR behaviors is that improving product and service quality, philanthropy and donation money or equipments to students in remote regions and environmental protection. This article uses questionnaire research methods to explore corporate social responsibility strategies after brand scandal for long-term if can have a comprehensive repair effect on brand trust and purchase intention.

24.2 Literature Review

Dawar and Lei [2] defined brand scandal as an instances of well-publicized claims that a key brand proposition is unsubstantiated or false. These crises can cause severe damage to the brand, regardless of the veracity of the brand-undermining claims themselves. At present, the concept of corporate social responsibility (CSR) is generally defined that enterprise create profits and for the interests of shareholders, at the same time, undertake social responsibility to employees, consumers, the community and the environment, including compliance with business ethics, production safety, occupation health, protect the legitimate rights and interests of workers, protect environment, support charity and vulnerable groups.

Dawar and Pillutla [3] and Zheng [4] thought that brand scandal seriously affect the brand image, brand trust and purchase intention, Souto [5] explored that the root cause of frequent brand scandals laid in ignoring CSR and seeking nothing but profits. Later some scholars found that the scandal's negative influence can't be eliminated through short-term repair strategy, but must take continual long repair in the perspective of social responsibility.

At present, many domestic and foreign scholars have found that corporate social responsibility without scandal have a positive effect on brand image [6], brand trust and consumption intention [7–9]. But domestic and foreign research seldom involved if social responsibility can actively influence the same consumer s' behaviors in the event of brand scandal, only Jiang and Chen [1] did explore charitable donation have insurance effect on brand reputation after brand scandal, but did not consider mainly CSR behaviors' comprehensive repair effect on brand trust and consumption intention in the scandal in China, these commonly used CSR behaviors is that improving product and service quality, philanthropy and donation money or equipments to students in remote regions and environmental protection.

24.3 Model and Hypothesis

Enterprise is a social citizen, production and business operation shall abide business ethics, pay attention to safety of products and services, honestly operate case and feed back society; once happened scandal, it should take responsibility courageously actively take remedial measures to repair the image, and fulfilling the social responsibility is the best win-win behaviorfor e.g. taking responsible for consumer after scandals, improving product and service quality, be enthusiastic philanthropy & education and other public welfare, dedicated to perform its due commitment and responsibility, all of these can increase consumer to trust brand, and establish overall brand's impression, increase consumer's trust in the company and brand. Zhou et al [8] and Xie and Zhou [9] affirmed that corporate social responsibility behavior indirectly influence on consumer purchase intention; Sen and Bhattacharya [7] proved the performance of CSR level would directly impact on consumer purchase behavior, but be limited by degree of consumers' trust in brand and customer support. Luo and Bhattacharya [10] thought that corporate social responsibility can lead to customer satisfaction, consumer were more satisfied with brand, trust was more higher, Research showed whether treat employees kindly, environmental protection or charitable donations, corporate social responsibility has positive influence on consumer purchase intention [8, 9]. Laroche and Sadokierski [11] formally examined brand trust had effect on purchase intention.

In short, a number of studies suggest that enterprise social responsibility behavior can positively influence consumer attitudes and buying behavior, so it can be predicted, in the event of brand scandal, enterprises social responsibility behavior also play a positive role on brand trust and willingness to consume reconstruction.

Based on the above analysis, the following assumptions and research model are established.

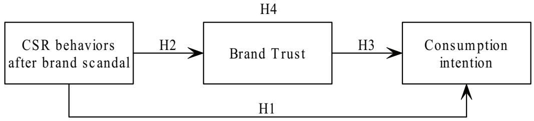
Hypothesis 1. Corporate social responsibility activities after brand scandal will have significant effects on reconstruction brand consumption intention;

Hypothesis 2. After brand scandal, corporate social responsibility has a significant impact on brand trust reconstruction;

Hypothesis 3. Corporate social responsibility activities have significant influence on recovering on consumer purchase intention;

Hypothesis 4. Reconstruction brand trust play mediate function in the process of corporate social responsibility activities affects recovery of consumption intention.

Fig. 24.1 Conceptual model



24.4 Methods and Scales

24.4.1 Design Questionnaire

Through the questionnaire method, this research will measure if corporation social responsibility strategy in the long term can have a positive effect on renewal brand trust and consumption intention after brand scandal, so the questionnaire includes six parts: introduction of enterprises, brand scandal corporate social responsibility activities after scandal, items about measuring brand trust and consumer purchase intention, and surveyed personal information. We should have selected the brand which consumers are familiar with, taking into account respondents perception about some real brand may affect the study, so used a virtual dairy products brand A; In addition to describe situations as well as the enterprise in scandal adopted a series of social responsibility activities after six months (long-term), scandals situation and corporate social responsibility of A brand are based the actual market consolidation.

There are a lot of evaluation index about corporate social responsibility, but the general content include six parts: the responsibility for employees, corporate governance, environmental protection, community support, product and service, requirements for supply chain remembers. Through interviewing 6 marketing PhD students and 10 consumers, and tracking social responsibility activities of 27 companies after the scandal, this study selected three of them: for products and services, charitable donations and grants of port community, as well as protection environments.

24.4.2 Variable Measurement

After brand scandal, brand image destroyed and confidence crisis emerged so that purchase intention will reduce, therefore, this topic uses brand trust and purchase intention to measure social responsibility effect in the process of repairing scandal brand image Brand trust refers to a willingness of acceptation the brand which based on consumers' positive expectations to brand quality, behavior intention and commitment when a brand is in the risk situation; these reflect on consumers' recognition and emotion to the brand [12]; Purchase intention refers to a probability of consumer buying brand product or service after brand scandal [13].

This study involved two latent variables (brand trust and purchase intention) which come from the predecessors' findings and modifies it combining with the scandal situation, characteristics of virtual product category with some slight. Brand trust scale uses three items based on Sirdeshmukh et al [14], Xie and Zhou [15] with slight modifications in language, respectively, "These CSR activities let me feel the A brand product reliability again", "these CSR activities let me trust the A brand product quality again", "these activities let me full of confidence in the A brand products". The scale of purchase intention adopt mature one by Sirdeshmukh [14]:

"I will repurchase A brand products", "I will recommend A brand products to the surrounding people", "I will try again to consumer A brand new products". All 7-point Likert scales is in all items, and range from1 (strongly disagree) to 7 (strongly agree).

24.5 Data Analysis

24.5.1 Sample Description

Data collection was carried out in a college of business administration senior students, a total of 140 questionnaires were issued, recovery of 130, effective questionnaire 127, recovery rate was 97.7%, the effective questionnaire rate is 94.5.8%, the data were analyzed by SPSS18.0. The investigators' age range from 20 to 23 years old in the sample, 60 men, 67 women, the sample is in equal numbers of men and women.

24.5.2 Test Reliability and Validity

In this study, the test items were referenced to predecessors' findings and revised, relationship between items and variables according to the brand scandal, which come through the empirical research and published. Confirmatory factor analysis was performed using SPSS, the parameter estimates in Table 24.1, Cronbach coefficient were 0.903, 0.813, are greater than 0.7, indicating the scale had good convergent validity, moreover each item factor loadings was greater than 0.503, showed that the internal consistency was better.

Table 24.1 Items' reliability and validity index

Variable	Item	Cronbach α ratio	Factor loading
Brand trust	B1. These CSR activities let me feel A brand product reliability again;	.903	.902
	B2: These CSR activities let me to trust A brand product quality again ;		.898
	B3. These CSR activities let me full of confidence in the A brand products.		.769
Brand purchase intention	C1. I will repurchase A brand products;	.813	.513
	C2. I will recommend A brand products to the surrounding people;		.503
	C3. I will try again to consumer A brand new products.		.602

24.5.3 Test Hypothesis

According to the Baron's [16] recommendations, to establish mediation, the four conditions must hold: First, the independent variable must affect the mediator notability in the first equation; second, the independent variable must be shown to affect the dependent variable in the second equation. And third, the mediator must affect the depend variable in the in the third equation. If these conditions all hold in the predicted direction, then the effect of the independent variable on the dependent variable must be less in the third equation than in the second; Since the research variables are nominal variables, the analysis method was variance. Before analysis, test data normality and homogeneity.

This study test process of the mediators as follows:

Step 1. Testing corporate social responsibility how to impact on purchase intention after the scandal using multivariate analysis of variance by SPSS17.0 AVONA, According to the analysis results, Sig. = 0.024, after brand scandal, enterprise social responsibility can effectively repaired consumption intention, Hypothesis 1 Had been verified, Sample statistics and analysis results are shown in Table 24.2 and Table 24.3.

Table 24.2 Descriptive statistics

CSR activities after brand scandal	Gender	Mean value	Std. Deviation	*N*
1	female	12.72	3.064	67
	male	12.95	3.362	60
	Total	12.83	3.197	127

Dependent variable: A brand consumption intention After being repaired

Table 24.3 Single sample T-test

	Test value = 0					
	t	df	Sig.	Mean Error	95% confidence interval	
					Lower Bound	Upper Bound
Brand consumption intention after being repaired	45.208	126	.024	12.827	12.27	13.39

Step 2. Testing corporate social responsibility how to impact on brand trust after brand scandal. Brand trust being as the dependent variable, corporate social responsibility as variables, carries out variance analysis Sig = 0000 < 005 which showed that corporate social responsibility had a significant impact on brand trust after the scandal Sample statistics and analysis results are shown in Table 24.4, Table 24.5.

Step 3. Testing corporate social responsibility and brand trust how to influence purchase intention, results indicated in Table 24.6. After the scandal, CSR effect on the purchase intention of the effect was not significant, brand trust has a significant

Table 24.4 Single sample statistics

	N	Mean value	Standard Deviation	Std. Error Mean
Brand trust after being repaired	127	11.96	3.582	.318

Table 24.5 Single sample statistics

	Test value = 0					
	t	df	Sig.	Mean D -value	95% difference interval	
					Mean Error	Lower Bound
Brand trust after being repaired	37.628	126	.000	11.961	11.33	12.59

Table 24.6 Analysis of the variables under the purchase intention

Independent variable	Dependant variable	df	Mean Square	*F*	Sig.
CSR activities after scandal	Brand consumption intention after being repaired	16	42.718	9.096	.329
Brand trust		16	42.749	8.149	.000

impact on purchase intention, which indicated that after scandal, corporate social responsibility affected on purchase intention through the mediating role of brand trust, Hypothesis 3 and Hypothesis 4 can be verified.

24.6 Conclusion and Discussion

(1) Conclusion

Data analysis shows that hypothesis is validated. Research draws two conclusions, first, after brand scandal, CSR activities have significant impact on purchase intention; second, In this process, rebuilding brand trust is an mediator variable.

(2) Management inspiration

Based on the above analysis, the conclusions of this study are summarized as two points: first, when the enterprise is in the scandal of the products quality, enterprises can effectively repair the brand through developing social responsibility; second, the enterprise should bear the responsibility, and actively improve the product quality, supplemented by charity donations and protect environment social responsibility can repair damaged consumption intention.

(3) Defects and further study

Defects are that A questionnaire object is only a student, and did not involve other people, respondents and the actual market reaction may have gap. In addition, the selected products quality scandal occurred in the dairy industry which had been a big real quality scandal, earlier events may reflect *t* respondents, whether the results apply to more product categories remains to be further examination.

Future research can focus on several aspects: One is the sample involve the wider population; the other is using experimental method, whether the repair effect of three types of CSR, which is mostly used after brand scandal, are different.

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Chapter 25
Human Capital, Collective Psychological Capital and Regional Innovation: Provincial Evidence from China

Xiaoye Qian, Baiyin Yang and Qian Li

Abstract Technology progress is an important driving force for economic growth. Nowadays, the insufficiency of self-dependent innovation and the inefficiency of R&D staff have become two obstacles to China's technological advancement. This study focuses on the role of psychological capital and originally discusses the impact of collective psychological capital on regional innovation performance. In this study, we firstly construct a theoretical framework to describe how psychological capital impacts regional innovations through human capital. Secondly, a proxy variable is used to measure the collective psychological capital on the regional level; then, using provincial-level panel data from year 1997 to 2010, we examine the relationship among human capital, psychological capital and innovation performance with spatial panel regression method. The following empirical results are obtained: (1) Regional innovation activities have positive spatial clustering effect across China. (2) The estimated coefficient of psychological capital is also positive in innovation regressions and the results are quite robust in both OLS and spatial estimations. (3) Human capital mediates the relationship between psychological capital and innovation performance.

Keywords Regional innovation · Human capital · Psychological capital · Spatial panel model

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25.1 Introduction

Technology progress is an important driving force for economic growth. Nowadays, the insufficiency of self-dependent innovation and the inefficiency of R&D staff have become two obstacles to China's technological advancement. In the current literatures focusing on innovators, abundant studies discuss the correlations between individual's knowledge, skills and innovation performance [8, 11], however, the impact of innovator's subjective psychological state on their innovation performance has been long-neglected.

The confidence, morale and perseverance have long been realized to be critical in the performance of athletic tournaments, stage performance and college enrollment examination etc. Goldsmith et al [17] argued that the positive psychological character is a valuable asset for individuals. In the working environment, especially the fast changing environment featured with abundant information and intense innovation requirements, the negative psychological and emotional feeling, such as tension, pressure, anxiety and uncertainty, will have great impact on the working behaviors and outcomes.

Innovation activities are featured with complex processes, great uncertainty and high risk of failure. Accordingly, innovation activities especially require the individual to have positive psychological capital. For individuals with higher self-efficacy, they will be more confident about their capability and more willing to take risks; People who can better cope with pressure and frustration are more likely to 'bounce back' to their normal state and persist innovation. Many studies have provided evidence to support the positive effect of psychological capital to innovation activities on individual level [2]. Suggested by Luthans who proposed the concept of psychological capital, team-level or collective PsyCap has special implication for organization and region, hence they should not be excluded from the PsyCap studies [27]. However, except for a few studies theoretically discussing the collective psychological capital, there are rarely any empirical studies exploring the effects of collective psychological capital. This study will answer the following questions: Is the collective PsyCap a valuable asset for a region? Can the collective PsyCap improve the regional innovation performance?

25.2 Collective Psychological Capital

25.2.1 Psychological Capital

The concept of psychological capital proposed by Luthans is widely accepted. Like the application of positive psychology in workplace, psychological capital are the core construct of positive psychological traits that meet certain criteria [27], including four components, which are: "(1) having confidence (self-efficacy) to take on and put in the necessary effort to succeed at challenging tasks; (2) making a positive attribution (optimism) to succeeding now and in the future; (3) persevering toward goals and, when necessary, redirecting paths to goals (hope) in order to succeed; and (4) when beset by problems and adversity, still insisting to attain success" [27]. Following studies further develop this concept by examining the value of PsyCap as a higher-order core construct, clarifying the "state-like" rather than "trait-like" feature of PsyCap and creating the PsyCap Questionnaire [5].

25.2.2 Collective Psychological Capital

In daily life, Individuals' behaviors are mutually dependent with others'. A group of people tend to form shared psychological states by interaction and communication. For example, Benabou and Tirole [7] notice that, people in different regions formed different collective beliefs. World Value Survey data suggests only around 30% Europeans believe that hard work will bring a better life in the long run while 60% Americans hold such belief. Up to 60% Europeans believe income is determined by luck rather than effort or education, but the ratio of Americans is only 30%. Following the way that Bandura [6] translated personal efficacy to "collective efficacy", Walumbwa et al [35] firstly define the collective psychological capital as: "the group's shared psychological state of development that is characterized by (the four attributes indicated above for individual-level psychological capital)". His study also provides evidence that collective PsyCap does have impact on organizational behaviors and suggests adopting the shift model to transfer the individual PsyCap questionnaire (PCQ) to collective-level.

25.3 Related Studies

Compared with the rich studies on the effects of PsyCap on job performance, work attitude, intensions to quit and OCB [4, 22, 33], there are few literatures concerning the relationship of PsyCap on innovation activities and performance.

On individual level, Gough [18] argues that, individuals with higher creativity are more self-confident, ambitious and self-affirmative. Abbas and Raja [2] provide empirical evidence that employees with higher PsyCap exhibit more innovative behaviors. Luthans et al [28] conduct an experiment involving 1526 individuals, proving the significantly positive predictive power of four components including PsyCap as a core construct influencing innovative performance. There are also a few studies discussing the effect of PsyCap on Chinese employee's innovative behaviors.

On the organizational and regional level, there are few studies concerning the role of psychological capital in innovation performance. Related studies find that the group leader's positive psychological traits are related with the high-technology firm's performance [31]; Organizational resilience (resilience is a construct of PsyCap has positive impact on organizational innovation and technology diffusion [15];

resilience is important in the regional innovation networks, which is well exemplified by Silicon Valley and Boston's Route 128 [25].

In sum, the role of collective psychological capital in improving regional innovation has been neglected by current literature, the mechanism of how PsyCap influence innovation performance worth further exploration. This study will fill in the blanks and contribute to the literature in the aforementioned two aspects.

25.4 Theoretical Model

25.4.1 Human Capital and Regional Innovation

Human capital, proposed as a valuable asset attached to humans, is a breakthrough in economic and management theories; it explains the residual part of the productivity that cannot be explained by fixed asset and labor. Studies find that human capital (skills, educations and experience) significantly impact technology development and innovation [19, 29].

In the neo-classic economic growth theory, technology is treated as an exogenous variable. In this model, the economic product (Y) is the function of labor force (L), capital (K) and technology condition (A).

$$Y = Af(k,L). \tag{25.1}$$

The endogenous growth theory argues that treating the technology as an exogenous variable is a too simple abstract of reality [26, 34]. In fact, technology development is a result of human's innovation capacity. Therefore, it formally introduces the human capital into the model. The new technology product is the monotonic increasing function of innovator's accumulated human capital (H^j) and mastered technology masters, which is part of the aggregate knowledge A.

$$A^j = \delta H^j A^j. \tag{25.2}$$

For a region, the aggregated idea production function is described as:

$$A = \delta H_A A, \tag{25.3}$$

where δ is the technology productive coefficient, $\delta > 0$, H_A is the accumulated human capital of a region. A is the monotonic increasing function of H_A, which suggests innovation performance in one region is higher when human capital is higher.

25.4.2 Human Capital and Regional Innovation

Personal factors have been found to stimulate innovative behaviors at workplace. Psychological resource is one of the important personal factors. Individuals possessing self-efficacy (self-confidence) will have strong faith in achieving desired innovative goals, who may try alternative paths until success. Hope is necessary in innovative performance; hence, individuals with hope have intense desire to success. Consequently, they are stimulated to put more effort in innovative activities. Optimistic individuals tend to attribute the good results to their intrinsic nature. They are more likely to have good predictions of the future outcome, hence have stronger capabilities to solve the problems that occur during innovation. Resilient individuals have the ability to quickly adjust to the risk and frustration, leading to better performance in innovative activities. Also, employees with positive psychological capacity have broader view to analyze problems, who will be able to propose better innovative solutions [6].

Introducing the PsyCap into the idea production function can reflect the influence of positive psychological capital on innovative outcome, the idea production function therefore is:

$$A^j = \delta H^j R^j A^j, \tag{25.4}$$

where R^j is the positive psychological capacity of innovator. Using R_A to represent the collective positive psychological capacity, The aggregate innovation production function therefore is:

$$A = \delta H_A R_A A. \tag{25.5}$$

Hypothesis 1. Psychological capital is positively related to a region's innovation performance.

The mechanism of PsyCap's influence on innovative productivity is an indirect effect, that is, the PsyCap firstly contributes to the innovative performance through improving the human capital accumulation. Two groups of studies find psychological state will improve the human capital accumulation. Psychologists found that psychological factor significantly correlated with individual's academic performance and learning ability [24]. In the learning process, confidence and optimism greatly improve the learning persistence, as well as provide encouragement to raise questions and solve problems [13]. Therefore, PsyCap positively affects the learning process and benefit the human capital accumulation.

Economists introduce the psychological factor into the classic human capital investment model. Piatek and Pinger [32] discuss how psychological factor influence individuals' schooling decision. The self-confidence and optimistic prediction about the future will increase the predicted future income earning after finishing college education and therefore increase the expected net value of education investment; As a result, individuals are more likely to spend time in taking further education rather than taking jobs.

Both groups of theories predict the positive relation between PsyCap and human capital accumulation. The Equations (25.4) and (25.5) can be specified as:

$$A^j = \delta H^j(R^j)R^jA^j, \tag{25.6}$$

$$A = \delta H_A(R_A)R_AA. \tag{25.7}$$

That is human capital is the monotonic increasing function of human capital. The psychological capital contributes to innovative performance through enhancing human capital accumulation.

Hypothesis 2. Human capital mediates the relationship between psychological capital and innovative performance.

25.5 Variables and Data

Following the previous studies on regional innovation [11], we use the number of patent applications or grants as the proxy for innovation[1]. Human capital is measured by two variables: the percentage of workers with tertiary, secondary, or primary education. Following Chi [9], we use workers' educational attainment to measure human capital because it is a better measure of a province's human capital level than the widely used school enrollment data. It also has fewer measurement errors[2].

25.5.1 Measurement of Collective Psychological Capital

One possible reason for the lack of regional study on psychological capital is the difficulty to measure the abstract psychosocial state. The traditional psychometrics employ questionnaire to measure the psychological variables, however, it is hard to apply in the regional level which usually requires large samples. The alternative method to measure the unobservable variable is using proxy variable. Guiso et al [20] successfully employed the blood donation and election voting rate to measure the social capital in one region. They argued that high social capital implied high generalized trust in regions.n a region featured with high trust, people are more likely to involve in the public activities such as voluntary blood donation and voting in election. Heckman et al [21] employed the illegal and delinquent behaviors as the proxy variable to measure individual's non-cognitive skill to study the non-cognitive skill's impact on high school students' future income.

[1] We use patent applications rather than patent grants to measure innovation because patent granting procedure may be lengthy. China's patent is classified into three categories: invention patent, utility model patent and design patent. We employ the invention patent to measure innovation since it can better reflect knowledge creation.

[2] To ensure robustness of the estimates, we also use the total patent applications, R & D expenditure, and invention patent grants as the measure of innovation in the estimation, as well as the average years of schooling as the measure of human capital. The results are available from the authors upon request.

One of the economic behaviors affecting by psychological state is stock market investment. Alpert and Raiffa [3]'s study found that individuals with more confidence about the rules and profitability of stock market preferred to take higher risks. Odean [30] found that high self-evaluation individuals are more likely to be the stock traders or open new accounts and conduct frequent operation. Daniel et al [14]'s finding support that investors who attribute success to internal reasons are positively connected to the stock trading volume. Therefore, we employed the stock market trading variable to measure collective psychological capital in a region. Since the data of better proxy variables, like trading frequency and trading commission, are difficult to obtain at the regional level[3], we employ the number of trading account as the gross proxy of collective psychological capital.

25.5.2 Data

Data used in this study are drawn from public statistic yearbooks from 1998 to 2010, including China Statistical Yearbooks, China Labor Statistical Yearbooks, Shenzhen stock exchange fact books, and China urban life and price yearbooks. Provincial GDP, population, the size of labor force, educational attainment of workers, newly opened stock trading accounts, family income, fixed capital investment (FCI), and patent applications are selected. Workers' educational attainment is reported in labor statistical yearbooks from 1996. In 1997, Chongqin became the fourth municipal city directly under the central government and began reporting data separately from Sichuan province. Since estimating spatial models such as SEM, SLM and spatial panel model require a geographic matrix that consists of the fixed number of sub-areas, we use data from 1997[4].

25.6 Empirical Findings

25.6.1 Regional Disparity of Regional Innovation

Moran's I is used to test the spatial clustering in the Chinese provincial innovative performance. Moran's I is calculated as:

[3] The data of these two variables are available at the country level.

[4] Two spatial matrixes are used in the estimation: one is generated based on whether two provinces are neighboring, where neighboring provinces are defined as those who share a common border line; the other is the spatial coordinate matrix obtained from the fundamental geographic information system in the National Geomatics Center of China.

$$\text{Moran's I} = \frac{\sum_{i=1}^{n}\sum_{j=1}^{n} W_{ij}(Y_i - \bar{Y})(Y_j - \bar{Y})}{S^2 \sum_{i=1}^{n}\sum_{j=1}^{n} W_{ij}}, \tag{25.8}$$

where $S^2 = \frac{1}{n}\sum_{j=1}^{n} W_{ij}(Y_j - \bar{Y})$, and $\bar{Y} = \frac{1}{n}\sum_{j=1}^{n} Y_i$. Y_i represent the observation of sub-area i, e.g. the number of patent applications of province i. n represents the total number of subareas. W_{ij} denotes the spatial weight matrix. In order to provide robust estimates, we employ three types of weight matrixes, the adjacent spatial weighted matrix based on neighboring criteria, distance criteria, and the K-nearest spatial weighted matrix.

Table 25.1 Spatial correlation of innovation activities, 1997-2009

	Contiguity matrix (1)		Distance weighted matrix (2)		K-nearest neighbor matrix (3)	
Year	Moran's I	Z-value	Moran's I	Z-value	Moran's I	Z-value
1997	0.088	2.355	0.0142	0.025	0.0505	0.045
1998	0.068	1.970	0.0074	0.030	0.0149	0.166
1999	0.062	1.473	0.0133	0.048	-0.0063	0.804
2000	0.054	1.026	0.0122	0.064	-0.0435	0.634
2001	0.085	1.562	0.0164	0.050	-0.0205	0.709
2002	0.176	2.397	0.0187	0.054	0.0542	0.193
2003	0.190	2.441	0.0220	0.052	0.0631	0.156
2004	0.202	2.519	0.0212	0.049	0.0739	0.135
2005	0.178	2.290	0.0207	0.052	0.0439	0.187
2006	0.174	2.241	0.0228	0.048	0.0462	0.189
2007	0.163	2.174	0.0214	0.057	0.0438	0.214
2008	0.140	2.117	0.0201	0.052	0.0397	0.174
2009	0.146	2.059	0.0211	0.049	0.0472	0.169
Observations	31	31	31	31	31	31

For most years, Moran's I is significant at the 5 percent level or lower with the contiguity weighted matrix, suggesting the existence of clustering effect in innovation activities across provinces. The high level of innovation in one province tends to be spatially correlated with the high level of innovation in neighboring provinces. The estimates of Moran's I with distance-weighted matrix and KNN matrix is not significant in most years, indicating that the contiguity matrix can better describe the spatial feature of the innovation across provinces. Therefore we use contiguity model in the following regression models. Also the trend of spatial correlation increases from 0.088 in 1997 to 0.202 in 2004, suggesting that the spatial dependence of innovation is increasing. However, in the last five years, the positive correlation of regional innovation has decreased.

25.6.2 Regression Results

The empirical model is based on the idea production function proposed by Griliches [19], which is a Cobb-Douglas form production function. It describes the innovation as a product output from the human capital and fixed capital input.

(1) Panel data model

Panel data is considered to be more informative than cross-sectional or time-series data. Based on different decompositions of error terms, panel spatial models can be divided into fixed-effect and random effect models. We construct the panel regression model based on the Cobb-Douglas form idea production function:

$$\ln \text{patent}_{it} = \alpha_i + \beta_2 \text{PsyCap}_{it} + \beta_3 HC_{it} + \beta_4 Z + u_{it}, u_{it} \sim iid(0, \sigma_{it}^2), \quad (25.9)$$

where In*patent* measures the innovative performance, which is represented by the logarithm of patent application per 10000 people. *HC* are variables measuring human capital. Specifically, "High", "Secondary", and "Primary" denotes the percentage of workers with primary, secondary or tertiary educational attainment. *PsyCap* represents the collective psychological capital, represented by the logarithm of number of newly opened stock trading account Z are control variables, including the logarithm of fixed capital investment, the logarithm of employee size[5], α_i are unobservable heterogeneous factors, u_{it} is identically independently distributed. We conduct the Hausman test to select the fixed effect model, which suggests that the random model can better predict the effect of *PsyCap* on innovative performance.

$$\ln \text{patent}_{it} = \alpha_i + \beta_2 \text{PsyCap}_{it} + \beta_3 HC_{it} + \beta_4 Z + u_{it}, u_{it} \sim iid(0, \sigma_{it}^2). \quad (25.10)$$

Table 25.2 reports the correlation matrix of primary variables in the model. We found that the correlation of FCI and innovation is high. Therefore the VIF (Variance Inflation Factor) test is also run for 12-year pooled data and for year 1997 and 2009 data, to examine the possible multicollinearity problem that may occur in the model. The VIF coefficients are all around 3, indicating that the influence of multicollinearity to the model is acceptable.

Table 25.3 reports the panel model estimates. The baseline specification (1) estimates the impact of physical capital and labor force on innovative performance. Specification (2) examine the contribution of PsyCap to innovation aside from physical capital and labor input; Specifications (3) $\sim$ (5) examine the mediate effects of human capital in the relation between psychological capital and innovative performance. The percentage of workers with tertiary, secondary, or primary education are used to measure human capital in different specifications.

A few important findings are also obtained from Table 25.3. Firstly, without considering human capital, the estimates of coefficient of psychological capital is significantly positive, suggesting that psychological capital is positively related to a

[5] These two factors were found to be strongly correlated with innovative activities in previous studies.

Table 25.2 Correlation matrix of primary variables

	1	2	3	4	5	6	7
1. Logarithm of patent application per 10,000 people	1						
2. Logarithm of number of trading account	0.691	1					
3. Logarithm of FCI	0.815	0.485	1				
4. Logarithm of Employee	0.089	0.618	−0.098	1			
5. Primary education	−0.712	−0.697	−0.483	−0.210	1		
6. Secondary education	0.558	0.684	0.354	0.351	−0.949	1	
7. College education	0.755	0.422	0.571	−0.210	−0.680	0.413	1

Table 25.3 The spatial regression estimates on the innovative performance (1997-2009)

	(1)	(2)	(3)	(4)	(5)
Logarithm of FCI	1.012***	0.836***	0.777***	0.815***	0.757***
	(0.029)	(0.042)	(0.041)	(0.047)	(0.045)
Logarithm of employee	0.443***	0.056*	0.229***	0.040	0.052
	(0.105)	(0.101)	(0.086)	(0.104)	(0.098)
Logarithm of number of trading account		0.319***	0.147***	0.309***	0.217***
		(0.054)	(0.053)	(0.057)	(0.057)
College education			0.087***		
			(0.009)		
Secondary education				0.007	
				(0.005)	
Primary education					−0.026***
					(0.005)
Observation	403	398	368	368	368
Number of provinces	31	31	31	31	31

Dependent Variable: Regional Innovation Activities, measured by the logarithm of the number of patent applications per 10,000 people
Source: China Statistical Yearbooks, China Labor Statistical Yearbooks, China Statistical Yearbook on Science and Technology, 1997-2007, author's own calculation.
Note: Coefficient estimates are reported. *, **, and ***, indicating the 10, 5, and 1 percent significance level, respectively. Standard error estimates are reported in the bracket. The trading account number data does not have 31 observations for year 1998, hence specification (2) has 398 observations. The estimation of (3) $\sim$ (5) does not use data from 2000 because employees' educational attainment not reported for 2000.

region's innovation performance. The hypothesis 1 is proved[6]. Secondly, in specification (3) $\sim$ (5), the estimates of coefficient of human capital is significantly positive, indicating that human capital is another important factor to explain the

[6] One thing need to point out is that, the stock trading account number is the proxy variable of psychological capital, therefore it can describe the regional disparity of PsyCap and reflect the positive effect of PsyCap. However, the absolute value of account number is not equivalent to the level of PsyCap, therefore the value of coefficient cannot be used to interpreted the marginal effect of PsyCap.

innovative performance. After adding the human capital variable, the estimates of coefficient of PsyCap become smaller, suggesting that the effect of PsyCap on innovative performance become smaller when the human capital factor is considered. In the regression (3), PsyCap coefficient estimates has greatest extent of change after controlling for human capital, which decreases from 0.319 in (1) to 0.147, indicating that almost half of the Psycap's contribution to regional innovative performance is through the pathway that PsyCap firstly enhance college education then improve the innovative performance. The mediation effect of human capital in hypothesis 2 has been proved. The primary education negatively mediates the PsyCap and innovative performance.

We notice that the stock trading account may not only be affected by psychological state, but also by other factors such as the capital market development, the wealth of residence, the convince of investing etc. Therefore we control the average household income in a region to conduct robustness check. The estimates are significantly different from that in Table 25.3[7].

(2) Spatial panel model

For regional data, the conventional OLS analysis is rendered to be invalid. For traditional OLS regressions assumptions will be violated since neighboring areas often share more common characteristics than those are far apart due to the interaction and spillover effects between regions. Therefore, a spatial econometric method is required in regional studies. Elhorst [16] developed panel models for spatial regression[8].

We build the fixed-effect spatial error model and the fixed-effect spatial lag model[9] which include all the explanatory factors used in the panel regression estimation. In this model, the unobserved spatial fixed effects are controlled. Spatial fixed-effects refer to the effects that vary across regions but do not change over time, such as factor endowment. The fixed-effect spatial error model is:

$$\begin{aligned} \ln \text{patent}_{it} = {} & \eta + \delta + \beta_2 \text{PsyCap}_{it} + \beta_3 HC_{it} + \beta_4 \ln \text{FCI\_cap}_{it} + \beta_5 \ln \text{employee}_{it} \\ & + \varepsilon_{it}, \\ \varepsilon_{it} = {} & \lambda \sum_{j=1}^{N} W_{ij} \varepsilon_{jt} + \mu_{it}, \end{aligned} \tag{25.11}$$

where η_i represents the spatial fixed-effects for sub-area i. W is the neighboring weighted matrix. The fixed effect lag model is constructed as follows:

$$\begin{aligned} \ln \text{patent}_{IT} = {} & \rho W \ln \text{patent}_{IT} + \eta + \delta + \beta_2 PsyCap_{it} + \beta_3 HC_{it} + \beta_4 Z + \varepsilon_{it}, \\ \varepsilon \sim {} & N(0, \sigma^2). \end{aligned} \tag{25.12}$$

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[7] The results are not reported here for limit space, but are available upon request.

[8] Baltagi [10] pointed out that if the data are limited to specific samples (such as the 31 provinces in this study), fixed-effect models are usually the better choice.

[9] The difference between SLM and SEM lies in whether spatial dependence is modeled by the spatially lagged dependent variable or introduced in the disturbance term. More detailed introduction about the two type of spatial panel can be found in Chi and Qian [11].

Table 25.4 The fixed effect spatial panel regression estimates on the innovative performance (1997-2009)

	Spatial panel error model				Spatial panel lag model			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Logarithm of FCI	0.780***	0.569***	0.744***	0.666***	0.777***	0.556***	0.740***	0.658***
Logarithm of employee	−0.280***	0.010	−0.279***	−0.211***	−0.273***	0.012	−0.273***	−0.207***
Logarithm of number of trading account	0.471***	0.255***	0.400***	0.291***	0.461***	0.243***	0.391***	0.283***
College education		0.082***			0.083***			
Secondary education			0.011***				0.011***	
Primary education				−0.019***				−0.019***
Spatial autocorrelation	−0.209***	−0.232***	−0.202**	−0.194**	−0.049	−0.009	−0.039	−0.026
Number of observations	310	310	310	310	310	310	310	310
Number of provinces	31	31	31	31	31	31	31	31
Log likelihood	−231.072	−171.315	−225.592	−208.239	−233.864	−174.740	−228.362	−210.979

Dependent Variable: Regional Innovation Activities, measured by the logarithm of the number of patent applications per 10,000 people.
Source: China Statistical Yearbooks, China Labor Statistical Yearbooks, China Statistical Yearbook on Science and Technology, 1997 ∼ 2007, author's own calculation.
Note: The column (1) ∼ (4) reports the panel SEM model, Column (5) ∼ (8) reports the panel SLM model. Coefficient estimates are reported. *, **, and ***, indicate the 10, 5, and 1 percent significance level, respectively. For limit space, standard error estimates are not reported. For year 1997, 1998, the trading account number data are less than 31 observations, cannot calculated the weighted matrix, hence been dropped. The estimation does not use data from 2000 because employees' educational attainment not reported for 2000.

Table 25.4 provides further evidence that psychological capital has significantly positive effect on regional innovation. The estimated coefficients in Column (1), the spatial error model, the column (5) and the spatial lag model are both positive and significant. The mediate effect of human capital between psychological capital and innovation performance is also supported. On one hand, the human capital is significantly positive related to innovation; on the other hand, after introducing human capital, the estimated coefficient of psychological capital is become much smaller. The PsyCap estimated coefficient is still significant, suggesting that human capital play a partial other than full mediate role between PsyCap and innovation performance. Comparing the estimates in Table 25.3 and Table 25.4, it is clear that after employing the spatial model, the estimate of PsyCap coefficient become larger. Combing with the fact that the spatial autocorrelation coefficient is significant, it is evident that spatial effect does have influence on the accuracy of regression estimation, which in hence should be considered in the model. The employment of spatial model is justified.

25.7 Conclusions

This study aims to study the impact of psychological capital on the innovation performance at regional level for the first time. The study has following contributions to the literature: Firstly, the study discusses the indirect effect of PsyCap on innovation performance, that is, psychological capital enhances the human capital accumulation in a region and then improves the innovative performance. Secondly, we innovatively use a proxy regional variable to measure the collective psychological capital on a regional level. Thirdly, employing the spatial panel regression model to deal with the spatial effects that may cause invalidity in traditional OLS, we prove the effect of PsyCap on innovation performance as well as the intermediate effect of human capital.

Using the newly-opened stock market trading account to measure the psychological capital is a very rough proxy; the coefficient of the regression cannot be used to estimate the marginal effects of psychological capital on innovative performance. Further improvements on the proxy variable are required to enrich this study.

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Chapter 26
Efficiency Evaluation of Chinese Press and Publication Listed Companies Based on DEA Model

Jia Liu and Yongzhong Yang

Abstract This paper empirically analyzes the performance of 26 listed companies in press and publication industry from 2009 to 2011 by using CCR and BCC model of DEA. The result shows that the industry is growing stably, but the overall efficiency of the whole industry is descending which is composed of stable pure technical efficiency and descending scale efficiency. This paper also gives the policy suggestions that Chinese press and publication industry need to focus on the scale efficiency improvement so that the "big but weak" situation of the national listed companies can be fundamentally changed.

Keywords Relative efficiency · DEA · Performance evaluation

26.1 Introduction

In China, as the development of the economic and living standard, the whole society has a high level requirement for the demand and quality of the press and publication industry, hence it has become an urgent and realistic problem to improve the efficiency of this industry. Since the listed companies play a crucial role in the leading and demonstrating function for the whole industry, the study of the performance of these listed companies of the press and publication industry is significant to the sustainable development of this industry.

Many scholars have researched the press and publication industry from different respects. Ji [1] explored the current status and the character of the China digital publishing, and discussed the available path of the future development. He [2] analyzed the performance of Chinese publishing industry from the angle of institution. Tang [3] did empiric analysis and appraisal of market performance and management

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achievement of five publishing companies, and thought the publishing industry has a good long-term prospect. Jiang and Hu [4] tested the structure-performance relationship and found evidence to support the "relative market power hypothesis" and "X efficient hypothesis" in Chinese book publishing industry. Dai and Xu [5] evaluated relative efficiency of 23 listed companies of press and publishing industry with only one-year data in 2010 by DEA model, and concluded that the efficiency of those companies is relatively lower because of the inefficient scale that leads to its low technology efficiency and most of those companies are not operated in the form of the optimum scale whose efficiency is decreasing. Above all, there is no time series performance and efficiency analysis of the listed companies of Chinese press and publication industry. This paper empirically analyzes the operation efficiency by the CCR and BCC model of DEA, investigates the technical and scale efficiency of Chinese publishing industry, and gives the suggestion of future development.

26.2 Method and Data

26.2.1 DEA Model

Data Envelopment Analysis (DEA) is the non-parametric mathematical programming approach to frontier estimation, which evaluates the relative efficiency among different decision making units (DMU). This method has the following advantages: (1) multi-input and multi-output; (2) no requirement of dimension when selecting the indicators of inputs and outputs; (3) no requirement to identify the function of the inputs and the outputs.

After several decades' development, a large number of models of DEA methodology are extended and applied in empirical analysis. CCR and BCC are two most famous models of them. The CCR model was introduced by Charnes et al [6], in which DEA is applied for constant returns to scale (CRS). Suppose there are a set of n peer DMUs, $\{\mathrm{DMU}_j : j = 1,2,\cdots,n\}$, which produce multiple outputs y_{rj} $(r = 1,2,\cdots,s)$, by utilizing multiple inputs x_{ij} $(i = 1,2,\cdots,m)$. Let the inputs and outputs for DMU_j be $X_j = (x_{1j},x_{2j},\cdots,x_{mj})t$ and $Y_j = (y_{1j},y_{2j},\cdots,y_{sj})t$, respectively, so the CCR model is as follows:

$$\min\theta,\quad \text{s.t.}\begin{cases}\sum\limits_{j=1}^{n} X_j\lambda_j + s^- = \theta X_0,\\ \sum\limits_{j=1}^{n} Y_j\lambda_j - s^+ = Y_0,\\ S^+ \geq 0, S^- \geq 0.\end{cases} \tag{26.1}$$

In this model, $\theta(0 < \theta \leq 1)$ is the efficiency value, and λ_j is the weight variable. Besides, S^- and S^+ are slack variable and surplus variable, respectively. If the value of θ is equal to 1, the related DMU is operating on the optimal production frontier, which implies that its outputs reach the overall efficiency optimum as for its inputs.

If introducing constraint condition $\sum_{j=1}^{n} \lambda_j = 1$, Equation (26.1) can be converted to the BCC model, which is a model applied for variable returns to scale (VRS). The values of θ calculated from CCR and BCC models are called overall efficiency (OE) and pure technical efficiency (PTE), respectively [7]. Scale efficiency (SE) can be calculated by equation $\mathrm{SE} = \mathrm{OE}/\mathrm{PTE}$ [8].

26.2.2 Indicators and Data

Considering the indicator selection should be scientific, comparable and available, three input indicators are chosen to reflect the factors of human resource, asset and capital. One of them is annual salary of employee instead of the number of employee, because the human structures are different in these companies; the second input indicator is fixed asset, which reflect the material input during operation; the third input indicator is equity, which reflect the capital investment to the company. Two output indictors are the income of main business and net profit, which reflect the company's operation ability.

All data of these listed companies are obtained from their 2009 $\sim$ 2011 annual financial statement. According to 2011 Press and Publication Industry Analysis Report issued by General Administration of Press and Publication of the People's Republic of China, at the end of 2011 total 26 listed companies are in China A Share Stock Market, which cover publishing, distributing and printing sectors. Since DEAP 2.1 Software can't deal with negative value, the listed companies with negative profit are exclusive. The efficiency are calculated by 24 listed companies, which include 10 publishing companies, 4 distributing companies and 10 printing companies (Table 26.1).

26.3 Empirical Analysis

Using CCR and BCC model, the overall efficiency (OE), pure technical efficiency (PTE) and scale efficiency (SE) of 24 listed companies were calculated by DEAP 2.1 Software. The results show that the efficiencies have the following characteristics.

26.3.1 Overall Efficiency (OE) Analysis of Press and Publication Industry

As the whole press and publication industry developing, total assets and equity are 1442 and 734.5 billion RMB in 2011 respectively, which have increased by 13.2%

Table 26.1 24 listed companies in 3 sectors

Publishing sector	
000719	Central China Land Media
601928	Jiangsu Phoenix Publishing & Media
600757	Changjiang Publish & Media
600633	Zhejiang Daily Media Group
600373	Chinese Universe Publishing & Media
601098	China South Publish a7 Media
000793	Huawen Media Investment Corporation
600551	Time Publishing & Media
600880	Chengdu B-ray Media
601999	Northern United Publishing & Media
Distributing Sector	
300148	Tangel Publishing
000529	Guangdong Guanghong Holdings
600825	Shanghai Xinhua Media
601801	Anhui Xinhua Media
Printing Sector	
002599	Beijing Shengtong Printing
002450	Beijing Kande Xin Composite Material
000659	Zhuhai Zhongfu Enterprise
000812	Shanxi Jinye Group
002014	Huangshan Novel
002117	Tungkong Security Printing
002191	Shenzhen Jinjia Color Printing Group
002229	Fujian Hongbo Printing
600210	Shanhai Zijiang Enterprise Group
600836	Shanghai Jielong industry group

and 12.5% compared with those in 2010. The whole market value of 26 listed companies is 152.5 billion RMB in 2011. But the OE is descending from 0.826 in 2009 to 0.765 in 2011 (Fig. 26.1). OE of publishing sector increases a little from 0.745 to 0.789, meanwhile, OE of distributing and print sectors decrease. Overall efficiency is a composition of pure technical efficiency and scale efficiency, so we need to analyze the changes of them further.

26.3.2 Pure Technical Efficiency (PTE) Analysis of Press and Publication Industry

Pure technical efficiency refers to the efficiency where only technical factor is considered under certain scale. Because of the variant scales of these listed companies, PTE usually is used to measure the efficiency of the usage of technology.

Fig. 26.1 Trend of OE

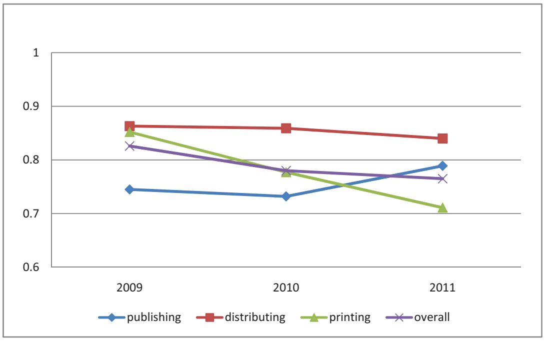
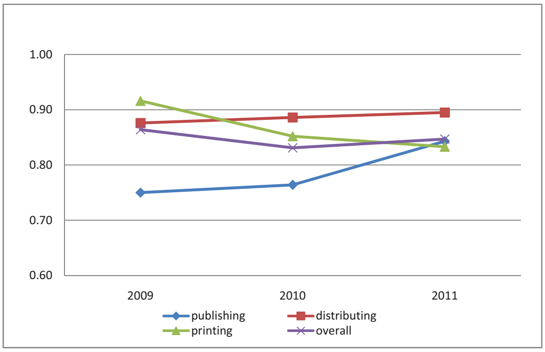


Fig. 26.2 Trend of PTE



PTE of the whole industry decreased from 0.864 in 2009 to 0.831 in 2010, then increased to 0.847 in 2011 (Fig. 26.2). PTE of publishing and distributing sectors keep increasing, but PTE of printing sector keeps decreasing. In 2009, 7 listed companies are efficient of PTE, the percentage is 47% of 15 listed companies, then 7 and 37% in 2010, 10 and 42% in 2011 (Fig. 26.3). The rate of printing listed companies with the optimum in PTE is decreasing yearly, from 5 out of 7 in 2009 to 4 out of 10 in 2010 (Fig. 26.4). Additionally, in 2011 four bigger publishing companies (000719, 601928, 600757, 600633) were listed, but only PTE of 600633 (Zhejiang Daily Media Group) is 1, the rest of 3 are no more than 0.8. This means that the bigger companies are operating with low efficiency.

With the technology development, the whole society is changing to informationization and digitization, which greatly impact on the traditional press and publication industry and entirely change previous the law of development, distribution carriers and channels. Facing challenges and taking opportunities, the whole industry has to change traditional idea and explore new way to fit the future development.

Fig. 26.3 Number of PTE efficient and percentage

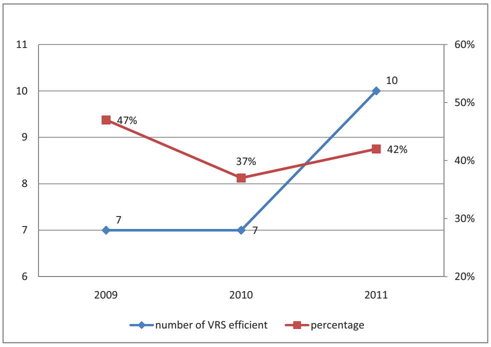


Fig. 26.4 Number of PTE by different sectors

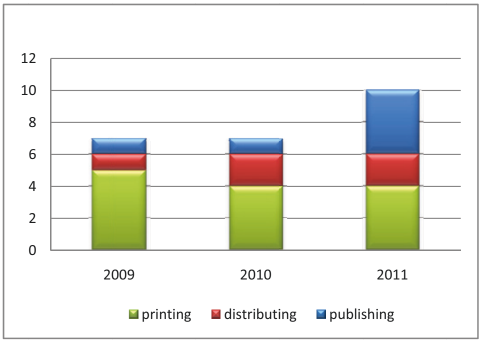
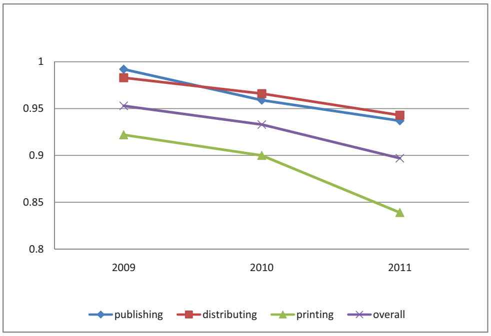


Fig. 26.5 Trend of SE



26.3.3 Scale Efficiency (SE) Analysis

Scale efficiency shows the gap between the optimal operating scale and the scale on which the company is operating. If SE equals to 1, the company is operating on the optimal scale. Not only SE of the whole industry but also that of each sector are descending as shown in Fig. 26.5. The descending trend is much more obvious in printing sector than in publishing and distributing sectors.

Table 26.2 Efficiency outcomes of 2009 ∼ 2011 Chinese press and publication listed companies

Listed company	2009				2010				2011			
	OE	PTE	SE	Return to Scale	OE	PTE	SE	Return to Scale	OE	PTE	SE	Return to Scale
000719									0.639	0.662	0.965	irs
601928									0.584	0.762	0.766	drs
600757									0.622	0.624	0.997	drs
600633									1	1	1	-
600373					0.647	0.649	0.997	irs	1	1	1	-
601098					0.675	0.806	0.838	drs	0.845	1	0.845	drs
000793	0.572	0.580	0.986	drs	0.745	0.787	0.947	drs	0.800	0.909	0.880	drs
600551	0.681	0.682	0.998	irs	0.608	0.623	0.975	drs	0.674	0.697	0.967	drs
600880	1	1	1	-	1	1	1	-	0.971	1	0.971	drs
601999	0.726	0.738	0.984	irs	0.717	0.718	0.999	drs	0.757	0.772	0.980	drs
	0.745	0.750	0.992		0.732	0.764	0.959		0.789	0.843	0.937	
300148					1	1	1	-	0.822	0.966	0.850	irs
000529	1	1	1	-	0.997	1	0.997	irs	1	1	1	-
600825	0.700	0.725	0.965	irs	0.652	0.688	0.948	irs	0.615	0.615	0.999	-
601801	0.890	0.903	0.985	irs	0.785	0.855	0.918	drs	0.921	1	0.921	drs
	0.863	0.876	0.983		0.859	0.886	0.966		0.840	0.895	0.943	
002599									0.471	0.872	0.540	irs
002450					1	1	1	-	1	1	1	-
000659	0.623	0.668	0.932	drs	0.589	0.638	0.924	drs	0.522	0.605	0.864	drs
000812	0.478	0.764	0.626	irs	0.467	0.688	0.679	irs	0.467	0.705	0.662	irs
002014	0.882	1	0.882	irs	0.986	1	0.986	irs	1	1	1	-
002117	1	1	1	-	0.524	0.626	0.837	irs	0.521	0.607	0.858	irs
002191	0.891	0.898	0.992	drs	0.792	0.810	0.978	drs	1	1	1	-
002229	0.941	1	0.941	irs	0.632	0.908	0.697	irs	0.446	0.630	0.708	irs
600210	1	1	1	-	1	1	1	-	0.938	1	0.938	drs
600836	1	1	1	-	1	1	1	-	0.749	0.912	0.821	irs
Printing sector Average	0.852	0.916	0.922		0.777	0.852	0.900		0.711	0.833	0.839	
Overall Average	0.826	0.864	0.953		0.780	0.831	0.933		0.765	0.847	0.897	
Number of companies with efficient PTE		7				7				10		
Percentage of efficient PTE		47%				37%				42%		

irs: increasing return to scales; drs: decreasing return to scales.

The reason why the SE descends can be explained from two aspects. As the development of digital technology and the popularization of internet and mobile terminal, the decreasing demand for paper publication impacts on the printing sector. On the other hand, the increasing speed of internet makes the protection of copyright more difficult than before, so the press and publication industry is affected to a certain degree correspondingly. In additional, rising price, increasing cost and higher investment of R&D, equipment and human resource affect the SE of this industry to a certain extent since the Chinese press and publication industry is in the exploratory stage.

Table 26.3 Market value vs. return to scale in 2011

Listed company code	Sector	Market value (billion RMB)	SE	Return to scale
601928	Publishing	21.23	0.766	drs
601098	Publishing	16.27	0.845	drs
601801	Distributing	9.92	0.921	drs
600373	Publishing	9.31	1	-
600880	Publishing	7.79	0.971	drs
000793	Publishing	7.60	0.880	drs
002450	Printing	7.34	1	-
600633	Publishing	6.20	1	-
002191	Printing	6.09	1	-
600825	Distributing	5.97	0.999	-
600551	Publishing	5.94	0.967	drs
000719	Publishing	5.93	0.965	irs
600210	Printing	5.77	0.938	drs
000659	Printing	4.45	0.864	drs
600757	Publishing	4.34	0.997	drs
601999	Publishing	4.29	0.980	drs
000529	Distributing	3.70	1	-
002014	Printing	2.64	1	-
002117	Printing	2.41	0.858	irs
300148	Distributing	2.36	0.850	irs
002229	Printing	2.22	0.708	irs
600836	Printing	2.10	0.821	irs
000812	Printing	1.90	0.662	irs
002599	Printing	1.40	0.540	irs

26.3.4 Return to Scale Analysis

When SE is inefficient, there are two directions (irs or drs) to make the listed companies to efficient. In the whole industry (Table 26.2), from 2009 to 2010 the number of drs is increasing in the publishing sector, but the number of irs is increasing in the printing sector. In 2011, among 18 listed companies with inefficient SE, 7 of 10 publishing companies are drs, which means they are operating in the situation higher than the optimum; 5 of 10 printing companies are irs, which means they are operating in the situation lower than the optimum.

The problem of Chinese press and publication industry listed companies is "big but weak" and "small but dispersed", which is reflected by the relationship between market value in 2011 and return to scale (Table 26.3). Most of the big companies with high market value are in decreasing return to scale, but the small companies are in increasing return to scale. In China, the big publishing companies are transferred from national companies whose development benefits from the institution, still keep the big scale, high investment but low efficient traditional development model, and haven't achieved intensification. Because of financial limitation, the small printing companies are operating under the optimal scale and show increasing return to scale.

26.4 Conclusion and Suggestion

This paper analyzes the operation performance of 24 listed companies in press and publication industry from 2009 to 2011 by CCR and BCC model of DEA and gets following conclusions: (1) Though the whole industry develops well and the economic indicator gradually increase, but the overall efficiency (OE) of both the whole industry and sectors are lower than before. (2) Pure technic efficiency (PTE) shows different trends among three sectors. PTE of publishing and distributing sectors are increasing, but that of printing sector is decreasing. (3) The descending of scale efficiency (SE) is the main factor to cause the OE descending. (4) The "big but weak" and "small but dispersive" problem still exists in the press and publication industry. Especially three big publishing companies listed in 2011 are operating in the high market value, but in low efficiency situation.

According to above conclusions coming from this empirical analysis, this paper also gives out some policy suggestions.

(1) Innovation drives the development.

Facing the progress of the technology of communication, digitalization and internet and the popularization of the mobile terminal such as smart phone, pad etc, press and publication industry should take the advantage of opportunities which come from the digital economic development, keep innovating on the technology and distribution channel, strengthen the development of new business model, such as digital book, digital newspaper, digital music, mobile book etc, support the R&D in digital publishing, digital printing, e-book and so on, explore the main applied paradigm of digitalization development in press and publication industry, and achieve the success in the future competition.

(2) Management promotes the ability.

On one hand, the country should strengthen and standardize the management of the press and publication industry, keep improving and strengthening the relative law, protect the copyright and create good environment. On the other hand, according to their own conditions, the companies need to deepen the reform, promote the management efficiency, realize the transformation from extensive development to intensive which enhance overall competition strength.

(3) Competition enhances the efficiency.

Firstly, the press and publication companies should break the region barriers, realize the mergence, reorganization and combination of different regions and different sectors and enlarge the business field and scope. Secondly, the big companies should enter and explore the international market, spread the traditional Chinese culture, compete with the international companies to enhance the strength. At the same time, China should introduce foreign advanced companies into the local market, learn their management experience and method, then improve the local companies' ability. Finally, China should encourage private and small groups to enter press and publication industry to compete with the national companies, which can bring the whole industry improvement.

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Chapter 27
Ten Years Accounting Informatization Research and Reviewes

Xiaoyan Hao and Peishen Ren

Abstract 21 century is a time that high-tech technology revolution promote human new civilization, and it was the era that human society comprehensively march to the accounting informatization. Accounting informatization technology research in China in the past has achieved fruitful results. In his paper, from the accounting informatization theory research, accounting informatization standard system construction and XBRL applications, accounting informatization technology and its application research, internal control and audit issues in the informatization environment, accounting informatization of personnel training and education, we review, combed the main achievements of the ten years of accounting informatization of the annual meeting, aimed at further promoting accounting informatization workers of the theory and practice further research, expanding the influence of the annual meeting of accounting informatization, promoting the accounting informatization research to make more results.

Keywords Accounting informatization · Annual meeting of accounting informatization · Studies review

27.1 Introduction

Accounting computerization has experienced 30 years of history in China from 1970s. Review the history of the achievements of China's accounting informatization with the government to vigorously promote the positive exploration of the theory and practice of community are inseparable, and the annual meeting of the previous information technology efforts are inseparable. The strong support of the Ministry of Finance, the Accounting Society of China, from the 2002 national accounting of information technology will form a systematic, held once a year, held

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a symposium on some hot issues in-depth study has been successfully held for the ninth made a significant contribution for the accounting informatization in China. Now we will review important achievements as to ten years accounting informatization annual.

Table 27.1 Information of ten years accounting informatization

Session	Date	Location	The number of enrolled thesis	Theme
The First	1988	Chengde, HeBei		Standardization and generalisation of Accounting by EDP
The Second	2003.11.25-2003.11.27	Hangzhou, Zhejiang	35	Building the systematic structure of Accounting by EDP
The Third	2004.11.13-2004.11.15	Changsha, Hunan	50	The development of Accounting by EDP in the process of full development of Accounting by EDP
The Fourth	2005.8.21-2005.8.23	Taiyuan, Shanxi	178	The Exploration of the system of EDP
The Fifth	2006.4.22-2006.4.23	Hefei, Anhui	122	The best practice of the education of the Accounting information system
The Sixth	2007.4.4-2007.4.6	Chongqing, sichuan	120	New functions of Accounting information system-avoiding disadvantages and taking advantages
The Seventh	2008.5.24-2008.5.25	Dalian, Liaoning	102	New accounting rules and informationize
The Eighth	2009.5.9-2009.5.10	Tianjin	139	Chinese Accounting informationization reviews and expectations
The Ninth	2010.5.22-2010.5.23	Shanghai	132	Connecting theory and practice, controlling future development
The Tenth	2011.7.11-2.11.7.12	Taiyuan, Shanxi	160	Promot the informative construction with our joint endeavor by the implement of general classified standards

27.2 Accounting Informatization Theory Research

China's accounting informatization theory research results concentrated on the information technology to the influence of accounting and accounting informatization theory system research. The influence of the information technology to the accounting are the three main aspects:

- The influence of information technology to accounting environment;
- The influence of information technology on the theory of accounting basis;
- The influence of information technology to the accounting pattern [1].

Accounting informatization theory system research mainly have Two types of research results:

- Accounting informatization system architecture is based on systems science and information engineering as the theoretical basis;
- Financial accounting theory research of extension. Accounting informatization system of academic theory on the basis of accounting informatization definition theory, accounting informatization technology application theory and accounting informatization environment theory, in the form of combination of a organic theory system.

The annual meeting of the two official puts forward "accounting computerization" to "accounting informatization" development. In the meeting, Yang Zhounan professor analysis to the computerized accounting change to the accounting informatization of the theoretical issues, expounds the concept of "accounting informatization", put forward "accounting informatization" architecture-ISCA model.

In the fourth annual meeting, Yang Zhounan professor do theme report "accounting informatization system to explore" and thoroughly discusses the theoretical basis and connotation and denotation of the accounting informatization, presents a complete accounting informatization system structure framework. Accounting informatization system structure should include: accounting informatization theory system, accounting informatization system and standard system, accounting informatization standardization system, accounting informatization risk control system, accounting informatization talents project system, accounting informatization industry system and accounting informatization industry management system, etc [2].

In the sixth annual meeting, Zhuang Minglai professor proposed two stages theory ideas based on accounting informatization development goals: we should get high quality financial information for the target on the first stage. Namely with standard accounting process as a benchmark, original vouchers to electronic data confirm for the pivot, fully automatic generation of proof of charge as the basis, the requirements for XBRL output conditions, with embedded real-time control and continuous audit techniques and methods for quality assurance, and gradually establish a unified, standardized and high quality unemployment or areas accounting informatization center; We should make the integration of financial and business information for the target on the second stage. That is the design framework ERP as the basis, the value method and matters of the fusion of design thought of as the forerunner, the business of the database up for key, in order to get financial and non-financial data and quantitative and qualitative analysis data for the purpose, set up a business and financial harmony for the integration of the business events warehouse [3].

In the ninth annual meeting Ying Wei vice priests think deeply about the influence of information technology to the accounting, and she think that the relationship of accounting and information technology ascend to the accounting informatization, which reflects not only the accounting to the use of information technology, but also the more reflects the information technology in turn to accounting theory, methods, means, role, status, function the deep influence of the proposed "the accounting professional transformation" concept. Modern information technology to accounting work environment, accounting personnel quality requirements and accounting model have a major influence.

27.3 Accounting Informatization Standard System Construction and XBRL Applications

Along with the development of market economy in China, the enterprise accounting informatization is more and more big, and accounting content also more and more complex, and the traditional accounting supervision cannot assure means a government regulator with limited human can implement comprehensive and effective regulation. To solve the question we should construct accounting informatizationization standard system, that ensure information accounting supervision work is unity, normative and comparability.

Accounting informatization standardization system mainly includes the following aspects:

- Accounting informatization expression form (metadata) of standardization;
- Accounting informatization of software development process standardization;
- Accounting informatization security control of standardization;
- Accounting informatization data exchange (interface) of standardization;
- Accounting informatization transmission (XBRL) of standardization;
- Accounting informatization management system of standardization, etc.

Hu Renyu professor studies the standard of the informatization construction of accounting system, and the accounting informatization standard system is divided into four parts: accounting informatization expression form of standard (countless according to), intermediate intermediate and ultimate output standard (XBRL), accounting informatization data exchange standard (data interface) and accounting informatization security control standard and so on, and analyzes the internal accounting informatization standard system of the relationship between the four standard. He thinks that the four parts of the accounting standard system for informatization organic whole. Metadata standards for data extraction, acquisition, mainly to solve the problem rapidly inquires and collect data; XBRL is a standard which is on the Internet and the financial report issued and the transfer, mainly to solve the financial report issued standard; Data interface standards is accounting software for data transfer between the standard, mainly to solve different accounting software of data between communication problems; Accounting informatization security control standard is the smooth completion of the three guarantee.

XBRL (can be expanded Business report Language, Extensible Business Reporting Language) is first proposed in 1998 in the United States. It is a set of open, platform independent financial report international standard, which can effectively improve the financial report of electronic data storage, operation, reuse and exchange of timeliness and accuracy. XBRL application in our country, the relevant experts and scholars put forward the following Suggestions:

- It needs the government authority to promote and guide, led by the ministry of finance shall make XBRL standards and promote a authority;
- With XBRL international organization, strength exchanges and cooperation and actively participate in XBRL standards, pay close attention to the latest international XBRL research results and development tendency;
- In the promotion of our country XBRL, we should continue to complete with stock exchange as primary focal point of pilot strategy deployed outside, still must use the authority of the government department, make XBRL standards in finance, tax and even web portal and other areas of application promotion to widely spread;
- Government departments shall support building XBRL China research organization, set up research topic and build communication and experience platform [4].

From Shanghai to the birth of the first accounting informatization of local standards for the implementation of national standards to September 20, 2004 IT-Accounting Software Data Interface, and then focus on XBRL, the accounting informatization standardized way to go firmand practical, mainly due to China's accounting management system, new theoretical programs tend to be able to soon be applied in government promotion.We should continue to foster strengths and circumvent weaknesses, play to the strengths of the accounting management system in our country, to capture the international advanced research level highlands, have more power in the international accounting regulation, so as to better protect our interests.

27.4 Accounting Informatization Technology and Its Application Research

Accounting informatization technology and its application in our country develop from accounting computerization, experiencing the single accounting data processing stage, departmental accounting data processing stage, financial and business integrative processing stage. It can be said that technology platform shows the advantage of accounting informatization technology and its application, accounting software presents the epochal character of accounting informatization technology and its application, the application in enterprises shows the popularity of accounting informatization technology and its application, management thinking highlights the integration of accounting informatization technology and its application. Business process management has been widely used in the process of accounting informatization in enterprises, XBRL will lead the development mode of internet financial statement, and business intelligence is the tool to achieve the strategic objectives of financial management. Accounting informatization technology and its application will has breakthrough in the accounting service model, the integration of accounting management process, the integration of multi-level accounting service application in the future.

According to different level of development, accounting informatization technology and its application in our country can be divided into four stages: the first stage is the development and application period of the accounting-type software (1979-1996). It is the early stage of development of China's accounting software, and it focused primarily on the development and application of accounting-type accounting software. The second stage is the development and application period of the management-type software (1996-2000), which is basically driven by Chinese financial software vendors. In 1996, with the support of YONGYOU company, the Accounting Society of China held a management-type accounting software seminar, proposing the developing direction from accounting-type to management-type. The third stage is the period of integrated development and application (2000-2006). In August 1998, YOUNYOU company put forward a new concept of network finance, it began full implementation of its internet strategy. For example, it established the first website which provided online financial, customer relationship management application service for SMEs in China in ASP (Application Service Provider) mode. The fourth stage is the development and application period of the embedded software (after 2006). In order to adapt to the development of XBRL, accounting computerization sector of China proposed the idea of the development of embedded financial software.

Of course, the application of accounting informatization can not do without the support of software system, it can be said that software system is the soul of accounting informatization. The development of software is inseparable from certain environment, nowadays, information network with Web technologies as the core is the next important direction of our accounting software platform and technology development.

With the aim of the main problem of financial management faced by the Group company in China, some experts believe that we must make full use of IT to build appropriate group company's financial informatization platform, and they proposed the framework of group company's financial informatization, which main contents include: guiding ideology and theoretical methods, the goal of informatization, the environment of informatization, key technologies, solutions, evaluation system and the mode of informatization. The basic platform of group company's financial informatization includes hardware network infrastructure, IT security assurance system, support software system and flexible platform. Group company's financial application system which is based on strategic management is divided into three levels: accounting level, management level, decision-making level [5].

A number of proved, in the past decade, accounting informatization technology and its application has made tremendous progress, at the same time, reviewing and summarizing the course of its development and achievements can help us future clarify ideas, summarize the law of the development of accounting informatization in China to make greater success.

27.5 Internal Control and Audit Issues in the Informatization Environment

A large number of internal control is accomplished by integrated information system, which will bring more risk to the system. During information system development and implementation stage, control requirements and audit requirement should be an important part of the information system requirement. The external audit should be applicable to the IT environment audit mode. The new audit rule issue, which reflect the convergence of international auditing standards requirements, help to the process of audit information work, also put forward higher request for the accounting informatization. Our country should combine theory with practice, reference foreign continuous audit experience, promote the development of continuous audit.

In the fourth audit annual meeting, Chen Wanling professor made the report which is entitled the computer-aided audit in our country's present situation and the development countermeasure analysis, points out that computer information system must be audit in the informatization condition, specific include: the information system of the control of the audit, the development of information system audit, system function of information system audit and electronic data auditing, etc. To promote the development of computer-aided audit in our country, we must improve the relevant regulations and standards, compulsory for information system provide audit interface, strengthen the audit software propaganda, optimization and promote the use of it, pay attention to the computer information system development and the function audit's study and attempt, the qualification of CPA exam in our country should join IT and its control and audit the related content.

OuYang dianping professor says financial report based on XBRL will make that audit is facing the document, the transaction data, an example label, classification standard etc audit object, and the application of XBRL make that online audit and continuous audit are implemented. Establishing perfect and rigorous audit information ark and the research framework is the problem which is urgent need to address.

Under information environment enterprise internal control research present three big heat:

- Introduce the engineering to the process of internal control, set up the internal control engineering ark wearing;
- With the wide use of information technology and e-commerce becomes mature, the enterprise competition gradually turned to competition between the more value chain which use industry as the link connection;
- In the information environment, how to control with IT, learn from foreign advanced COBIT, COSO etc ark wearing, based on examining the foreign related internal control law's implementation effect, and carry out the risk management study which is suitable for our country business.

Yang Zhounan professor put internal control up to the height of the engineering analysis and research, puts forward the theory and method of engineering into the internal control system, establish an internal control engineering, in-depth study an internal control of physical model building, the internal control engineering model, methods, tools, and internal control of management process, etc. This theory, expand the range of internal control, open a new research area [6].

On April 26, 2010, the ministry of finance and the securities regulatory commission, the national audit office, the banking regulatory commission jointly issued the enterprise internal control supporting guidelines. In the social informatization background, how to carry out the enterprise internal control, the information technology how to influence internal control, which were discussed in the ninth annual meeting. Among them, about the informatization with the internal control relation, mainly in the following opinions:

- Informatization and the internal control is the enterprise management of the two different sides, both indispensable, not an alternative;
- Understand the relationship of informatization to internal control, the key is to control theory including risk assessment, control activities, control environment and control objectives complete understanding;
- The objective of internal control and concept in the information system should of internal control deep impact, and on the basis of the enterprise internal control the function, behavior, method, etc as a whole;
- For informatization and internal control should be increased to the understanding of the management innovation and methodological innovation [7].

27.6 Accounting Informatization of Personnel Training and Education

In the accounting informatization the talent training and education, for many years, the efforts made by the majority of accounting informatization teaching workers, mainly in the following aspects:

- The establishment and development of accounting informatization education and training, formed the accounting personnel training and subsequent education, vocational education and undergraduate course, master's and doctoral kinds levels of accounting informatization talent cultivation system;
- The establishment and reform of accounting informatization course system, and the development of accounting informatization promote accounting education reform, and course system and teaching content according to accounting informatization talent have diversity and the characteristics of the hierarchical structure, towards to cultivating the compound talents who know both information technology and familiar with accounting theory and practice develop and reform;
- Accounting informatization teaching material construction and development, in accounting informatization of the development process, play an important role;
- The characteristics and development of accounting informatization experiment teaching information technology to promote the construction of the accounting laboratory, the development of commercialization accounting software reform

the teaching of accounting practice, and with the development of accounting informatizationization progress, in strengthen the students' basic skills, through the system optimization, the integrated, and that formed a "integration, multi-level and open, modular" new experimental teaching system.

27.7 Accounting Informatization Development and Utilization in Coal Industry

Corresponding with the accounting information trend moving from theory to practice, theory and practice fields in China promote the advancement of the coal industry accounting information. At the tenth annual meeting, tri-lateral representatives from product, teaching and researching fields exchanged their opinions, therefore contributing valuable thoughts to the development of accounting information in coal industry. These contributions are as following. Firstly, it is an undeniable fact that accounting information trend has advanced in certain area and should be strengthened in the near future. Secondly, accounting information technology, especially the ERP application, has become a significant constitution in corporates' strategic management. Thirdly, the urgent problem in accounting theory field and application realm is the standardization of accounting information. Fourthly, what we need is the breakthrough n the contribution of accounting information theories. The objects, boundary, and application model of corporate accounting information are supposed to be further clarified. Fifthly, we should accelerate the training of accounting information related talents. Shanxi Coal Import and Export Co., Ltd. has begun and applied group information strategy. Its concrete methods are: speeding up the integration of the financial system and the business system, enhancing the decision-making function of the development of the financial system, and so on [8].

27.8 Conclusion

Immersing in China's reform and opening up to 30 years of dew of spring breeze, the accounting informatization research fruits in our country. In the accounting informatization theory research, accounting informatization standard system construction and XBRL applications, accounting informatization technology and its application research, internal control and audit issues in the informatization environment, accounting informatization of personnel training and education, which are made progress. Reviewing the past, we are full of relief; and Looking to the future, we have a long way to go on the journey, we will try hard to write a new chapter of accounting informatization grand and work hard to struggle.

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Chapter 28
The Study on Sport Psychological Skills and Coping Styles of High-level Wrestling Athletes

Ying He

Abstract With the continuous development of wrestling sports and the gradual improvement of wrestling athletes' technical level, it is more and more obvious that psychological sport skills and coping style could influence on the result of competition and closely connected with the psychological skill and coping style of their own whether athletes can have excellent performance. However, in the practical study, it is rarely the related research on how psychological sport skills and coping style will affect their performance in regard to high-level wrestling athletes in Sichuan Province. The article makes a research on high-level wrestling athletes in Sichuan Province with the use of literature, questionnaire survey and mathematical method. The results showed that: (1) gender differences exist in the four dimensions of the collective spirit, anxiety, self-confidence, mental preparation in the sport psychology skills; no gender difference exist in attention and motivation; age differences exist in preparation of psychological skills and the collective spirit; sport psychological skill does not exist significant differences during the training period; sports grade differences exist in the collective spirit and self-confidence. (2) 4 dimensions of coping styles have no significant difference in gender; there was a significant difference during the training period in avoidant coping and centralized treatment of coping style; coping style in 4 dimensions no significant grade differences in movement. (3) there is a significant correlation between coping style and psychological sport skills, positive psychological sport skills contributes to the state self-confidence, so we should take positive coping style.

Keywords High-level wrestling athletes · Sport psychological skill · Coping style

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28.1 Introduction

Psychological skill is an operating system what could affect individual psychological state and process and formed through practice way. It is a kind of implicit skill of the formation in human internal with relevant to a human life, study, work, labor, health as well as regulate and improve human body potential. The athletes' psychological skill was divided into the general psychological skill and specialized psychological skill [3].

Coping is defined to deal with their own evaluation of specific internal and external environmental requirements beyond their ability and then make changing cognitive and behavioral efforts [1].

Nowadays, in competitive sports field, key factors in victory require that not only athletes have excellent sports level, but also athletes is better than others in psychological skill level and positive coping style. Especially for excellent athletes, when they equal in training means, training level and the overall quality, psychological factors and adopted properly coping style is one of the key factors that they can win in the competition. The present research results have been summarized that some athletes have necessary psychological qualities in order to obtain outstanding results, but the research on wrestling sport project is rare, research on relationship between these psychological qualities is rare. Therefore, the research sample is mainly competitive sports school's high-level wrestling athletes in Chengdu sports university in Sichuan Province, the article explores high-level wrestling athletes whether exist in difference and correlation in psychological skill and coping style and provide a theoretical support for psychological training and coping style of wrestling athletes.

28.2 The Research Object and Methods

28.2.1 The Research Object

High-level wrestling athletes in Sichuan Province are used as the research object, their sport grade is national second-level or more, which include 2 Master sportsman athletes, 13 national one-level athletes, 40 national second-level athletes, 40 male athletes, 34 female athletes.

28.2.2 The Research Methods

(1) The literature method

By retrieving cnki, VIP Periodical, wanfang data, Superstar eBooks website, inquiring some libraries, the related documents have been collected and read literature, including sports psychology skills, competition anxiety, exercise coping, psychology, sports psychology, sports training, sports statistics, and then classified and synthesized.

(2) The questionnaire

High-level wrestling athletes in Sichuan Province are investigated by questionnaire, including psychological skills questionnaire of wrestling athletes and Chinese athletes repartee chart CSCA. Before the investigation, the team coach was interviewed, the basic situation of each participating team was understood, sex, age, professional training, sports level are redefined.

(3) The mathematical statistics

The collected data was processed by SPSS13.0.

28.3 The Results

28.3.1 Comparison Difference on Different Gender Wrestling Athletes in Sport Psychological Skill

Table 28.1 shows that it is homogeneity of variance in all respects of the psychological skills, $p < 0.01$ in the psychological skills anxiety control (AX), mental preparation (MP) in corresponding to the critical level of confidence explain that it is significant difference in gender above two psychological factors. $p < 0.05$ in Psychological skills confidence (CF) and the collective spirit (TM) in corresponds to the critical confidence level explain that there are significant differences in gender confidence and collective spirit. $p > 0.054$ explain it was no significant difference in concentration (CC) and motivation (MV).

Table 28.1 Psychological skill analysis in different gender

Psychological skill gender	F	Sig.	t	Sig. (2-tailed)
AX	0.076**	0.784	−2.738**	0.008
CC	2.013	0.162	−0.663	0.510
CF	0.012*	0.912	−2.590*	0.010
MP	0.225**	0.637	−2.808**	−0.007
MV	1.930	0.171	−0.232	0.818
TM	0.111*	0.740	−2.336*	0.023

$*p < 0.05$, $**p < 0.01$

28.3.2 Comparison Difference on Different Age Wrestling Athletes in Sport Psychological Skill

By using one-way ANOVA about different ages, it can be drawn from Table 28.2 that there is difference in preparation (MP) and collective (TM), no significant difference in anxiety (AX), concentration (CC), confidence (CF), motivation (MV).

Table 28.2 Psychological skill analysis in different age

Psychological skill age	*F*	Sig.
AX	1.309	0.279
CC	0.439	0.647
CF	0.450	0.640
MP	3.304	0.045
MV	0.498	0.610
TM	3.392	0.041

$*p < 0.05$, $**p < 0.01$

28.3.3 Comparison Difference on Different Training-year Wrestling Athletes in Sport Psychological Skill

Different training years' wrestling athletes in sport psychological skill compare by using independent samples T-test. As can be seen from Table 28.3, anxiety control (AX), attention concentration (CC), confidence (CF), preparation (MP), motivation (MV), the collective spirit (TM) showed no significant difference in corresponds to critical confidence level in training period.

Table 28.3 Psychological skill analysis in different training-year

Psychological skill training-year	*F*	Sig.	*t*	Sig. (2-tailed)
AX	0.094	0.761	0.951	0.347
CC	11.171	0.002	0.486	0.630
CF	3.226	0.080	0.375	0.710
MP	2.491	0.122	1.673	0.102
MV	0.951	0.335	0.802	0.427
TM	0.000	0.994	1.278	0.209

$*p < 0.05$, $**p < 0.01$

28.3.4 Comparison Difference on Different Sport Level Wrestling Athletes in Sport Psychological skill

Can be drawn from Table 28.4, master sportsman athletes and national one-level athletes master better in confidence (CF) and collective (TM), that is to say, master sportsman athletes and national one-level athletes is significantly higher than the second-level athletes in confidence (CF) and collective (TM). Significant difference exists in different sport level wrestling athletes in above two aspects.

Table 28.4 Psychological skill analysis in different sport level

Psychological skill sport level	*F*	Sig.	*t*	Sig. (2-tailed)
AX	0.295	0.589	−1.643	0.106
CC	3.537	0.066	1.615	0.113
CF	0.346	0.559	−2.070*	0.044
MP	0.359	0.552	−1.394	0.169
MV	2.516	0.119	−0.676	0.502
TM	3.969	0.052	−2.771**	−0.008

$*p < 0.05$, $**p < 0.01$

28.3.5 Comparison Difference on Different Gender Wrestling Athletes in Coping Style

Can be drawn from Table 28.5, by using T-test of homogeneity of variance, coping style differences analysis and comparison of results are as follows, the four coping styles latitude corresponding critical confidence levels greater than 0.05, it indicates that the four dimensions of coping styles have no significant difference in gender.

Table 28.5 Coping style analysis in different gender

Coping style gender	*F*	Sig.	*t*	Sig. (2-tailed)
PC	0.874	0.354	−0.772	0.444
EC	4.768	0.033	−0.392	0.170
AC	0.224	0.838	−0.177	0.860
TC	1.619	0.209	−1.575	0.121

$*p < 0.05$, $**p < 0.01$

28.3.6 Comparison Difference on Different Age Wrestling Athletes in Coping Style

Can be drawn from Table 28.6, Latitude Sig. value is greater than the significance level of 0.05, so there is no significant difference between the different ages wrestling athletes and coping styles Latitude.

Table 28.6 Psychological skill analysis in different age

Coping style age	F	Sig.
PC	0.090	0.914
EC	0.510	0.604
AC	0.010	0.990
TC	0.610	0.574

$*p < 0.05$, $**p < 0.01$

28.3.7 Comparison Difference on Different Training-year Wrestling Athletes in Coping Style

By using the independent sample T test to compare difference on different training-year wrestling athletes in coping style, as can be seen from Table 28.7, the confidence interval values were greater than 0.05 in emotion-focused coping (EC) and avoidance coping (AC), there have a significant difference on problem-focused coping (PC) in the corresponding confidence interval Sig. = 0.019. $p < 0.05$, corresponding confidence interval Sig. = 0.008, $p < 0.01$ show a more significant difference on transcendence coping (TC). In summary, significant difference has been shown on transcendence coping (TC) and problem-focused coping (PC) in training year.

Table 28.7 Coping style analysis in different training-year

Coping style training-year	F	Sig.	t	Sig. (2-tailed)
PC	0.006	0.941	-1.009^{*}	0.019
EC	1.347	0.253	-0.029	0.977
AC	1.249	0.270	-0.416	0.679
TC	0.099	0.755	1.645^{**}	0.008

$*p < 0.05$, $**p < 0.01$

28.3.8 Comparison Difference on Different Sport Level Wrestling Athletes in Coping Style

Can be drawn from Table 28.8, Sig. value is greater than the significance level of 0.05 in all latitude of coping style. Therefore, different sport level was no significant difference on between each latitude groups.

Table 28.8 Coping style analysis in different training-year

Coping style sport level	*F*	Sig.
PC	1.192	0.312
EC	0.693	0.505
AC	0.819	0.447
TC	1.033	0.363

$*p < 0.05$, $**p < 0.01$

28.3.9 Correlation between Sports Psychology Skill and Coping Style

As be seen from Table 28.9, there are more significant correlation between psychology skill and coping style. There is a more significant correlation between problem-focused coping (PC) and anxiety (AX), attention concentration (CC), preparation (MP). There is a more significant correlation between emotion-focused coping (EC) and anxiety (AX), attention concentration (CC). There is a more significant correlation between avoidance coping (AC) and preparation (MP), confidence (CF), attention concentration (CC), anxiety (AX). There is a more significant correlation between transcendence coping (TC) and anxiety (AX), confidence (CF), preparation (MP), motivation (MV).

Table 28.9 Coping style analysis in different training-year

Psychology skill coping style	PC	EC	AC	TC
AX	−0.041**	−0.056**	−0.048**	−0.275**
CC	−0.070**	−0.116**	0.041	0.195
CF	0.064	0.320	−0.193**	−0.048**
MP	−0.52**	0.201	−0.209**	−0.179**
MV	0.068	0.255	0.052	−0.174**
TM	0.074	0.366	0.013*	0.013*

$*p < 0.05$, $**p < 0.01$

28.4 Conclusions

Gender differences exist in the four dimensions of the collective spirit, anxiety, self-confidence, mental preparation in the sport psychology skills; no gender difference exist in attention and motivation; age differences exist in preparation of psychological skills and the collective spirit; sport psychological skill does not exist significant differences during the training period; sports grade differences exist in the collective spirit and self-confidence.

Four dimensions of coping styles have no significant difference in gender; there was a significant difference during the training period in avoidant coping and centralized treatment of coping style; coping style in 4 dimensions no significant grade differences in movement.

There is a significant correlation between coping style and sport psychological skills, positive psychological sport skills contributes to the state self-confidence, so we should take positive coping style.

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Chapter 29
Integrating Safety Culture into OSH Risk Mitigation via Information Technologies

Dong Zhao, Yingbin Feng, Yincheng Ye and Min Jae Suh

Abstract The occupational safety and health (OSH) risk management continues to be a key topic for worldwide industries, especially in the construction industry. Most of prior technologies were used to directly but passively impact safe working engineering in a technical way. However, technologies may also indirectly but actively influence workers' safe performance in a managerial way. This research aimed to examine this severe safety problem in the construction industry, and taking which as an example, prevention measures for OSH risk mitigation are discussed. The analyses find that large portion of the OSH fatalities and injuries are related to workers' unsafe acts and lack of awareness on the OSH hazards. The lack of effectiveness was ascribed the OSH training content as well as the one-off nature of construction industry. An innovative approach is proposed, which integrates the safety culture into the OSH risk mitigation via the application of cutting-edge information technologies. Particularly, a virtual reality-based pilot application which links the safety culture and risk mitigation is demonstrated.

Keywords Risk management · Safety culture · Construction · Occupational safety and health

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29.1 Introduction

Risk management presents a concept of risk recognition and control in advance, which includes four processes of risk identification, risk assessment, risk mitigation and risk avoidance. Risk mitigation, the actions and measures applied to reduce the occurrence probability of an undesirable event and its consequent losses, turns to be the primary step for risk management among the four processes.

Occupational safety and health (OSH) continues to be a key component of risk management for industries. However, OSH related injury records, such as the electrocution in the construction industry, remain a reason for worldwide consistent concerns. According to the U.S. Bureau of Labor Statistics (BLS), the construction industry bore a disproportionate share in the electrocution statistics (see Fig. 29.1). Between 2003 and 2011, the construction sector hired approximate 5.05% of the entire U.S. employees, but involved in 47.80% of the electrical fatal injuries. Also taking the year 2011 for instance, the U.S. construction industry proportioned 39.18% of the electrical fatal injuries but merely 4.19% of employment. That means, in 2011 the death rate from electrocutions for the construction industry was 12.0 per one million full-time construction workers while it was 1.8 per one million full-time workers across all industries. Literally, as a result, the electrocution rate in construction is as much as 6.8 times of the average rate for all industry as a whole.

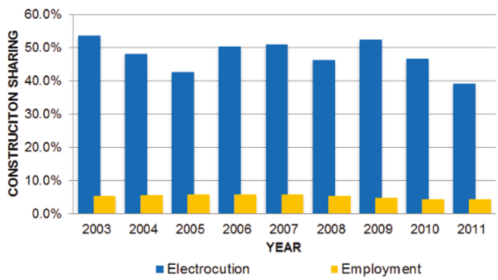

Fig. 29.1 Construction's shares in electrocution and employment, 2003-2011 data source: U.S. bureau of labor statistics

To be noticed that this disproportionately high electrocution rate is not a recent phenomenon, but has lasted for decades within the U.S. construction industry. Echoing back to the years between 1992 and 2002, the fatal electrical injury rate for construction was five times that for all industry levels [1].

Prior efforts have been taken to reduce OSH risks as well as losses in construction and provided good understandings on construction OSH accidents, either in terms of overall construction [2] or a specific hazard [3]. However, most of these analyses were based on personnel approach instead of a system approach. In fact, risk occurrence is seen as consequences rather than causes, having their origins not so much in the perversity of human nature as in "upstream" systemic factors [4], or an action or decision that results in one or more unintended negative outcomes [5]. Also, the interpretation and the determination of risk management were largely contextual. In this regard, any attempt to probe into the OSH risk management should begin with the investigation in a systematical context.

This research aims to examine this severe safety problem in the construction industry, and taking which as an example, prevention measures for OSH risk mitigation are discussed. The proposed approach integrates the safety culture into the OSH risk mitigation via the application of cutting-edge information technologies. In addition, the approach is demonstrated for the mitigation of electrical injuries in the construction industry, but it is not limited to this area.

29.2 OSH Risk Analysis

29.2.1 Immediate Causes of Electrocution

The causes of construction electrocutions differ between electrical workers and non-electrical workers. Between 2003 and 2005, the main cause of electrocution of electrical workers, consisting of electricians, electrical power installers and repairers, their apprentices and helpers doing electrical work, and their supervisors, was contact with energized, or "live", equipment and wiring. The secondary cause of electrical workers' deaths was contact with overhead power lines (see Fig. 29.2a). The main cause of electrocution for non-electrical workers was contact with overhead power lines and the secondary cause was by machinery and appliances with faulty electrical systems (see Fig. 29.2b). Contact with overhead lines includes direct contact by the person (accounting about 20% of the incidences) and indirect contact such as energized objects transferring the current and causing electrocution.

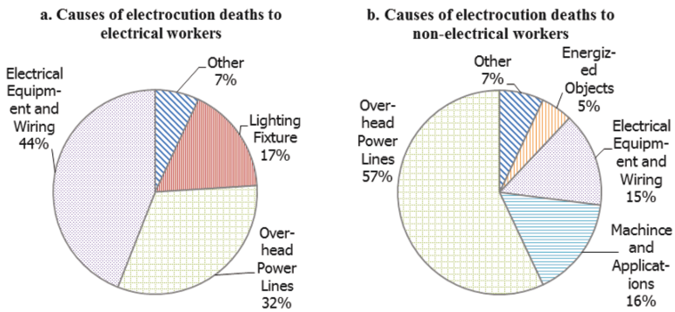

Fig. 29.2 Distribution of electrocution deaths in construction, 2003-2005 data source: center for construction research and training [CPWR] [6]

The construction occupations having the highest average electrocutions per year were electricians, construction laborers, supervisors/managers, electrical power installers and repairers. For 2003-2006, only 26% of electrical deaths were electricians, while the rest were associated with other trades within the construction industry [7].

To be noted that most of the above causes or hazards are well-known by the industry and the relative prevention measures have been documented in regulations, codes, and even daily safety procedures. Nevertheless, a large amount of construction workers still got injured or skilled every year, which appears to be more noteworthy.

29.2.2 Worker Behaviors

The human error has been widely considered as one key factor that contributes to up to 80% of occupational accidents in the aviation, petrochemical, healthcare, construction, mining, and nuclear power industries [8]. Rasmussen [9] has claimed three types of operator performance and three types of associated errors: skill-based, knowledge-based, and rule-based. Reason [10] has combined the knowledge-based and rule-based errors into human mistakes and extends human error as three types: skill-based errors, mistakes and violations. Skill-based errors derive from the limited capacity of information processing resources, including attention. Mistakes can occur when an individual has either no schema available to apply to the situation or applies the wrong rule or schema. Schema is developed through experiential learning which could occur through repeated exposure to a particular situation, or through learning opportunities provided in training programs. Violations are distinct from errors in that they are intentional. As Strauch [5] summarized, human errors commonly involved failure to identify the hazards involved in completing a task or the incorrect use of equipment, while violations were typically related to failure to follow organizational procedures such as completing a job safety audit or using personal protective equipment. In this regard, human mistakes, as a kind of human error, are the problems which can be solved by appropriate training.

Various reasons may induce human errors while the insufficient training is a significant one. Mistakes may occur if training fails to provide experience in dealing with unfamiliar situations, or fails to deliver a broad range of experiences to provide an understanding of when rules apply, leading to flawed interpretations of a situation and poor decision making [11]. Hobbs and Kanki [12] point knowledge-based errors significantly associated with training through retrospective accident analyses. Read et al [11] have verified that task demand factors, such as high workload, distractions and time pressure, are associated with skill-based errors and that a lack of knowledge, task inexperience and deficiencies in training were associated with mistakes, using Contributing Factors Framework (CFF). Jaselskis et al [13] argue that unsafe practices often lead to incidents or accidents since work execution is influenced by project condition, schedule, and budget constraints as well as the lack and less frequency in safety training, availability of proper safety equipment, and wrong or no enforcement of safety rules or best practices.

29.2.3 Nature of Construction Industry

Construction is a project-based industry, where each project is unique and requires independent stakeholders to collaborate at various stages during the project life-cycle. Each construction project can be considered a multidiscipline organization which may or may not continue to work together once the project is completed [14]. This one-off nature of construction, heavy fragmentation and connective structure makes construction a significantly complex process. Construction is also labor-intensive, with high workforce turnover, making management and training more difficult than other industries.

The above unique nature of construction industry largely constrains the performance of traditional training platforms and formats in OSH. First of all, different with manufacture industry which has fixed factory facilities, construction workers are continually moving among different construction sites. It comes to be hard for construction site to provide a specific training venue and it is not easy for the spouted constructions workers to assemble meanwhile. Secondly, compared to the repeating works in production lines, every construction project is irreplaceable and, as a result, its every construction work is highly specific. Thirdly, in contrast with high mobility of employees and small company scale, the benefit appears to be low while the cost high. For example, in the United States, 92% of the 1.25 million construction companies are less than 20 persons. Lastly, it is hard to squeeze out a big block of time for construction workers to be trained due to extremely tight construction schedule.

29.2.4 Safety Training Practices

Construction employers typically approach OSH practices for their workforce as part of the overall training orientation within company safety program. Some companies require new workers to participate in the Occupational Safety and Health Administration (OSHA) 30 hour outreach training program for general safety training, which uses the electrical module of that training class to inform their employees of general OSH risk awareness. Site specific electrical risks are often covered at weekly meetings at each site or during daily hazard meetings [15].

In typical structured training programs, information is presented through slides or the use of video tapes and is reinforced with handouts and study guides [15]. Quizzes are commonly used and supplied within a training packet to ensure comprehension of the covered material by the trainees.

Participatory training has been widely accepted as one of the most effective training approaches for adult training. As claimed by Goldenhar et al [16], the best way for training and learning is to do the real thing and to simulate the real tasks to obtain experience. However, most of current of OSH training practices are not in such participatory format and, as a result, turn to be less effective.

29.3 OSH Risk Mitigation: An Integration with Safety Culture

The aforementioned analysis indicates that unsafe acts and procedural violations of working personnel such as forgetfulness, inattention, poor motivation, carelessness, negligence and recklessness are the primary causes leading to OSH injuries. Consequently opportunities for these unsafe behaviors can be reduced by appropriate and effective training, though cannot be eliminated. Goldenhar et al [16] suggested that the most direct way to change the statistics in human mistake was through effective worker safety and health training. Neville [17] suggested that effective training programs can help save large costs by preventing accidents. Effective training does not only save lives with fewer accidents but eliminates the extra indirect costs associated with accident investigations, insurance rates, equipment downtime and repair, lost productivity, and finding replacement help.

The project-based nature of construction brings more barriers to OSH risk management, requiring innovations that provide benefits to whole industry. Toole [18] defined the innovation process as “application of technology that is new to an organization and that significantly improves the design and construction by decreasing the cost, increasing the performance, and improving the business process”. Gann and Salter [19] later pointed out that project-based firms rely upon combining technical expertise from other organizations in order to deliver their own technical capabilities, usually in one-off processes.

In the construction trade, OSH innovations are often related to ergonomic to improve health and increase safety. Over time, contractors have looked to educational institutions to provide a cadre of skilled construction employees to bring new construction technologies into the workforce. The construction industry is particularly eager in seeking new technologies to control risks in site variability, one-off nature, longevity of warranties, supply uncertainty and uncertainty inherent in the built environment [20].

As Fig. 29.3 shows, much of the construction innovation followed a “technical path” in which technology was applied directly into protective engineering promotion. However this approach can only impact the essential OSH role - personnel - in a passive way, which relatively lowers the effectiveness of technology in OSH risk mitigation. To some extent, the rapid adoption of ergonomic, health and safety technologies such as safety harnesses may even discomfort, impede and slow down individual workers. In contrary, a “managerial path” that apparently relates to technology in an indirect way may actively impact the worker’s OSH performance. In other words, despite the direct adoption of new technologies, the culture innovation is a powerful force that can shape the firm’s overall effectiveness and long-term success [21]. Safety culture unconsciously but consistently influences all aspects of organizational life such as workers’ attitude to safety and their decision made at every substantial moment.

It is a challenge to integrate subsistent technologies into culture, a set of beliefs, attitudes and values. However it becomes possible when culture is associated with the concept of “habitus”. In this perspective, culture is less often treated as only a set of beliefs and values than as the “whole way of life”, which includes practices and

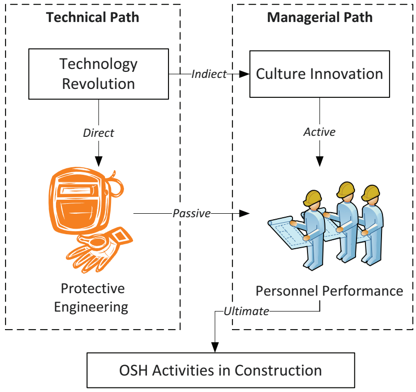

Fig. 29.3 Managerial path towards OSH risk mitigation

routines [22]. Bourdieu [23] referred to this set of predispositions which guide improvisations in daily routines as the habitus and this habitus is practical knowledge as repeated routines. A strength of understanding culture as habitus is that routines can be observed and documented, whereas values and beliefs must be inferred, making them less amenable to research. As a result, rather than formulating risk control as a break in habitus it may prove more useful to conceive of OSH risk mitigation as a process which requires that people reorganize their own propensities to improvise in certain ways when problems are encountered.

Therefore, habitus, sets of practical routines and dispositions toward certain ways of solving problems encountered in construction projects, has been suggested as a useful approach to the safety-culture-integrated OSH risk management. Risk mitigation is a continuous process of controlling rather than a group of static control points checking. In the habitus control process, safety training becomes instinctual through risk management, complementing sustainable productivity growth within an industry.

29.4 A Pilot Application via Information Technology

The dangerous characteristics of most construction-related tasks including electricity hardly allow trainees of participatory training in terms of task rehearsal even in on-the-job training. As a result, the effectiveness of OSH training in construction is reduced due to the traditional training methods.

In contrast, information technologies such as the virtual reality (VR) technology allows safe simulation of real-life events in a digital environment that might otherwise be too dangerous or expensive to create [24]. VR is described as a 3-dimensional world seen from a first-person point of view that is under real-time control of the user [25]. It also has the ability to create a problem-based learning exercise in an environment that replicates the trainee's actual working environment

[26]. Training programs via VR offers an interactive, active, and cognitive learning experience for the user [27, 28]. In consequence, they are often used in place of on-the-job training or full size simulation.

VR also benefits trainees with a participatory training environment. Such participatory training brings a real life aspect into the training in an "it can happen to you" scenario and allows the trainees to relate conditions and regulations with real life situations and a life or death importance [15]. The best scenario is when people do not have to consciously think about following safety procedures because it is second nature to them [29]. Moreover, VR provide trainees with the ability to experiment without concern for "real-world repercussions" and the ability to "learn by doing". With a VR program, the user controls the objects and couples this with information and descriptions and later task-based testing, thus, an interactive and active-learning experience is created.

Moreover, this simulation may contribute to build up the safety culture in terms of safe practical routines. Through this technology, training programs allow construction workers to familiarize the common hazards, including electrical hazard, and to mock up relevant prevention practices without real injury repercussions. It may not only improve trainees' awareness of potential risks in the real working environment, but also unconsciously influence their routine behaviors as their second nature, which will largely lead to the safety culture.

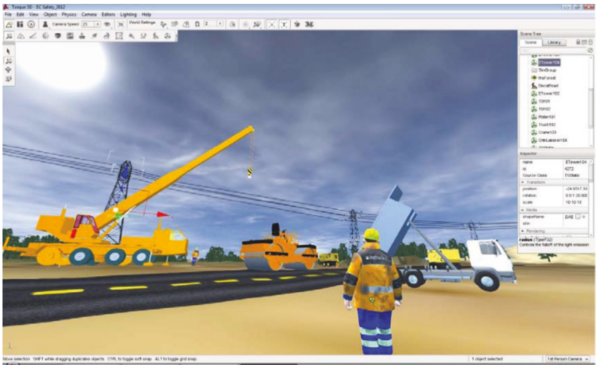

Fig. 29.4 VR-integrated OSH training program application

A pilot VR-integrated OSH training program was developed (see Fig. 29.4) and adopted in a construction project in the U.S. Also, OSH hazards and prevention measures that are simulated in the program are required to be repeatedly learned and practiced during certain period of time for workers. Construction workers will have them prepared for the future tasks and feel the failure, such as getting electrocuted, if they fail to conduct all safety procedures. The animation of failure will not only illustrate trainees the outcome of possible injuries but also shock their feelings. With successful and effective rehearsals in a virtual world, workers will set up the safety concept in their minds and will put this concept into practices in the real word. In this way, knowledge and awareness can be transferred into workers' OSH practical reunites - the safety culture.

In addition, this application is accessible through internet which fits the fragmented nature of construction projects. The performance of this pilot application will be put into feature long-term assessment and will be revised based on the feedbacks.

29.5 Conclusions

The occupational safety and health (OSH) risk management continues to be a key topic for worldwide industries, especially in the construction industry. Most of prior technologies were used to directly but passively impact safe working engineering in a technical way. However, technologies may also indirectly but actively influence workers' safe performance in a managerial way. This research examined the serious electrical safety problem in the U.S. construction, and took which as an example to analyze the possibility of integrating safety culture into the OSH risk mitigation.

The analysis found that large portion of the OSH fatalities and injuries were related to workers' unsafe acts and lack of awareness on the OSH hazards. Effective training turns to be most direct approach to solve this problem but in the real life practices, OSH training programs was not effective as they should be. The lack of effectiveness was ascribed the OSH training content as well as the one-off nature of construction industry. Accordingly, a new approach for OSH risk mitigation which is integrated with safety culture was presented and discussed. This research argued that the safety culture might directly benefit the workers' safety performance and it also be fostered into workers' safety practices via information technology once it is viewed as habitus. A pilot application which used virtual reality technology in the OSH training was demonstrated to help to set up the safety culture in workers' daily practices, and ultimately to mitigate the OSH risks in construction projects. This application is a mere pilot attempt in construction safety, but it could apply to various industries after the feature validation assessment is complete.

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Chapter 30
Applying Cognitive Psychology to Research the Identity-oriented System of General Hospitals

Yueyu Li

Abstract This paper aims to construct the theoretical framework of describing oriented information for Identity-oriented System in General Hospital, theoretically define and describe the information of spatial information nodes and channel routes of hospital departments to construct information structure model. With principles of cognitive psychology, theoretically defining and analyzing the cognitive process characteristics of oriented information clues for Identity-oriented System in General Hospital, constructing its information structure model of spatial information nodes and channel routes in Identity-oriented System. Through analyzing cognitive process of the path-finding lost and failure mechanism, investigating the effectiveness and efficiency of information transfer of Identity-oriented System in General Hospital, studying scientific set method that fit with the Identity-oriented System in General Hospital. From the external personnel's point of view, the results of this paper improve information transfer efficiency of Identity-oriented System in General Hospital and accurately define and set Identity-oriented System in General Hospital.

Keywords General Hospitals · Identity-oriented system · Failure mechanisms · Cognitive psychology

30.1 Introduction and Objectives

Three A-level General Hospitals (hereinafter referred to as General Hospital) are large regional hospitals which have high level and specialist health services and higher education, scientific research mission, and generally have more than 500 beds with a variety of medical treatment departments and outpatient departments. General Hospital buildings refer to the housing facilities suitable for hospital medical activities, including medical treatment, teaching, scientific research, medical

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aids and other departments, and these characteristics determine the complexity of the structure of the General Hospital buildings.

Patient, family members and visitors who first arrived at the hospital environment are called external personnel in this paper. Doctors, nurses and staff who are already familiar with the General Hospital environment are called internal personnel.

Hospital Identity-oriented System is a system engineering to solve the problem of path-finding lost in internal and external environment of hospital, in which considering the facilities and spatial characteristics both inside and outside the hospital buildings, the service function of the medical departments, treatment processes, and external personnel's psychological and physiological characteristics, then using visual recognition strategy, setting a variety of oriented signage to build a bridge of communication between the space with external personnel, in order to guide external personnel to the destination effectively in the shortest time.

This paper focuses on the cognitive processes of external personnel's path-finding in the General Hospital, also including the new internal personnel.

Some scholars have studied some problems in Hospital Identity-oriented System, Carpman and Grant [2] studied the visibility problems of coordination elements in different regions of the hospital. Ulrich et al [3] studied the oriented signage of hospital and information clues. Haq and Zimring [4], Peponis [5] analyzed the specific characteristics of rooms and whole structure of the corridor system which affect people how to select routes. Baskaya [6] found that people do not get lost at the main corridor of hospital's entrance. Study of Werner and Schindler [7], Ruddle and Peruch [8] shown that the hospital building layout may promote or hinder the attributes of people walking in the hospital. Arthur and Passini [1], Carpman and Rooke [2] studied hospital appearance settings providing architectural oriented clues. Ruddle and Peruch [8] studied the text and graphics information consistent with the characteristics of hospital building environment's appearance. Rooke [10] considered that the signage of oriented system effectively designed for the complex hospital environment must be ensure that the right information with the right form passed to the right people at the right time. Mollerup [11] studied how to do hospital have as little oriented signage as possible, and analyzed the visible and readable dual function of signage. Huelat [12] thought that the design for hospital Identity-oriented Systems must be understand the needs of patients and visitors. Rooke et al [13] considered hospital Identity-oriented System should be embedded with knowledge of marks, color, architectural and graphic information of environmental characteristics, in order to make up for the lack of signage information.

The above studies were mainly experience descriptive study based on Hospital Identity-oriented System, which were lack of systematic and general theoretical definition, cognitive description and model analysis of identity-oriented information.

30.2 Materials and Methods

This paper uses the principles of cognitive psychology, intends to study the oriented information characteristics of Identity-oriented System for General Hospital theoretically, defines its spatial information nodes and information structure model of channel routes, theoretically studies the cognitive processes of Identity-oriented System, and explores the basic principles of Identity-oriented System's design and setting in General Hospital.

Cognitive psychology thought that the solution to a problem is a search (search map or search tree) process in problem space which is determined by the operators, and the operator refers to an action turned one problem state into another state. The steps are: first, whether there are operators in the searching space? Second, how many operators are at the same time? How to choose the operator? How to find out the path to reach the goal?

Through studying the process that external personnel of General Hospital successfully reach the destination of the various departments of General Hospitals from the start point for the first time, finding that they will generally instinct to search the oriented information clues (operator) to destination in the current space as much as possible. These oriented information clues generally obtained by discovery, to be told, or observing other people to use.

Since external personnel can use the backup avoidance, difference reduction and means-ends analysis to choose oriented information clues, those behaviors of finding destination are goal-oriented behavior which usually set sub-goals to apply the oriented information clues, and also are behavior sequences finding out these clues. Whether external personnel can successfully solve the path-finding problem is determined by the available oriented information clues and the ways to guide search these clues.

This paper first defines and constructs the information structure of the cognitive maps of General Hospital's physical space, and then analyzes the cognitive process characteristics of its oriented information clues, based on this; finally discuss the principle of the set of oriented information.

30.2.1 Information Nodes and Classification

Abstracting the various departments and regions of General Hospitals regarded as information nodes, and finding the doors, windows and entrances can find these departments and regions, as shown in Fig. 30.1 and Fig. 30.2. Note that oriented information description of all the information nodes is relative.

Classification of information nodes (the following definitions as Fig. 30.1 (see Table 30.1), a partial plan view of a General Hospital, and Fig. 30.2, abstract plane information node-chain chart as an example to pictorial instructions).

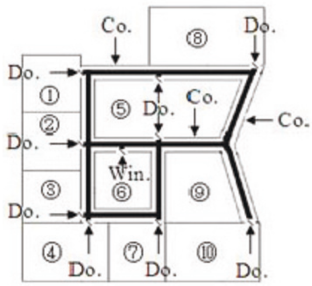


Fig. 30.1 Partial plan view of a General Hospital

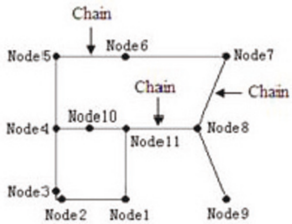


Fig. 30.2 Abstract plane information node-chain chart diagram

Table 30.1 No.-department correspond table for Fig. 30.1

No.	Departments	No.	Departments
①	Traditional Chinese medicine pharmacy	⑥	Registration fees room
②	Western medicine pharmacy	⑦	Department of gynecology
③	Laboratory room	⑧	Infusion center
④	Observation room	⑨	Green area
⑤	Hall	⑩	Treatment room

Note: Co.-corridor, Win.-window, Do.-door

- **Starting Node**: the external personnel departure location, such as Node 10 to Node 9, Node 10 is the starting node.
- **Destination Node**: external personnel to reach the place of destination, it is clear the above example Node 9 is the destination node.
- **Intermediate or Branch Node**: external personnel from the place of departure to the place of destination access channel routes, through some of the intermediate locations, such as from Node 10 to Node 9, the intermediate Node 11 and Node 8 are intermediate(branch) nodes.
- **Visual Node**: external personnel can see the oriented information clues of nodes for departments and regions within the normal line of sight, such as from Node 10 external personnel can see oriented information of Node 11, and then Node 11 relative to Node 10 is visual node.
- **Non-visual Node**: external personnel cannot see the oriented information clues of nodes for departments and regions within the normal line of sight, such as

external personnel from Node 10 impossible see information of Node 9, and then Node 9 relative to Node 10 is non-visual node.

- **Interfering Node**: due to Node 3 and Node 2 door close proximity, external personnel whose destination is Node 3 approach and must judge and make the decision to choose which door of sections according to oriented information clues, so the Node 2 relative to Node 3 is interfering node.
- **Decision Node**: it is nodes that external personnel access channel routes need to determine path-finding direction, such as external personnel from Node 10 to Node 9, via Node 8, must be judged for which channel route according to oriented information clues, Node 8 is a decision node.
- **Oriented Chain Node**: it is called the oriented information link node, or oriented link node which somewhere on the channel routes (oriented chains) between two nodes set the oriented information clues in order to facilitate continuous transfer oriented information clues.

30.2.2 Classification of Oriented Information Chain and Cognitive Process Analysis of Oriented Information Clues

The channel routes (flow line) of General Hospital within and outside can be abstracted regarded as the oriented information chain, as shown in Fig. 30.1 and Fig. 30.2, external personnel go to the destination by means of the oriented information clues in channel routes. The oriented information chain is the main form which connected the oriented information of various departments and regions of the hospital. Note that all oriented information description of oriented information chain is relative.

Although the various channel routes of General Hospital within and outside are different types, mainly two kinds are straight route and curved route, so the classification of oriented information chain mainly include straight-chain and curved chain two major categories, which can be combined into different forms of oriented information chain.

(1) **Straight-chain**: Channel route between two nodes is a straight line, known as the straight-chain, such as external personnel from Node 5 to Node 6, or from Node 5 by Node 6 to Node 7.

Straight-chain include again: visual straight-chain (short chain) and non-visual straight-chain (long chain). Straight-chain includes:

- **Visual straight-chain (Short-chain)**, the straight channel routes that external personnel at the starting node, within the normal line of sight can see the oriented information clues of destination node (or the next node).
- **Non-visual straight-chain (Long-chain)**, the straight channel routes that external personnel at the starting node, within the normal line of sight cannot see the oriented information clues of destination node (or the next node).

If external personnel from starting node of straight-chain departure successfully reach the destination node, the cognitive process characteristics of oriented information clues is that in general they will distinctly search oriented information clues of the destination node in the physical space of the starting node within the normal line of sight.

- **Visual straight-chain or short-chain**, as shown in Fig. 30.3, from Node 5 to Node 6, in scope of physical space at the starting node of the straight-chain external personnel can search and obtain oriented information clues to destination node within the normal line-of-sight, and would be formed characterization schema of oriented information clues to destination node. The scenarios features of straight-chain will generally result in backup avoidance effect, and therefore straight-chain has external personnel remained the default value of this characterization schema for oriented information clues until they successfully reach the destination node, path-finding speed quick, and efficiency high.

Fig. 30.3 Visual straight-chain or short-chain

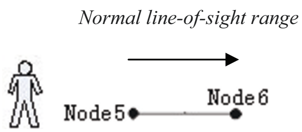
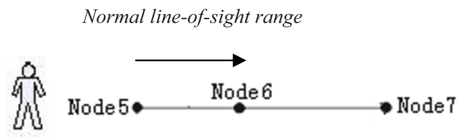


Fig. 30.4 Non-visual straight-chain



- **Non-visual straight-chain or long-chain**, as shown in Fig. 30.4, from Node 5 to Node 7, because Node 7 far away (such as more than 50 meters), in scope of physical space at the starting node of the straight-chain external personnel cannot search and obtain oriented information clues to destination node within the normal line-of-sight, which means information clues broken down, then they will be taken the difference reduction principle at the starting node, try to move forward and constantly search for oriented information clues to destination node within the normal line-of-sight. However, this process reduced difference (hill climbing operator) can neither guarantee that they can search and obtain oriented information clues to destination node, nor guarantee to successfully reach the destination node. Furthermore, in this path-finding process external personnel will continue to use means-ends analysis attempt to create a new way to obtain oriented information clues to destination node, such as trying to find and acquire any internal and external personnel within straight-chain channel route, until reach the destination node. This path-finding process cause path-finding hesitated for external personnel, that path-finding lost, and thus greatly reduce the speed and efficiency of path-finding.

(2) **Curved-chain**: As shown in Fig. 30.5, Fig. 30.6, the channel route between the two nodes is bending (turn), called a curved-chain, the curved-chain may be regarded as a combination of straight-chains. Such as external personnel walk from the starting node Node 4, via Node 5 to Node 6, or from the starting node Node 3, via Node 4, Node 5 and Node 6, to Node 7. The scenario characteristics of curved-chain generally means between two nodes is not visible.

Fig. 30.5 The curved-chain of starting node visual

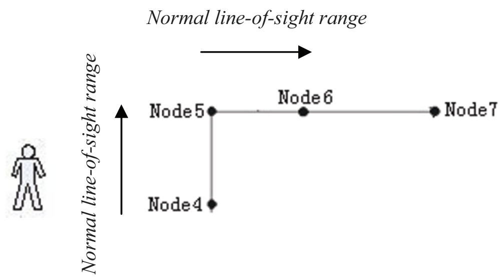
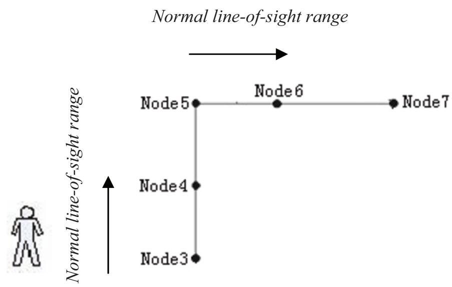


Fig. 30.6 The curved-chain of starting node non-visual



While external personnel from the starting node of the curved chain departure successfully reach the destination node, the cognitive processes characteristics of oriented information clues similarly lead they generally instinct will search oriented information clues to destination node in the physical space of the starting node within the normal line of sight. The cognitive processes characteristics of oriented information clues at straight-chain portion of the curved chain are the same as straight-chain.

As shown in Fig. 30.5, if in scope of physical space at the starting node of the curved-chain, such as Node 4, external personnel can search and obtain oriented information clues to destination node within the normal line-of-sight, and would be formed characterization schema of oriented information clues to destination node. The default value of this characterization schema generally maintained until the bend (Node 5), the decision node. Due to the scenarios features in bend generally lead the effect of the backup avoidance failure; the external personnel will search, compare and check whether the default value of characterization schema is consistent.

- If consistent, such as Node 6 of the destination node and within normal line-of-sight, they will continue to find path according to the default value of the characterization schema until successfully reach the destination node, path-finding speed quick, and efficiency high.
- If inconsistent, meaning information clues broken down, such as Node 7 of the destination node outside the normal line-of-sight, they take the difference reduction and use means-ends analysis attempt to obtain oriented information clues to destination node, until reach the destination node. This path-finding process causes path-finding hesitation for external personnel, that path-finding lost, and thus reduce the speed and efficiency of path-finding.

As shown in Fig. 30.6, if in scope of physical space at the starting node of the curved-chain, such as Node 3, external personnel cannot search and obtain oriented information clues to destination node within the normal line-of-sight, which means information clues broken down, like the cognitive processes of non-visual straight-chain or long-chain, they will take the principle of difference reduction and try moving forward until the bend (such as Node 5), a decision node. This path-finding process has caused path-finding hesitated and path-finding lost for external personnel. And external personnel in bend (Node 5) will continue to search the oriented information clues to destination node.

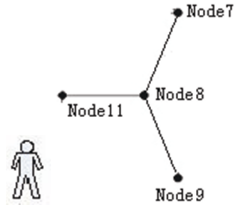
- If in the bend (Node 5), able to search and obtain oriented information clues to destination node within the normal line-of-sight, such as Node 6, external personnel will be formed characterization schema of oriented information clues to destination node and have remained the default value for the characterization schema until successfully reach the destination node.
- If in the bend (Node 5), unable to search and obtain oriented information clues to destination node outside the normal line-of-sight, such as Node 7, information clues broken down. This path-finding process causes serious path-finding hesitation for external personnel as well as path-finding lost, thereby greatly reduce the speed and efficiency of path-finding, which is the worst situation.

Therefore, the key to the cognitive processes of oriented information clues for curved-chain is whether in the decision node of the bend external personnel can search and obtain oriented information clues to destination node.

(3) **Branch-chain**: As shown in Fig. 30.7, it is the branch channel route, two branch-chains and multi-branch-chains, which are the combination form of curved-chains, such as from Node 11 to Node 9, or Node 7, via Node 8 among them. And the Node 11, Node 8, Node 9 and Node 7 constitute a two branch chain, then Node 8

is a branch node which is also an important decision node, at which external personnel must judge which channel route to go according to certain oriented information clues. The cognitive processe characteristics of oriented information clues for

Fig. 30.7 Branch-chain

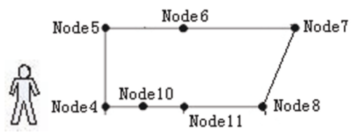


branch-chain like the same as the straight-chain and curved-chain. Just for branch-chain, branch node, such as Node 8 is the most critical decision-making information node, especially for multi-branch chain.

- If external personnel at the branch node can search, compare and check oriented information clues to the destination node, they will always keep the default value of this characterization schema until successfully reach the destination node, path-finding speed quick, and efficiency high.
- If external personnel at the branch node cannot search, compare and check oriented information clues to the destination node, information clues broken down, they will try to moving forward any direction of branch channel routes, and will take the principle of difference reduction and use means-ends analysis attempt to obtain oriented information clues to the destination node. This path-finding process will be faced with the possibility of return, therefore, this path-finding process can cause serious path-finding hesitation for external personnel as well as path-finding lost, thus greatly reduce the speed and efficiency of path-finding.

(4) **Confluent-chain**: As shown in Fig. 30.8, that is channel route which from a starting node, two or more branch channel routes converge a destination node, and it is also a combination form of the curved-chain. Such as from Node 4 to Node 7, external personnel can select through Node 5, Node 6 reach Node 7 or also choose through Node 10, Node 11, and Node 8, reach Node 7. Node 4 is the starting confluent-node; Node 7 is the destination confluent-node. The cognitive processes characteristics of oriented information clues for confluent-chain like the same as the straight-chain and curved-chain.

Fig. 30.8 Confluent-chain



To confluent-chain, the starting confluent-node, such as Node 4 is an important decision node, at which external personnel must judge which channel route to go according to certain oriented information clues. Similarly there are both situations which can and cannot search and obtain oriented information clues to the destination node.

The starting confluent-node is the key for path-finding process of confluent-chain, how to search and obtain oriented information clues to the destination node, how much oriented information clues of the corresponding channel routes and how to determine choose which channel route could greatly affect the speed and efficiency of the path-finding to successfully reach the destination node, otherwise it will appear path-finding lost.

30.2.3 Setting Principles of Oriented Information for Identity-oriented System

Cognitive psychology thought that a path-finding solution is a search process in problem space which is determined by this operator of oriented information clues. First, whether the oriented information clues to destination node in the physical space of the starting node? Second, how much oriented information clues to destination node to be searched at the same time? And then decide how to choose the oriented information clues to destination node? How to find out the channel routes to the destination node?

- **Non whole-chain**: channel routes that external personnel can not be continuous search oriented information clues to destination node within the normal line-of-sight, called incomplete information chain or non whole-chain. Because search no oriented information clues(operator) to destination node, they can not find the path to goal. Shown in Fig. 30.4, from Node5 to Node7, due to the long distance between the two nodes the external personnel cannot see oriented information cluesof Node7, this will cause path-finding hesitation for external personnel as well as path-finding lost, thereby reduce the speed and efficiency of path-finding.
- **Whole-chain**: channel routes that external personnel can be observed continuously the next oriented information clues to destination node within the normal line-of-sight, or set up continuous oriented information clues of channel routes, to form a complete oriented chain nodes, called complete information chain, or whole-chain.

In this way, the external personnel first formed the characterization schema of oriented information clues to destination node at the starting node, because within the normal line-of-sight via each node they can search for oriented information clues to destination node, just at each node compare and match with the default values of original characterization schema are the same, to avoid the effects of backup avoidance failure, so external personne have remained the default value of this characterization schema until successfully reach the destination node, path-finding fast, and efficiency high. Shown in Fig. 30.5, from Node 4 to Node 5 due to the short distance between the two nodes external personnel can see oriented information of Node 5, so can walk to Node 4 without need for other oriented information. Or from Node 5 to Node 7, if from Node 5 and Node 6 nodes have be set oriented information clues to Node 7, as well.

Theoretically the oriented information set principle of oriented information chain is to try transfer the Non whole-chain to the Whole-chain.

Specifically, it is that at the channel routes from any starting node, should be set in successive oriented information clues to destination node within the normal line of sight, let the external personnel form characterization schema of oriented information clues to destination node until the destination node. If meeting with these decision node of the bending, branching and merging as well as long-chain, in order to avoid the effect of backup avoidance failure, should be in these nodes set oriented information clues corresponding to the destination node to let external personnel can search, compare, check and select, otherwise will feel path-finding lost.

30.3 Results

This paper, on the basis of existing research, using the principles of cognitive psychology, theoretically defines and analyzes the information features in Identity-oriented System of three A-level hospitals from the perspective of external personnel, and build the spatial information node and the information structure model of channel routes. Above analysis of the cognitive processes for path-finding lost and failure mechanisms explores the effectiveness of Identity-oriented System and the efficiency of information transfer for General Hospitals, obtained science design principles and setting method of Identity-oriented System for General Hospitals, therefore, there is the great significance of theoretical and applied aspects.

30.4 Limitation and Discussion

This article focuses on path-finding cognitive problems of the external personnel, as well as the new General Hospital's internal personnel in oriented signage system of General Hospital environment, no studies path-finding cognitive problems which internal and external personnel have been familiar with General Hospital environment. Also notice all oriented information descriptions of oriented information chain are relative, and this paper is lack of study for the relativity and complexity. Due to length limitation this paper does not discuss the oriented information carrier, signage and Kanban of Identity-oriented System for General Hospital and the detail as shown [14].

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Chapter 31
Operation Monitoring System Model of Small and Medium-sized Enterprises in Sichuan Province in 2012

Rui Wang, Yue Shen, Huijun Lin and Gongzong Yu

Abstract It is a long-term strategic task for Sichuan province to vigorously develop small and medium enterprises. This paper uses the monitoring data of small and medium enterprises in Sichuan province in 2012 to establish a system model consisted of two models by employing support vector machine and group method of data handling. Research results show that the pre-warning level of the operating status of each month which obtained from the system model is almost the same with the official information, so we can use this model to effective early warn the operating status about small and medium-sized enterprises in Sichuan province. Meanwhile, the system model can find key factors which influence and restrict the healthy development of small and medium-sized enterprises in Sichuan province; there are some positive effects to deal with the survival and development crisis which small and medium-sized enterprises in Sichuan province are going through and to develop accurate support policies.

Keywords Small and medium-sized enterprises · Operation monitoring · Pre-warning · Influence factors · System model · Data mining

31.1 Introduction

Small and medium-sized enterprises (SMEs) are the foundation strength of promoting national economic development, structuring market economy main body and promoting social stability. Especially in the current, SMEs are playing an increasingly important role on ensuring appropriate growth of the national economy, reliev-

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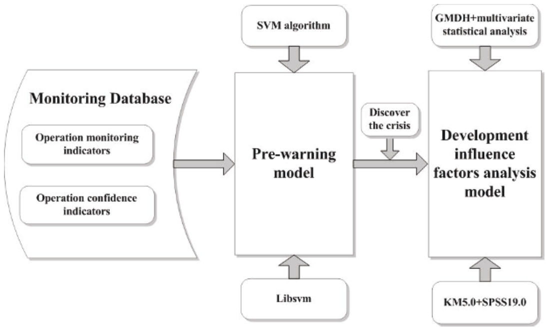
ing employment pressure, invigorating the country through science and technology and optimizing the economic structure and so on.

SMEs in China encountered unprecedented difficulties in 2011. Under the international finance crisis shadow, the international market terminal fluctuated wildly; the domestic economy declined generally, GDP growth rate fell below 8% for the first time. Under such circumstances, support policies about SMEs were continually put in place by Chinese government, but the effect is not ideal. Therefore, due to provide data for developing more accurate support policies, China first launched SMEs operation monitoring work in 2012. There are two main specific purposes: one is to timely make pre-warning identification about the health status of operation of SMEs; the other one is to develop "targeted" support policies which aim at alarm level to reduce the alarm level and crisis damage.

The achievements of the two goals depend on the research about data mining model. At present, this kind of research is still in its infancy in China and it urges to promote. So, this paper uses the monitoring data of SMEs in 2012 to establish a system model consisted of two models by employing support vector machine and group method of data handling. The system model is shown in Fig. 31.1.

Fig. 31.1 The organization chart of system model



Among them, the first model is the operation situation pre-warning model of SMEs, we use it to identify the operating status about SMEs, and to distinguish whether suffer a crisis and the crisis warning level. The second model is the development influence factors analysis model, we use it to find key factors which influence and restrict the healthy development of SMEs when there is a crisis in SMEs operation, then to service for policy making. To study the effectiveness of the system model, the paper carried on the empirical analysis which aimed at operation monitoring data about SMEs in Sichuan province in 2012. The names of operation monitoring data are shown in Table 31.1.

Table 31.1 The names of operation monitoring data

X1	Deficit	X2	Deficit area	X3	Total industrial output value
X4	Export delivery value	X5	Power consumption	X6	Production capacity (equipment) utilization rate
X7	Operating receipt	X8	Operating cost	X9	Final loan balance
X10	Financial expenses	X11	Accounts receivable	X12	Finished goods
X13	Total profit	X14	Tax payable	X15	Employees per enterprise
Y1	Production and business operation conditions (actually this month)	Y2	Production and business operation conditions (forecast next month)	Y3	General business conditions in the industry to which companies belong (actually this month)
Y4	General business conditions in the industry to which companies belong (forecast next month)	Y5	Enterprise labor shortages situations	Y6	Domestic market order situations
Y7	Product export order situations	Y8	Whether corporate cash flow is sufficient	Y9	Whether financing needs of enterprises are satisfied
Y10	Recent raw material purchase price change situations	Y11	Recent energy purchase price change situations	Y12	Whether raw material needs are satisfied
Y13	The influence of rising labor costs	Y14	Management personnel configuration situations	Y15	Professional and technical personnel situations
Y16	Loan redemption situations	Y17	Whether the needs of land for production are satisfied	Y18	Support policy implementation situations

31.2 The Operation Situation Pre-warning Model of SMEs

The original SVM algorithm was invented by Vladimir N. Vapnik and the current standard incarnation (soft margin) was proposed by Vapnik and Corinna Cortes in 1995. The quality of generalization and ease of training of SVM is far beyond the capacities of these more traditional methods. SVM performs well on data sets that have many attributes, even if there are very few cases on which to train the model. There is no upper limit on the number of attributes; the only constraints are those imposed by hardware. Traditional neural nets do not perform well under these circumstances. From the perspective of classification, the paper establishes SMEs pre-warning model by SVM approach to monitor the operation situations of SMEs.

31.2.1 Pre-warning Model

Now the methods of enterprise crisis pre-warning used and researched widely include Z-score [1], multivariate discriminate analysis [2], logistic regression [3], principal component analysis [4], fuzzy comprehensive evaluation [5] and artificial neural network [6], etc. SVM is a hotspot in machine learning. Studies have reported that SVM was comparable to and even outperformed other classifiers including ANN, MDA, and logistic in terms of pre-warning performance.

(1) SVM model

The binary classification SVM is the base of SVM, which divides all the samples into two classes by creating an optimal hyperplane as a decision surface and the margin of two classes is maximized. Suppose that $D = \{x_i, y_i | i = 1, 2, \cdots, n\}$ $(x \in R^p, y \in R^q)$ can be divided correctly by hyperplane $H: w \bullet x + b = 0$, and the margin is maximized. If the training data (x_i, y_i) $(i = 1, 2, \cdots, n)$ are linearly separable, its construction of optimal separating hyperplane can be expressed in the following convex quadratic programming Equation (31.1):

$$\begin{aligned} &\min_{w,b} \frac{1}{2} ||W|| = \min_{w,b} \frac{1}{2} W^T W, \\ &\text{s.t. } y_i[(w \bullet x_i) + b] - 1 \geq 1, \quad (i = 1, 2, \cdots, n). \end{aligned} \tag{31.1}$$

By introducing Lagrange multipliers α, its dual form is Equation (31.2):

$$\begin{aligned} &\max_{\alpha} \sum_{i=1}^{n} \alpha_i \alpha_j y_i y_j (x_i x_j), \\ &\text{s.t. } \sum_{i=1}^{n} y_i \alpha_i = 0, \quad (\alpha_i > 0;\ i = 1, 2, \cdots, n). \end{aligned} \tag{31.2}$$

The decision function is Equation (31.3):

$$f(x) = \text{sgn}\left\{ \sum_{i=1}^{n} \alpha_i y_i (x \bullet x_i) + b \right\}. \tag{31.3}$$

Among them, $\text{sgn}(\bullet)$ is symbolic function, and b is classification threshold.Dealing with nonlinear problem, it can create nonlinear classifiers by applying the kernel trick to maximum-margin hyperplanes. The resulting algorithm is formally similar, except that every dot product is replaced by a nonlinear kernel function $k(x, x_i)$. The optimization problem becomes Equation (31.4):

$$\begin{aligned} &\max_{\alpha} \sum_{i=1}^{n} \alpha_i - \frac{1}{2} \sum_{i,j=1}^{n} \alpha_i \alpha_j y_i y_j k(x_i, x_j), \\ &\text{s.t. } \sum_{i=1}^{n} y_i \alpha_i = 0, \quad (0 \leq \alpha_i \leq C;\ i = 1, 2, \cdots, n). \end{aligned} \tag{31.4}$$

The corresponding decision function is Equation (31.5):

$$f(x) = \mathrm{sgn}\left\{ \sum_{i=1}^{n} \alpha_i y_i k(x, x_i) + b \right\}. \tag{31.5}$$

(2) Implementation steps

- Selecting index. We choose six indicators from operation monitoring indicators which best reflect enterprises operation condition to analyze. They are deficit, deficit area, export delivery value, operating receipt, operating cost and total profit. And we choose seven indicators from confidence indicators to analyze. They are production and business operation conditions (actually this month), production and business operation conditions (forecast next month), general business conditions in the industry to which companies belong (actually this month), general business conditions in the industry to which companies belong (forecast next month), domestic market order situations, recent raw material purchase price change situations and the influence of rising labor costs.
- Processing data. Deficit, deficit area and operating cost are reverse indicators, so we should translate the reverse indicators into positive indicators through the equation $x_{ij}^{'} = \max_{1 \le i \le m} x_{ij} - x_{ij}$. For convenience, we record $x_{ij}^{'}$ as x_{ij}. And using normalization method that column sum is equal to 1 to standardize as Equation (31.6):

$$y_{ij} = \frac{x_{ij}}{\sum_{i=1}^{m} x_{ij}}, \; (1 \le i \le m, \; 1 \le j \le n). \tag{31.6}$$

  Finally, we get the comprehensive evaluation value of each month by using arithmetic average method.
- Dividing alarm level. Using clustering analysis method in SPSS 19.0 to classify comprehensive evaluation value, and divide alarm level of each month.
- Establishing pre-warning model. Dividing 12 months into two parts: one part is training samples, the other one is testing samples. We choose RBF function as kernel function by trial and error. Afterwards, using the training set to train the SVM model, and then use the model to predict the classification labels of the testing set. Eventually, we can get the accuracy of the model.

31.2.2 Pre-warning Model of Overall Operation Situation

- Data processing as shown in Table 31.2
- Dividing alarm level as shown in Table 31.3
- Pre-warning model of SVM

The running results of SVM model shows that testing samples have no misclassification; the accuracy rate of pre-warning is 100%.

Table 31.2 Standardized data of operation monitoring indicators and confidence indicators

Index	Jan.	Feb.	Mar.	Apr.	May.	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.
X1	0.07	0.01	0.10	0.02	0.14	0.13	0.10	0.00	0.01	0.01	0.18	0.23
X2	0.05	0.00	0.01	0.00	0.08	0.10	0.08	0.08	0.07	0.09	0.18	0.26
X4	0.11	0.08	0.23	0.22	−0.07	0.35	−0.07	0.31	0.15	0.02	−0.30	−0.02
X7	0.12	0.11	0.10	0.11	0.08	0.07	0.08	0.13	0.05	0.12	0.05	−0.03
X8	0.03	0.03	0.05	0.04	0.07	0.11	0.10	0.00	0.14	0.01	0.16	0.26
X13	0.12	0.09	0.09	0.09	0.13	0.08	0.01	0.13	0.04	0.14	0.06	0.02
Y1	0.09	0.09	0.09	0.09	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08
Y2	0.09	0.09	0.09	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08
Y3	0.09	0.09	0.09	0.09	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08
Y4	0.09	0.09	0.09	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08
Y6	0.09	0.09	0.09	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08
Y10	0.07	0.07	0.07	0.08	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09
Y13	0.08	0.08	0.08	0.08	0.08	0.08	0.09	0.09	0.09	0.09	0.09	0.09

Table 31.3 Alarm level division based on the comprehensive evaluation value

Index	Jan.	Feb.	Mar.	Apr.	May.	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.
Comprehensive evaluation value	1.087	0.907	1.172	1.075	1.014	1.424	0.881	1.224	1.032	0.969	0.908	1.307
Alarm level	2	3	1	2	2	1	3	1	2	3	3	1

Notations: 1 means no alarm, 2 means light alarm and 3 means serious alarm.

31.2.3 Results Analysis

Pre-warning results about SMEs which released by the government departments in Sichuan province are shown below. March, June, August and December have no alarm; January, February, April, May and September have light alarm; July, October and November have serious alarm. They accord with the results which obtained by SVM pre-warning model except February. It implies that the model has strong learning ability and generalization ability, and has good pre-warning effects.

If the pre-warning result about a month is no alarm, it means that SMEs are in the stable period of normal development at this time. However, its future movements may fall or rise in the short term, so policy makers should pay close attention to the occurrence of factors which may lead to SMEs imbalance.

If the pre-warning result about a month is light alarm, it means that SMEs development have tended to decline, its future in the short term has the possibility to decline or stabilize, so government should pay close attention to the future trend of pre-warning, and take forceful measures appropriately to boost the growth of enterprises.

If the pre-warning result about a month is serious alarm, it means that SMEs development is in the state of atrophy and operating conditions are deteriorating. This moment government should look for the factors which causing deterioration of SMEs development and take effective measures to stimulate the vitality of market.

The pre-warning results of multiple months are light alarm or series alarm, it implies that the operation of SMEs in Sichuan province have some crises.

31.3 The Development Influence Factors Analysis Model of SMEs

According to the result of pre-warning, there are some problems about the operation of SMEs. Therefore, we need to find key factors which influence and restrict the healthy development of SMEs, so that government can develop "targeted" support policies. The paper uses combination model which is formed by GMDH and econometrics to discovery key factors.

31.3.1 Model Building

(1) Combination model

Data mining is application-oriented that aims at finding patterns from data to support models for decision [7]. Different from data mining, self-organization data mining doesn't require much on knowledge level and practical experience of its researchers and users. Much work has been undertaken to research about self-organization data mining by Ivakhnenko [8] and AMuller [9]. And the main modeling technology of elf-organization data mining is GMDH [10]. GMDH is a kind of intelligent modeling technologies based on inductive method which is widely used in recent years. It begins from initial model (function) sets which are composed by reference function, and produces thousands of intermediate candidate models according to certain rules, then, carries out multi-layer network selection through the selected standard until the optimal complexity model is found. GMDH can create a high-order polynomial relationship between the independent variable and dependent variable and obtain a polynomial model which has explanatory ability for dependent variable. The required software is KnowledgeMiner5.0 (KM5.0). This report uses the simplest model form, which is multiple linear modeling. The combination model is shown in the following Fig. 31.2.

(2) Implementation steps

The fitting accuracy of GMDH modeling method is much higher than multivariate statistical modeling, but its software KM5.0 does not provide a statistical test. Therefore, this report also uses the theoretical analysis modeling approach based on deductive method–multivariate statistical analysis. To compensate for the inadequacy of KM software, the report uses software SPSS19.0 on variable statistical correlation analysis, stepwise regression modeling and model statistical tests, thus forms the "KM + SPSS" comprehensive technical route. The specific steps are as follows:

Step 1. Data processing. Processing only production operation monitoring indica-

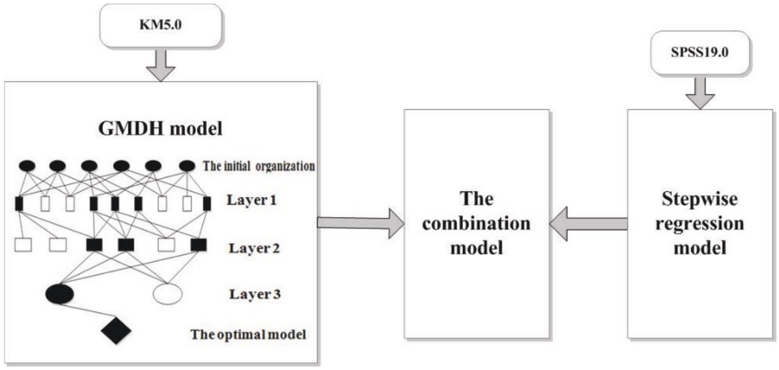


Fig. 31.2 The organization chart of development influence factors analysis model

tors data, the confidence indicators data don't do processing. Considering the companies which fill in the information are different every month, so the percentage indicators which include deficit area and production capacity (equipment) utilization rate use increase or decrease in value during the month. The formula is increase or decrease in value during the month = value of this month − value of last month. The remaining indicators use average per enterprise value in the current month. The formula is average per enterprise value in the current month = (accumulative total value during the month − accumulative total value in last month)/the number of companies which fill in the information during the month + average per enterprise value in the current month in last month.
Step 2. Input all data in KM5.0.
Step 3. Determining the independent variable and dependent variable of the model in KM5.0.
Step 4. Setting up input output model, viewing the results and selecting the model which has economic significance.
Step 5. Statistical testing the previous model which has economic significance in SPSS 19.0. If it passes inspection, then, keep this model, and go to Step 7. Otherwise, go to Step 6.
Step 6. Carrying out correlation analysis and collinearity inspection on the independent variable of the model in SPSS 19.0. The first is to adjust the independent variable set of the model and return to Step 3. The second is to statistical modeling to model by stepwise regression method and return to Step 5.
Step 7. Integrating the results of KM modeling and SPSS modeling and got the combination model.

31.3.2 Influence Factors Analysis Models Based on Operation Monitoring Data

The paper chooses four indicators from operation monitoring indicators as dependent variable to analyze the influence factors about the overall situation of SMEs. They are total profit, operating receipt, operating cost and deficit, and these four indicators refer to per enterprise average situation.

(1) The influence factors model of total profit

Fitting total profit of enterprise monitoring indicators by using KnowledgeMiner5.0 and screening model with economic significance, the result is:

$$X13 = 0.000000 - 0.159033X2 + 0.870249X7.$$

The model passes statistical tests in SPSS19.0. Inspection results are as follows:

R is 0.999, R Square is 0.998, and Adjusted R Square is 0.997, it implies fitting degree is high. F value is 1821.590, sig. is 0.000, it is less than a given significance level 0.05; and sig. of t value of X2 and X7 are 0.000, they are less than a given significance level 0.05. It shows that the model has significant statistical significance. VIF value of X2 and X7 are less than 10, it means that it doesn't have collinearity among variables.

(2) The influence factors model of operating receipt

Fitting operating receipt of enterprise monitoring indicators by using KnowledgeMiner5.0 and screening model with economic significance, the result is:

$$X7 = 0.000000 + 1.000879X3 - 0.016862X15.$$

The model passes statistical tests in SPSS19.0. Inspection results are as follows:

R is 1.000, R Square is 1.000, and Adjusted R Square is 0.999, it implies fitting degree is very high. Sig. of F value is 0.000, it is less than a given significance level 0.05; and sig. of t value of X3 and X15 are 0.000 and 0.040, they are less than a given significance level 0.05. It shows that the model has significant statistical significance. VIF value of X3 and X15 are less than 10, it means that it doesn't have collinearity among variables.

(3) The influence factors model of operating cost

Fitting operating cost of enterprise monitoring indicators by using KnowledgeMiner5.0 and screening model with economic significance, the result is:

$$X8 = 0.000000 + 0.999265X7 + 0.009682X15.$$

The model passes statistical tests in SPSS19.0. Inspection results are as follows:

R is 1.000, R Square is 1.000, and Adjusted R Square is 1.000, it implies fitting degree is very high. Sig. of F value is 0.000, it is less than a given significance level 0.05; and sig. of t value of X7 and X15 are 0.000 and 0.017, they are less than a given significance level 0.05. It shows that the model has significant statistical significance. VIF value of X7 and X15 are less than 10, it means that it doesn't have

collinearity among variables.
(4) The influence factors model of deficit

Fitting deficit of enterprise monitoring indicators by using KnowledgeMiner5.0 and screening model with economic significance, the result is:

$$X1 = 0.000000 + 0.984994X14.$$

The model passes statistical tests in SPSS19.0. Inspection results are as follows:

R is 0.985, R Square is 0.970, and Adjusted R Square is 0.967, it implies fitting degree is very high. Sig. of F value is 0.000, it is less than a given significance level 0.05; and sig. of t value of X14 is 0.000, it is less than a given significance level 0.05. It shows that the model has significant statistical significance. VIF value of X14 are less than 10; it means that it doesn't have collinearity among variables.

31.3.3 Influence Factors Analysis Models based on Confidence Indicators

The paper chooses two indicators from confidence indicators as dependent variable to analyze the influence factors about the overall situation of SMEs. They are production and business operation conditions (actually this month) and production and business operation conditions (forecast next month)
(1) The influence factors model of production and business operation conditions (actually this month)

Fitting production and business operation conditions (actually this month) of confidence indicators by using Knowledge Miner 5.0 and screening model with economic significance, the result is:

$$Y1 = 0.000000 - 0.060016Y17 + 0.039389Y16 + 0.912613Y3 + 0.085284Y7.$$

The model passes statistical tests in SPSS19.0. Inspection results are as follows:

R is 0.998, R Square is 0.996, and Adjusted R Square is 0.993, it implies fitting degree is very high. Sig. of F value is 0.000, it is less than a given significance level 0.05; and sig. of t value of Y3, Y7, Y17 and Y16 are 0.000, 0.021, 0.04, and 0.017, they are less than a given significance level 0.05. It shows that the model has significant statistical significance. VIF value of Y3, Y7, Y17 and Y16 are less than 10, it means that it doesn't have collinearity among variables.
(2) The influence factors model of production and business operation conditions (forecast next month)

Fitting production and business operation conditions (forecast next month) of confidence indicators by using KnowledgeMiner5.0 and screening model with economic significance, the result is:

$$Y2 = 0.000000 + 0.977560Y4 + 0.062621Y12.$$

The model passes statistical tests in SPSS19.0. Inspection results are as follows:

R is 0.994, R Square is 0.988, and Adjusted R Square is 0.986, it implies fitting degree is very high. Sig. of F value is 0.000, it is less than a given significance level 0.05; and sig. of t value of Y4 and Y12 is 0.000 and 0.025, they are less than a given significance level 0.05. It shows that the model has significant statistical significance. VIF value of Y4 and Y12 are less than 10, it means that it doesn't have collinearity among variables.

31.3.4 Policy Recommendations

Total profit of SMEs in Sichuan province associated with deficit area and operating cost. Under the condition of the other factors unchanged, the lower the deficit area, the greater the profits; and the higher operating costs, the higher profits. It implies that the production scale of SMEs has not yet reached the diminishing marginal returns area, so SMEs can enlarge the scale of production to increase corporate profits.

Operating receipt is positively correlated with the total industrial output value and negatively correlated with employees per enterprise. Operating cost is positively correlated with operating receipt and employees per enterprise. Therefore, the dynamics of improving labor productivity should be stronger. And SMEs should increase efficiency by downsizing staff. Moreover, it is imminent to shift from labor-intensive to capital and technology intensive, and they should expand the scale of production moderately.

Deficit is positively correlated with tax payable. It shows that the dynamics of reducing tax and burden for SMEs should be stronger.

Production and business operation conditions (actually this month) is positively correlated with general business conditions in the industry to which companies belong (actually this month), products export order conditions and loan repayment conditions, and negatively correlated with whether the needs of land for production are satisfied. It implies that enterprise management state is influenced by industry trend. Besides, government should give guidance to SMEs to vigorously expand the market and to construct the reasonable structure of debt.

Production and business operation conditions (forecast next month) is positively correlated with general business conditions in the industry to which companies belong (actually this month) and whether raw material needs are satisfied. Government should guide SMEs to take measures such as adjust the product structure and the brand effect to digest the pressure caused by raw material price increases; then, cancelling the products which consume a lot of raw materials and have low gross profit margin and expanding some products which are cheap and need less consumption of raw materials.

31.4 Conclusion

This paper uses the monitoring data of small and medium enterprises in Sichuan province in 2012 to establish a system model consisted of two models: one is the operation situation pre-warning model of SMEs, and the other one is the development influence factors analysis model. Research results show that the pre-warning level of the operating status of each month which obtained from the first model is almost the same with the official information, so we can use this model to effective early warn the operating status about small and medium-sized enterprises in Sichuan province. Meanwhile, the second model can find key factors which influence and restrict the healthy development of SMEs in Sichuan province; there are some positive effects to deal with the survival and development crisis which SMEs in Sichuan province are going through and to develop accurate support policies.

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Chapter 32
Optimal IPO Timing: Based on Growth Changes of Cash Flow

Jun Wang and Kun Li

Abstract In this paper, we use model and analysis to study the IPO optimal timing based on a real option framework. We assume IPO will change the growth mode of cash flow and relax the original assumption in previous mode that the company's growth rate of cash flow will maintain constant after IPO. Analysis showed that the greater the growth potential of the listing companies, the earlier they got listed; when listing costs is larger, the entrepreneurs will obviously delay IPO; The more optimistic of the company, the sooner the company go public; the more optimistic the corporate decision makers look upon the company, the later the IPO take place; the higher uncertainty of future earnings, the later company will be list. The concluding provided a good reference for the regulator of capital market who can makes effective safeguard for stability of the market and reasonable listing standards for listed companies, and for entrepreneurs to form the correct IPO concept as well as make reasonable IPO decision.

Keywords Optimal IPO timing · Real option · Cash flow increase

32.1 Introduction

As the launch of GEM, round and round of rich effects begin to appear. Driven by this, more and more entrepreneurs want to realize their wealth dreams by following their antecessor. Many of them tried every means to go public whenever have a chance, which reflected the blind decision-making on IPO timing. On the one hand, It may cause a large number of immature and Low-quality companies entering into capital markets and ultimately break the base of capital market which rely on, on the other hand, companies may not maximize their overall utility, and bear of unnecessary high costs once they have been punished (such as being punished because

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of the accounting data fraud, delisting for performance declining shortly after the listing etc.). So what factors influence the decision-making of the company listed? how to achieve the maximization of their own utility by effectively timing the market? So far, domestic and foreign research on market opportunity can be divided into two categories: one is based on life-cycle theory. which treat IPO as a certain stage as company grow and a choice need to be experienced [1–3]. Another one is based on external timing. The main point of such studies is that company can take advantage of the non-validity of the market, issuing shares when share price is overvalued [4–8]. However, from their study, most of these analyzes are based on static analysis, and isolat internal and external factors of this problem. In fact, although the internal maturity and external maturity are largely influenced by different factors, and reflecting different aspects of corporate decision-making. It is undeniable that these two factors still have a certain connection which affects each other. The company's own endogenous factors constitute the company's internal maturity structure, directly determining the company's ability to secure public financing eligibility. External maturity formed by companies' external factors affect the companies actually act. As for listing decisions of the company's internal and external maturity play different role of themselves, internal factors are determinants of external which work through internal factors. Therefore, the final IPO timing issues should integrated the interaction of internal and external maturity. In recent years there have been some research starting to concern both [9–12]. In order to further study this issue, Based on the previous research, we build a dynamic timing model of investment decisions. The model contains both internal maturity, and external maturity. Because it is very necessary to reflect the impact of both on the timing issue and traditional net present value analysis method can not measure the value of the market opportunity option which inherent in the uncertainty process of subsequent market changes and leads to deviations in decision-making. Learning form Draho's model [12], using idea of real options to solve this problem, we have done some further improvement.

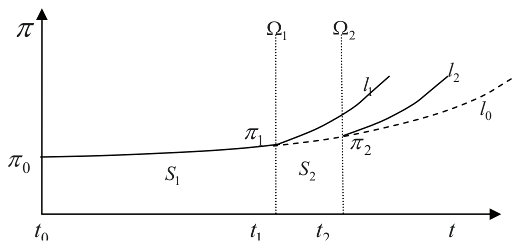
32.2 Real Option Model of IPO Timing

Like most other corporate decision-making, IPO decision-making is also an economic decision-making. So the basic analytical framework of this issue is based on the income and cost. Traditional investment decision-making theories and frameworks can also be used to analyze. But IPO decision-making also has its unique, which makes the traditional investment decision theory encounter some obvious shortcomings. Especially for projects with long span of time, big amount of investment, high uncertainty, and the net present value method is not the best one, which always underestimates the value of the project and also led to a serious shortage of expected project investment.

Based on the shortcoming of traditional DCF analysis, real options theory came into being. The concept of real options was originally proposed by Stewart [13]. It applied modern financial option pricing theory to real investment decision-making, and opened up a new path for the optimal IPO timing research. IPO can be regarded as an investment behavior: exchanging project investment funds with equity. Here, the value of the IPO opportunities can be seen as cash flow coupled with a set of options. In addition to the analysis of the company's net cash flow which exists in the earlier net present value method, we should give a value for the IPO option. IPO qualified company also holds an option. When entrepreneurs decided to go public, it means they exercise this option. As a rational decision-makers, only when benefits of exercise the options are greater than the gains to hold options, then go public.

In the model of Draho, The main hypotheses are that company value is determined by the cash flow of the company, the company use dividends to reward shareholders with all earnings, the shares held by now will gain from rights of future dividend distribution. In his study of IPO Timing It is important to consider the income into two parts, one part is Cash flow gains for Shares held until the IPO, the other part is IPO gains for selling shares. The rational entrepreneur will strive to maximize the overall revenue of two parts. Also in Draho's model, a key assumption is that IPO does not affect the natural growth of the cash flow. But in reality, Both listing and financing, will bring a lot of money for more large-scale expansion of reproduction which may also be used to create a new, improved technology R&D center, improve the marketing network, supplement corporate operation cash, implement mergers and acquisitions, and other acts, which will greatly promote the further development of the company and generate more cash flow. Therefore, doing some modified to this assumption is important because: one hand, the purpose of company listed is the pursuit of a higher growth rate and a larger market share, such a revision is realistic. On the one hand, from the internal terms of maturity, there are also two aspects, one is the company's profitability which usually can be described by using traditional financial indicators, and on the other hand the growth potential of the company. Here, the existing profitability can be indicated by the company's existing cash flow growth ratio, the growth potential performance can be indicated by the cash flow growth ratio after the IPO. So such amendment can be used to distinguish the impact of these two factors on IPO timing. Here, this article assumes that companies will have a greater cash flow growth rate after IPO, as shown in Fig. 32.1.

Fig. 32.1 Cash flow changes of IPO timing



In Fig. 32.1, l_0 is cash flow, under normal circumstances, l_1 and l_2 are cash flow when IPO at t_1 or t_2, the growth rate was significantly greater than l_0. Therefore consider the time value; we proposed the main consideration of IPO timing income is three parts:

- Discounted cash flow for hold shares θ from the decision-making point to IPO, where θ is the sold proportion of shares in IPO;
- Present value of the direct income for selling θ shares in IPO;
- Present value of new revenue for continuing hold the $1-\theta$ shares after IPO. Cause the new project will always make profitability enhance, If company decided to go IPO at t_1, the revenue will equals the present value of the right of the graph surrounded by curve l_1 and l_1.

32.3 Optimal IPO Timing

Net cash flow at current point t_0 is π_0, the cash flow π_t at a certain future time t has highly uncertainty, and where π_t follow geometric Brownian motion:

$$\frac{d\pi_t}{\pi_t} = \mu dt + \sigma dz, \tag{32.1}$$

where μ is the expected growth rate of cash flow in normal circumstances. σ is cash flow volatility, which represents the uncertainty. dz is the incremental of Wiener process, z represents the standard normal movement. $z \sim N(0,1)$, σdz actually measure the system uncertainties, which include the entire market system risks and the company's industry-specific risk.

According to Equation (32.1), as we know that at time t_0 cash flow π_0, future cash flow follows logarithmic normal distribution, the variance increases linearly with time, as time goes by, the future cash flows is uncertain, but the more time passes, the greater the variance of the estimated value of their cash flow, the more inaccurate estimates, reflecting a kind of flexibility and uncertainty. There is an implicit assumption that π_t is positive, and will not be negative. Once equal to 0, will always to be 0.

Once we know the initial level of cash flow π_0 in the current moment $t = 0$, according to Equation (32.1) we can determined cash flow π_t at any point t. Taking into account the presence of uncertainty σ, and the discount factor ρ, the expected present value of: cash flows will be

$$E(\pi_t) = \pi_0 e^{ut} e^{-\rho t}. \tag{32.2}$$

There is a potential condition: $\mu < \rho$.

Otherwise, the entrepreneur will not choose to give up their shares and go public, the best time of the IPO will be in the infinity future. In order to make the problem practical $\mu < \rho$ must be meet.

We assume that the company's future net income will be used for dividends allocation to shareholders, so at the decision points in current time t_0, the value of the company's shares V_0 is equal to the present value of all the proceeds of these shares in the future:

$$V_0 = E\left(\int_0^{+\infty} \pi_x e^{-\rho x} dx\right) = \int_0^{+\infty} \pi_0 e^{\mu x} e^{-\rho x} dx = \frac{\pi_0}{\rho - \mu}. \tag{32.3}$$

Similarly, in any decision-making point t, the value of the shares V_t are bound to be met:

$$V(\pi_t) = E\left(\int_t^{+\infty} \pi_x e^{-\rho(x-t)} dx\right) = \int_t^{+\infty} \pi_t e^{\mu(x-t)} e^{-\rho(x-t)} dx = \frac{\pi_t}{\rho - \mu}. \tag{32.4}$$

Whether entrepreneurs or market investors, there is a risk valuation for the company's expected future return. Assume that entrepreneurs and market investors forecasts the company's future risk valuation level are ρ^p and ρ^m. We assume the valuation of future earnings meet $\rho^p > \rho^p > \mu$. We can use ρ^p and ρ^m as entrepreneurs and investors discount rate for future income.

Obviously, $V_t^p < V_t^m$.

Assuming that the company will choose the moment $t = t^*$ to IPO, and the company's cash flow is π^*. According to Equation (32.1), when the future cash flow follows a geometric Brownian motion, there is a high uncertainty, it is difficult to accurately calculate the parameters t^* and can not be accurately solved. So we can consider turn to the analysis of the critical value π^* instead, as alternative IPO timing variables $t^* = t^*(\pi^*)$. Once the company's actual cash flow reach π^*, IPO chosen. But how to solve π^*? As mentioned before, here three factors needs to be considered, as shown in Fig. 32.2, when $\pi = \pi^*$ the sum of three part of gain become maximized:

(1) Present value of cash flow for continuing hold the shares θ, from decision-making point to IPO:

$$f_1 = \theta \cdot E\left(\int_t^{t+t^*(\pi^*)} \pi_x e^{-\rho^p(x-t)} dx\right). \tag{32.5}$$

(2) Present value of direct income for selling shares θ in IPO.

When $t = t^*$, The company's cash flow will be $\pi = \pi^*$, the company will sell shares θ, market investors' assessment value of the company will be $V_{t^*}^m$; due to the external maturity is an important factor affecting the timing of IPO, there is also need to take full account of the IPO costs. To sum up:

$$\Omega = e^{-\rho^m t^*(\pi^*)} \left[\frac{\theta\pi^*(1-\lambda_1-\beta\lambda_2)}{\rho^m - \mu} - C\right], \tag{32.6}$$

where λ_1 is the ratio of underwriters' commissions accounted for the amount of financing in IPO direct costs. The cost is usually charged in accordance with the certain percentage of the amount of the financing. C is other direct costs in IPO, including the fees charged by accounting firms, law firms and other intermediaries and other expenses such as advertising. λ_2 is IPO underpricing, As we always do not treat all IPO underpricing as the indirect costs of the IPO, so a correction factor β need to be multiplied.

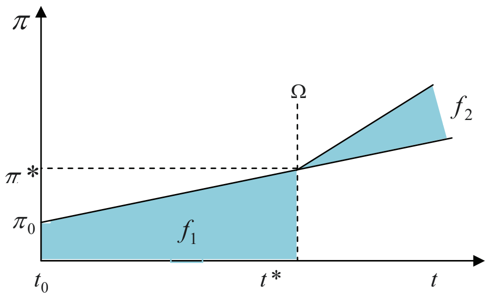


Fig. 32.2 The optimal IPO timing model

(3) The present value of the additional revenue for continuing hold shares $1-\theta$ after IPO.

After IPO, Company put the proceeds into more projects to enhance the company's profitability, and strengthen the R&D and marketing system, thus inevitably change the company's cash flow growth rate. Here we assume that IPO Company's cash flow τ_t also follows a geometric Brownian motion:

$$\frac{d\tau_t}{\tau_t} = \mu' dt + \sigma dz, \tag{32.7}$$

where μ' means expected growth rate of future cash flows after IPO. Meet $\mu' > \mu$. And when $t = t^*$, meet $\tau^* = \pi^*$, in reality, changes in corporate cash flow growth is a continuous process, even if a new project is put into operation, the return is realized gradually. So at that point the company's cash flow will be a smooth curve. So, the present value of the incremental cash flows brought by IPO are:

$$f_2 = (1-\theta)\left(\frac{\pi^*}{\rho^p - \mu'} - \frac{\pi^*}{\rho^p - \mu}\right) = \frac{\pi^*(1-\theta)(\mu'-\mu)}{(\rho^p-\mu')(\rho^p-\mu)}. \tag{32.8}$$

In summary, the solution process for π^* is essentially to find a π^* meet:

$$\begin{aligned} F(\pi_t) = \ & \max\left[\theta E\left(\int_t^{t+t^*(t^*)} \pi_x e^{-\rho^p(x-t)} dx\right)\right. \\ & \left. + e^{\rho^p t^*}\left[\frac{\theta \pi_t(1-\lambda_1-\beta\lambda_1)}{\rho^p-\mu}\right] + \frac{\pi^*(1-\theta)(\mu'-\mu)}{(\rho^p-\mu')(\rho^p-\mu)}\right]. \end{aligned} \tag{32.9}$$

The specific solution process omitted, solving equations to obtain the general solution:

$$F(\pi) = a_1 \pi^{b_1} + \frac{\theta}{\rho^p - \mu}, \tag{32.10}$$

where the coefficients a_1 and b_1 are:

$$b_1 = \frac{1}{2} - \frac{\mu}{\sigma^2} + \sqrt{\left(\frac{\mu}{\sigma^2} - \frac{1}{2}\right)^2 + \frac{2\rho^p}{\sigma^2}}, \tag{32.11}$$

$$a_1 = \frac{1}{b_1}\left(\frac{b_1 - 1}{b_1 C}\right)^{b_1 - 1}\left(\frac{\theta(1-\lambda_1-\beta\lambda_2)}{\rho^m - \mu} + \frac{1-\theta}{\rho^p - \mu'} - \frac{1}{\rho^p - \mu}\right)^{b_1}. \tag{32.12}$$

Optimal IPO timing is:

$$\pi^* = \frac{Cb_1}{b_1 - 1}\left[\frac{\theta(1-\lambda_1-\beta\lambda_2)}{\rho^m - \mu} + \frac{1-\theta}{\rho^p - \mu'} - \frac{1}{\rho^p - \mu}\right]^{-1}. \tag{32.13}$$

32.4 Static Comparative Analysis

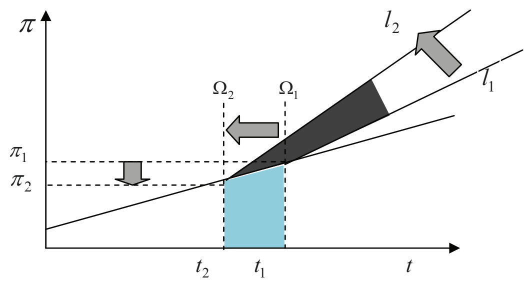
Having analyses the optimal IPO timing π^* above holding constant all other parameter values, we can find following relationship:

(1) Internal maturity and IPO timing

According to the definition and composition of internal maturity, we measure the future profitability of the enterprise. From two aspects, one is the past and current profitability of the firm, which can be used to predict future cash flow by inertia, this part can be directly reflected by the level of cash flow growth μ. While the other part is the measure of the potential growth. This capacity does not create the opportunity value before IPO, and can not achieved if the companies can not raise additional funds through IPO. This part can be indicated in model as $\Delta\mu = \mu' - \mu$.

If we use $\Delta\mu + \mu$ replace μ' and observe the location and signs of the coefficients we can find $\frac{\partial \pi^*}{\partial \Delta\mu} < 0$. The greater the potential growth of the firm for business growth, the larger $\Delta\mu$ achieved, the smaller the threshold π^*, the earlier IPO timing chosen.

Fig. 32.3 Changes in market opportunity



As shown in Fig. 32.3, if there are higher internal maturity and better development prospects for the company, the cash flow growth curve after the IPO moves from l_1 to l_2, holding shares $1-\theta$ in the company after the IPO may achieve more gains (deep color area). So the reduce gain (light color areas) for not continue to hold shares θ because of advance IPO from t_1 to t_2 can largely be made up. It is worth noting that, with the advance of the IPO time, the proceeds Ω of the sale of shares θ in the IPO are also changed, according to the formula (32.12) discount factor become smaller, also the value of the shares at the same time become smaller, so the changes in total income can not be determined. However Needless to say, the final result is that the market timing was reduced from π_1 to π_2.

(2) External maturity IPO timing

Here, the parameters to measure the IPO cost like brokerage commission rate λ_1, the level of IPO underpricing λ_2, underpricing adjustment factor β fixed costs C are positively correlated. With π^*. In other words, when IPO costs are big, entrepreneurs will obviously postpone IPO timing, waiting for a more favorable external environment.

(3) The more optimistic about the company by external market, the sooner IPO

Higher ρ^m will reduce the market valuation of the company, thereby reducing the motives of IPO, and vice versa.

(4) The more optimistic about the company by a decision maker, the later IPO

The impact of ρ^p on the market opportunity is just the opposite to ρ^m. Higher ρ^p will reduce the relative market value of the company, and thus postpone the company's time-to-market.

(5) The higher uncertainty of future income, the later IPO

The option value increases with increasing volatility, which will delay the time to market. The impacts of σ on π^* are both independent of the entrepreneur's risk appetite, also independent of the system and non-system risk decomposition of σ.

32.5 Conclusions and Recommendations

This paper introduces the real options model to analyze the IPO timing issues. On the basis of the model of Draho we tried to relax the assumption of the original model that the Company's cash flow growth rate remains constant after the listing. This paper considers that IPO will produce significant changes on the growth of the company's cash flow. This relaxation also in line with the usual definition of the maturity of the listed companies. Listed maturity is composed by two aspects, first, the company's current profitability; the second is the company's potential growth. Based on this, by analysis and derivation of the model, we solved the cash flow threshold of the optimal IPO timing, and statically analyzed this threshold. We found that the larger the company's potential growth, the earlier IPO of the Company. The higher the existing profitability, the sooner the IPO. Considering the cost factor in external maturity, with the increased costs, the company will postpone the time-to-market and wait for more favorable market opportunity.

Based on the above conclusions, for the irrational acts of blind listed on the capital market and related issues, we propose the following policy recommendations:

(1) Distincting disclosure standard of Main Board and GEM

Although there are obvious difference listing standards on the Main Board and GEM, we note that this difference only reflects the difference amount of the specific indicators, such as the higher scale requirements for listed companies in Main Board market. Taking into account that the GEM company are most SMEs, this difference is very appropriate. However, it should be noted that this difference should not only be reflected in the amount of specific indicators but also be reflected by different indicators. Taking into account the GEM investors often pay more attention to the company's future growth and new technologies monopoly. More quantifiable indicators of growth and some quantitative indicators of technological monopoly should be added in the listing standards for Companies to be listed on the GEM. When quantitative targets are difficult to achieve, a similar credit rating method should be applied to characteristics the technical level of these enterprises.

(2) Strengthen the education for small investors

As the disadvantage of small investors to access information and professional background, it is difficult for them to form the rational understanding of listed companies, in particular, the understanding of the internal maturity. Therefore, in order to avoid blind investment behavior occur, a set of indicators to measure the internal maturity system should be provided to them and make them understand the listed companies' listed motivation and listed the timing behavior. Regulatory authorities should do certain professional education to investors (especially small and medium investors) when they access to capital markets (such as account opening), to strengthen their cognitive ability to judge.

(3) Enhancing the counseling of listed companies

Considering using listed maturity index build system as metric of listed mature, and constantly improve the corporate governance structure, improve its governance level, counseling listed companies to form a healthy concept of financing. Advocating timing decisions. Recognizing that IPO has brought huge gains, but also need to pay the high cost. Comprehensive assessing the long-term interests maximize of the company, so as to conducive to other stakeholders. These measures, in turn, can enhance the confidence of investors in the corporate governance of listed companies. Let investors grow with the company, to achieve a win-win situation.

(4) Improving the legal protection of investors

A large number of theoretical and empirical studies have shown that on one hand, in the absence of constraint in the market, coupled with the irrational investors, small investors gaming in the capital market will always be in vulnerable groups, but on the other hand, small investor is the basis for the survival of the entire capital market. Whether a State capital markets can develop or not, whether the capital market can really play a role in resource allocation and optimal efficiency, often related to the level of legal protection of small investors in a country. China's stock market, existing all kinds of so-called "shady", will eventually damage the interests of small investors. Such damage is often related with the lack of legal protection of small investors. Therefore, accelerating the improvement of the system of legal protection of investors is an important means to avoid a large number of immature companies listed.

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Part III
Decision Support Systems

Chapter 33
An Empirical Research on the Relationship between Fulfilling Degree of Work Values and Organizational Citizenship Behaviors

Qingsong Zhu, Qin Huang and Siyin Zhou

Abstract In this study, we attempted to examine the relationship between fulfilling degree of employee's work values and organizational citizenship behaviors (OCBs). Many scholars had discussed the influence of employee's work values on their OCBs from the perspective of individual. However, staff's behaviors are affected not only by individual factors but also by organizational factors. Therefore we put forward the measurement indicator of "fulfilling degree of work values" in order to probe into the relationship of work values and organizational citizenship behaviors more comprehensively and precisely. In the present research, 529 pairs of employees and their direct supervisors from 36 enterprises were surveyed with the Work Values Inventory and the Chinese Organizational Citizenship Scale. It should be pointed out that items of the fulfilling degree of work values were added to the Work Values Inventory so as to measure the fulfilling extent of the employee's work values. And the data were analyzed at the individual level using correlation analysis and stepwise regression analysis. The results showed that (1) both the fulfilling degree of capability-developing dimension and status-independence dimension included in work values are significantly related to the five dimension of OCB; (2) status-independence dimension of work values has a significant positive impact on the factors of corporation-identity, altruism, individual-initiative and resource-protecting included in OCB. The degree of correlation between work values and OCB declined when using the indicator of "fulfilling degree of work values" compared with the results of previous studies. The results of this study have important implications on research and management.

Keywords Fulfilling degree of employee's work values · Organizational citizenship behaviors · Corporation staff

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33.1 Introduction

Organizational Citizenship Behaviors (OCBs) refers to individual behaviors that are discretionary, not directly or explicitly recognized by the formal reward system, and that in the aggregate not only promote the effective functioning of the organization, but also keep and enhance the favorable factors of organizations and psychological environment, thus helping the accomplishment of task performance [9]. Besides, Organ [8] has pointed out the significance of OCBs for organizational efficiency, effectiveness, innovation, and adaptability within diverse organizations. In view of the active role of OCBs in organizations, many domestic and foreign scholars have studied the motivation of OCBs. These motivations discussed in the studies fall into two categories, that is individual and situational factors [3]. Since work values serve as an important part of individual factors of employee, the relationship between the achievement degree of work values and organizational citizenship behaviors has attracted the attention of people from both theoretical and practical circles.

Super [13] pointed out that work values refer to work-related goals, work characteristics or properties of the internal needs of the individual and the activities pursued by the staff. Previous researches have successfully probed into the relationship between work values and OCBs. Such as Moorrman and Blakely [7] found that collectivism dimension of work values and OCBs showed a significant positive correlation; Podsakoff et al [11] stated that dispositional variables are key antecedents of OCBs through review of the theoretical and empirical literature. Ryan [12] studied the relationship between the PWE and organizational citizenship behaviors (OCBs) and he found a positive and significant relationship between OCB and two dimensions of the PWE, hard work and independence. Studies so far about their relationship have paid much attention on employees' work values–some have discussed the relationship between employees' whole work values and OCBs, others have demonstrated the correlation among dimensions of the two.

The social interaction theory argues that individual behavior is influenced by two aspects of intrinsic and extrinsic factors. Therefore, it is necessary to study the correlation between work values and OCBs from the perspective of both the organization and its employee. Based on the "fulfilling degree of employee's value" put forward by Zhu [4], this article brings forward the measurement indicator of "fulfilling degree of employees' work values", so as to develop and enrich the pervious theoretical researches by bringing the organizational factors into the study of the relationship between employee's work value and OCBs.

The fulfilling degree of employee's work value reflects whether the employee's ideal for work, work demands, the way of behavior, work goals and the like are fulfilled within the organization or not, to be exactly, the fulfilling degree of the needs mentioned above. This indicator not only focuses on the employee's work value itself, but also measures to which degree the organization supports its staff's work value, which is in favor of reflecting the intrinsic link between employee's work value and OCBs more objectively and comprehensively. Qin [1], Moorman and Blakely [7], Ryan [12] showed that employee's work value was significantly and positively related to OCBs. However, whether the fulfilling degree of employee's work value also has a significant relation with OCBs is still need to be examined, and if there's positive relation between them, which dimension of work value exist more powerful impaction on OCBs. The main purpose of the study is to solve those two questions.

33.2 Methodology

33.2.1 Sample

Participants for this study came from 36 enterprises in Sichuan, Chongqing, Hubei, Zhejiang and Shanghai. 1060 pairs of questionnaires were delivered to general staff and their direct supervisor with 624 pairs collected back. There are 529 pairs of valid questionnaires left, after excluding omissions and duplication, with the valid rate 50.9%. The demographic characteristics of the participants are showed in Table 33.1 and Table 33.2.

Table 33.1 Basic characteristic of the staff ($N = 529$)

Item	N	Per.	Item	N	Per.	Item	N	Per.
Gender			Position			Length of service		
Female	286	54.1	General	345	65.2	> 3 years	220	41.6
Male	239	45.2	Basic level	141	26.7	1 ∼ 3 years	175	33.1
Missing	4	0.7	Middle level	40	7.6	5 months ∼ 1 year	78	14.7
			High level	0	0	< 5 months	54	10.2
			Missing	3	0.5	Missing	2	0.4
Age								
> 40	58	11						
30 ∼ 39	160	30.2						
20 ∼ 29	305	57.7						
< 20	5	1						
Missing	1	0.1						

33.2.2 Measurement

This study involved two measurement instruments and both are 5-point Likert scales, ranging from (1) "strongly disagree" to (5) "strongly agree". Employee's work value questionnaires were answered by the staffs, while the OCBs questionnaires were scored by the staff's direct supervisor.

Table 33.2 Basic characteristic of the supervisor ($N = 529$)

Item	N	Per.	Item	N	Per.	Item	N	Per.
Gender			Position			Length of service		
Female	169	32	General	215	40.6	> 3 years	341	64.5
Male	286	54.1	Basic level	275	52	$1 \sim 3$ years	122	23.1
Missing	74	13.9	Middle level	32	6	5 months $\sim$ 1 year	51	9.6
			High level	7	1.3	< 5 months	10	1.9
						Missing	5	0.9
Age								
> 40	139	26.3						
$30 \sim 39$	292	55.2						
$20 \sim 29$	93	17.6						
< 20	0	0						
Missing	5	0.9						

Employee's work value were assessed using an instrument adapted from Manhardt. The three-dimensional work value scale comprised 21 items. The dimensions are comfort and safety (5 items), capacity and growth (9 items), status and independence (7 items). In this study, the Cronbach's α is used to test the scale's reliability, each α index of the three dimensions above is 0.823, 0.896, 0.864 and the overall Cronbach's α of the total scale is 0.898.

OCBs were assessed using an instrument adapted from Farh which was developed for China. The scale comprised 20 items with five dimensions: recognition of organization (4 items), altruism behavior (4 items), individual initiative (5 items), interpersonal harmony (4 items) and protecting corporate resources (3 items). Cronbach's α index of the five dimensions are: 0.831, 0.903, 0.85, 0.926, 0.912 and the overall index is 0.898.

This study added items of fulfilling degree of employee's work value to the previous work value scale. When calculating staff's fulfilling degree of his/her work value, items with score that was equal to or higher than 3 were thought to be important to the staff, average mean of the items were taken as each dimension's score.

33.2.3 Procedure

To examine the relationship between fulfilling degree of employee's work value and OCBs, data was test using SPSS11.5. Correlation analysis and regression analysis were used to examine the relationship.

33.3 Results and Analysis

33.3.1 Correlation Analysis between Fulfilling Degree of Employee's Work and OCBs

Table 33.3 presents the Pearson correlation matrix of fulfilling degree of employee's work value and OCBs, which shows that the overall fulfilling degree of employee's work value, capacity and growth dimension, status and independence dimension were significantly related to OCBs and its five dimensions, while dimension of comfort and safety was not significantly related to OCBs.

Table 33.3 Correlation matrix of fulfilling degree of work value and OCBs

Variable	1	2	3	4	5	6	7	8	9
Fulfilling degree of work value	1								
OCBs	.276∗∗	1							
Comfort & safety	.582∗∗	0.047	1						
Capacity & growth	.799∗∗	.169∗∗	.501∗∗	1					
Status & independence	.695∗∗	.228∗∗	.129∗∗	.418∗∗	1				
Recognition	.221∗∗	.716∗∗	−0.009	.121∗∗	.225∗∗	1			
Altruism	.213∗∗	.790∗∗	0.042	.099∗	.185∗∗	.707∗∗	1		
Initiative	.205∗∗	.742∗∗	0.002	.128∗∗	.152∗∗	.675∗∗	.699∗∗	1	
Interpersonal harmony	.136∗∗	.553∗∗	0.064	.104∗	.096∗	−0.017	.125∗∗	−0.011	1
Protect corporate resources	.174∗∗	.620∗∗	0.064	.128∗∗	.137∗∗	.109∗	.174∗∗	.109∗	.793∗∗

Note: ∗ : $p < 0.05$, ∗∗ : $p < 0.01$, ∗∗∗ : $p < 0.001$.

33.3.2 Regression Analysis

As Table 33.4 shows, fulfilling degree of employee's work value could predict 7.4% variance of OCBs. Among the three dimensions of fulfilling degree of work value, status and independence had a significant impact on recognition of organization, altruism, personal initiative and protect corporate resources, and this dimension could predict 5% variance of OCBs. Generally speaking, fulfilling degree of work value had a limited prediction power to OCBs, and status and independence dimension played an important role in the limited power.

Table 33.4 Summery table of stepwise regression analysis

Variables	Recognition		Altruism		Personal initiative		Protect resources		OCBs	
	ΔR^2	β	ΔR^2	β	ΔR^2	β	ΔR^2	β	ΔR^2	β
Status & independence	.049***	.177	.033***	.15	.022***	.125	.017**	.126	.051***	.135
Fulfilling degree of work value									.074***	.264

33.4 Discussion

This study demonstrated that the overall fulfilling degree of employee's work value has a significant and positive impact on OCBs ($r = 0.276$, $p < 0.01$). From the perspective of dimensions of work value, capacity and development, status and independence were significantly related to OCBs, while comfort and safety was not related to OCBs. The regression analysis showed there was limited prediction power from fulfilling degree of work value on OCBs.

Qin et al [1] studied the relationship between work value and OCBs, and the results showed that, comfort dimension was significantly related to dimensions of recognition, altruism, personal initiative of OCBs; both capacity & development and status dimension played a predictive function on OCBs. Liang's study [6], which took the front-line staff from service sector as the sample, demonstrated that both intrinsic value and external value served as good predictors for OCBs. Further analysis on his scale illustrated that its intrinsic value was similar to the dimension of capacity and status in this study, external value was similar to comfort and safety dimension in this study. Therefore, it is supposed that both the two studies above had the same conclusion that comfort dimension was significantly related to OCBs. However, results in this study showed that the fulfilling degree of comfort and safety dimension was not significantly related to OCBs. Reasons for the divergence maybe lie in the different measurement indicator adapted in this study. The fulfilling degree of work value has taken the organizational factors into consideration. According to Herzberg's Two-factor theory, health factors can only prevent the employee's dissatisfaction, only the motivating factors could promote employee satisfaction. Although staff may attach importance to comfort, it belongs into health factors, the high fulfilling degree could not generate staff's motivation, thus wouldn't significantly relate to the extra-role OCBs.

Ryan [12] studied relationship between the PWE and organizational citizenship behaviors and the outcome demonstrated that non-leisure did not significantly relate to OCBs, hard-working was significantly and positively related to OCBs, independence was significantly and negatively related to OCBs. From the scale in the study, Ryan's definition of independence more inclined to individualism, but the status and independence dimension in this study means independence and autonomy in work, which resulted in the different outcome of the two studies. Generally speaking, the results of the both studies were quite consistency.

Besides, Tian [2] researched the relationship between employee's work value and OCBs in private enterprises in Chongqing. The results of her study showed that self-development, interpersonal relationship, corporate reputation have a quite strong predictive impact on recognition, protecting corporate resources, helping colleagues and professionalism. But in this study, the stepwise regression analysis showed that, only fulfilling degree of status and independence could somewhat predict OCBs. And compared with the previous studies, the predictive power of fulfilling degree of work value had significantly declined. Explanation for this situation maybe: (1) the different measurement of OCBs, Organ and Ryan [10] reviewed the literature and found that self-report and others' evaluation in measuring OCBs played a significantly meditating role between work attitude and OCBs because self-report pattern would usually increase the relationship index between the two, which results from common method variance; (2) organizational factor may play an meditating role between fulfilling degree of employee's work value and OCBs. Such as the corporate environment, corporate culture and values, LMX and the like. However, the exact factor and to which extent the meditating has played need to be examined in the future. Previous studies did not consider the role of organization between work value and OCBs, and this study only used the fulfilling degree of employee's work value, therefore, more efforts and studies should be made to examine the relationship between work value and OCBs.

33.5 Conclusions

The overall fulfilling degree of employees' work value has a significant and positive impact on OCBs. Capacity and growth dimension, status and independence dimension were significantly related to OCBs and its five dimensions.

Status and independence dimension of work value had a small positive impact on recognition, altruism, individual initiative, protecting corporate resources of OCBs.

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Chapter 34
Efficiency of the Board and Quality of Information Disclosure: Based on the Perspective of Ultimate Ownership Structure

Rui Xiang, Qiqi Li and Yaqi Li

Abstract This paper empirically examines the relationships between the efficiency of the board, the efficiency of the board under the influence of ultimate ownership structure and the quality of information disclosure based on the data consisting of Chinese listed companies from Shenzhen Stock exchange from 2004 to 2007. The results from our sample show that, (1) The duality of board leadership and the number of board meetings have significantly negative impact on the quality of information disclosure; the board size has significantly positive impact on the quality of information disclosure; the board independence has not significantly impact on the quality of information disclosure. (2) The ultimate ownership structure (the ultimate nature of property rights, cash flow rights, the separation of cash flow rights and control rights) has significantly impact on the relationship between the board efficiency and the quality of the information disclosure. So we may prefect corporate governance and improve the quality of information disclosure by the conclusion of this paper.

Keywords Efficiency of the board · Ultimate ownership structure · Quality of information disclosure · Listed companies

34.1 Introduction

From 1990s, foreign scholars carry out a very extensive research on the relationship between corporate governance mechanisms and the quality of information disclosure. These studies mainly explores the influence of some factors on the quality of

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information disclosure, such as ownership structure [3, 32], institutional Investors holding shares [1, 15, 35], ownership concentration [4, 21], the degree of dispersion of the shareholding [5, 27, 28], the separation of cash flow rights and control rights [2, 24], board Independence [6, 22, 29], audit Committee [16, 33]. Compared with foreign research, the literature that researches the influence of corporate governance mechanisms on the quality of information disclosure is relatively less in China.These papers investigate ownership structure [7, 37, 42], board independence [7, 12, 36], director compensation [12] and other factors affect the quality of information disclosure.

But they don't combine ownership structure, especially the ultimate ownership structure, with board efficiency to research the influence on the quality of information disclosure. In other words, whether the relationship between efficiency of the board and information disclosure is changed or not in consideration of the influence of ownership structure on the board efficiency. Given this possibility, this paper will investigate systematically the relationships between the board efficiency, the board efficiency under the influence of ultimate ownership structure and the quality of information disclosure based on our special institutional background and provide important empirical evidence for the formulation of the relevant regulatory policy.

The remainder of this paper proceeds as follows. Sect. 34.2 is concerned with literature review and hypothesis development. Sect. 34.3 discusses the research design. The results are discussed in Sect. 34.4. Finally, Sect. 34.5 contains the conclusions.

34.2 Literature Review and Hypothesis

34.2.1 Efficiency of the Board

(1) The duality of board leadership

Fama and Jensen [17] found the duality of board leadership has the ability to pursue their own interests rather than the maximization of shareholder interests. Forker [16]showed that there is a negative relationship between the duality of board leadership and the quality of information disclosure. Lipton and Lorsch [26] thought that if chairman of the board served as general manager at the same time, the board would be difficult to complete its related functions. So in order to enable the board to be effective, it is important to achieve the functional separation of chairman of the board and general manager. Donelly and Mulcahy [13] found that the separation of general manager and chairman of the board improves the level of information disclosure. Rouf [31] discovered that the separation of general manager and chairman of the board and the level of voluntary information disclosure have positive relationship. Based on the analysis above, we think that when chairman of the board and general manager are combined, it will make the management have the right to speak on the board and then will result in the insider to control, which make board monitoring lose its independence. And this situation can aggravate the proxy conflict of the listed companies. At last, the quality of information disclosure will be reduced. Based on this reasoning, the paper puts forward the following hypothesis.

Hypothesis 1. In other conditions being unchanged, the quality of information disclosure will be low if chairman of the board and general manager are the same person.

(2) The board size

Generally, the board size is closely related to the company ability of obtaining external key resources [30]. More of the directors can bring more knowledge, experience and external resources. To a certain degree, this reduces the risk of the company. Moreover, the board having more directors contributes to coordinate the conflict of the interests among the stakeholder. Chaganti et al [8] argues that the large-scale board help to expand the services function of the board. Donelly and Mulcahy [13] found a positive correlation between the size of the board and the level of information disclosure. Based on the analysis above, we think that the large-scale board is more likely to improve the quality of information disclosure, and then alleviates the proxy conflict between ultimate controlling shareholders and minority shareholders. Therefore, this paper presents the following hypothesis.

Hypothesis 2. Provided that other conditions are unchanged, the larger the size of the board is, the higher the quality of information disclosure is.

(3) The board independence

Chen and Jaggi [6] believe that the higher the proportion of independent directors is, the higher the level of information disclosure is. Dimitropoulos and Asteriou [14] found that the higher the proportion of outside directors is, the higher the quality of earnings report. Chau and Gray [9] discovered a positive correlation between the percentage of non-executive independent directors and the quality of information disclosure. Thus, we hold that it helps to strengthen the independence of the board that the independent director performs its supervisory duties independently. And the conflict of interest between shareholders and managers is eased by improving the quality of information disclosure. So the paper forms the following hypothesis.

Hypothesis 3. With other conditions unchanged, the stronger the independence of the board is, the higher the quality of information disclosure is.

(4) The number of board meetings

Jensen [23] argues that the board meetings are often mainly a formality and the directors actually don't have much time to discuss the management performance. Vafeas [34] found that the frequency of the board meeting and the value of the company have negative relationship. Chen et al [10] found that there is a significant positive relationship between the number of board meetings and the incidence of the company's financial fraud. And Xiang and Feng [38] held that there is a significant negative relationship between the number of board meetings and the company's performance. Through the analysis above, we think that the directors don't play an effective role in corporate governance by the board meeting and high frequency of board meetings may be a response to some of the problems in the company. So the paper presents the following hypothesis.

Hypothesis 4. With other conditions unchanged, the more the number of board meetings is, the lower the quality of information disclosure is.

34.2.2 The Efficiency of Board of Directors Under the Influence of Ultimate Ownership Structure

(1) The ultimate nature of property rights

The ultimate controlling shareholders have a lot of voting right. By electing to their own into the board, they realize the strong control over the board of directors. Filatotchev et al [18] found that family members often gain control over the board of directors by means of nominating and controlling board members. Chen and Jaggi [6] held that the higher the proportion of independent directors on the board of directors is, the higher the level of information disclosure is, but if the company is control by family, the effect of independent directors will be restricted. Simon et al [33] found that the higher proportion of family members on the board is, the lower the level of company voluntary information disclosure is. Filatotchev [19] said that it increases the risk of misusing private information that family controlling shareholders control the board. After further research on the cause of pyramidal ownership structure, Fan et al [20] found that for state-controlled listed companies, implementing decentralization promotion policy is a major cause of forming pyramid shareholding structure. They also said that the main purpose of constructing pyramid equity structure for private enterprises is to relieve the financing constraints and form the internal capital market, which tend to be manifested as the behavior of encroaching minority shareholders' benefits. A study by Xie and Zhu [39] suggests that when most of board members is controlled by controlling family, corporate governance environment is poor and this environment gives priority to "the entrenchment effects". Based on the analysis above, we believe that compared with the enterprises whose ultimate property right is control by the state, the enterprises whose ultimate property is controlled by family can strengthen the control function of the board in a certain extent and then weaken the efficiency of the board, which result in reducing the level of information disclosure accordingly. So the paper raises the following hypothesis.

Hypothesis 5. In the family holding company, with other conditions unchanged, the duality of board leadership structure and the number of board meetings have more significantly negative impact on the quality of information disclosure, and the board size and the board independence will have significantly negative impact on the quality of information disclosure compared the enterprise whose ultimate property right is control by the state.

(2) Cash flow rights and the separation

The ultimate controlling shareholders take advantage of their own holding status or control power to recommend their representatives being board members, and these representatives are majority of board members. In nature, the board becomes the permanent institution of "controlling shareholders" and the board resolution can only represent the unilateral interests of controlling shareholders. As a result, the ultimate controlling shareholders take strong control of the enterprise by the board of directors, which makes them obtain greater benefits of control over cash flow right. However, the ultimate controlling shareholders tend to adopt methods of earnings management in order to conceal their behavior of encroaching on the interests of medium and small shareholders. Xie and Zhu [39] found that the proportion of controlling shareholders in the board is negatively related to the value of the company. Yeh and Woidtke [40] found that when the separation of cash flow rights and control rights is bigger, the controlling shareholders often affect the appointment of members of the board in order to further strengthen their position, as a result of which there is a negative effect on the value of the company. Yves and Richard [41] discovered that there is a negative correlation between the degree of separation of cash flow rights and control rights and effective corporate governance. At the same time, they also pointed out that ownership concentration has a negative influence on the board composition index. It shows that in order to make them easier to encroach on the interests of medium and small shareholders, controlling shareholders intends to weaken the internal control mechanism. So we believe that in order to gain control, the ultimate controlling shareholders will take advantage of the separation of cash flow rights and control rights to weaken the efficiency of the board, which help them to seize the interests of medium and small shareholders and obtain personal benefit. On the contrary, if ash flow rights are greater and the separation of cash flow rights and control rights is smaller, the ultimate controlling shareholder will strengthen the efficiency of board of directors to improve the quality of corporate disclosure. The paper raises the following hypothesis accordingly.

Hypothesis 6. For the listed companies whose ultimate cash flow rights are greater, in the case of other conditions being unchanged, the board size and the board independence have more significantly positive impact on the quality of information disclosure, and the duality of board leadership and the number of board meetings also have significantly positive impact on the quality of information disclosure.

Hypothesis 7. For the listed companies who have smaller separation of cash flow rights and control rights, in the case of other conditions being unchanged, the board size and the board independence have more significantly positive impact on the quality of information disclosure and the duality of board leadership, and the number of board meetings also have significantly positive impact on the quality of information disclosure.

34.3 Data and Methodology

34.3.1 Sample Selection and Data Sources

This paper chooses all of listed companies from Shenzhen Stock exchange from 2004 to 2007 as samples. Finally, we get 1876 samples after cutting out listed financial companies, the companies whose ultimate ownership structure is unknown, non-state and non-family holding companies, the companies of losing corporate governance data and other companies whose financial data is lost. Among them, there are 1252 companies whose ultimate controlling right is owned by state and there are 624 family holding companies.

We obtain the data about the quality of information disclosure by arranging the information disclosure evaluation results of sample companies from 2004 to 2007. And the information disclosure evaluation results of sample companies are got from the information disclosure evaluation results of all listed companies from Shenzhen Stock exchange published in "the credibility file" of its website (www.szse.cn); the data about the ultimate ownership structure are collected and trimmed by hand from annual reports of listed companies which come from Chinese listed company news website (http://www.cnlist.com); the board data and other financial data are from CSMAR research database.

34.3.2 Variable Definition

(1) Dependent variables

In this paper, the dependent variable is the quality of information disclosure. The measures the quality of information disclosure based on the evaluation results of information disclosure from Shenzhen Stock Exchange. Shenzhen Stock Exchange divides the quality of information disclosure into four grades, namely "excellent", "good", "pass" and "fail". This paper will review the results into two categories. "Excellent" and "good" companies are assigned to 1 and "pass" and "fail" companies are assigned to 0. We use dummy variable DISQ to express two categories.

(2) Independent variables

• The efficiency of the board

The board of directors is the core element of company governance mechanism and it has important influence on the quality of information disclosure. The efficiency of the board is appeared by its structural characteristics. In this paper, we set the duality of board leadership (DUALITY), the board size (BNUM), the board independence (OUTDIR) and the number of board meetings (BMEET) to reflect the efficiency of the board.

• The ultimate ownership structure

(a) The ultimate nature of property rights (FAMLY)

It is that the nature of ultimate control person is family or state controlling. The index is a dummy variable. If family controlling, the index is 1. Otherwise, it is 0.

(b) Cash flow rights (CR)

The paper adopts the calculation method put forward by La Porta et al [25] to estimate cash flow rights, namely calculating the value of the control right existing in each control chain (including direct control and indirect control) and then adding them together.

(c) The separation of cash flow rights and control rights (SR)

This paper refers to the calculation method of the separation put forward by Claessens et al [11], namely applying the ratio of cash flow right to control rights to measure the separating of cash flow rights and control rights. And about the calculation of cash flow rights and control rights, we apply the method put forward by La Porta et al [25]. SR is a reverse substitution variable about the degree of separation. That is, the greater SR is, the smaller the separation of cash flow right and control is, otherwise the bigger the separation of cash flow right and control according to company is.

(3) Control variables

The selection of control variables is based on a lot of foreign literatures about the factors of affecting the quality of corporate information disclosure, mainly including ROA, DEBT, SIZE, LIQU, IND and YEAR. We describe the control variables below: ROA - net income/total assets; DEBT - total liabilities/total assets; SIZE - the natural logarithm of total assets; LIOU - (current assets-current liabilities)/current liabilities; IND - industry dummy variable; Year - annual dummy variable.

34.3.3 Research Model

In order to investigate the influence of efficiency of the board on the quality of information disclosure, we build the Logit regression model (34.1) to test Hypothesis H1 to H7 put forward in the paper.

$$\begin{aligned}\mathrm{LOGIT}(P) = {} & \beta_0 + \beta_1 \times \mathrm{DUAL} + \beta_2 \times \mathrm{DUAL} \times \mathrm{ULTIMSTR} + \beta_3 \times \mathrm{BNUM} \\ & + \beta_4 \times \mathrm{BNUM} \times \mathrm{ULTIMSTR} + \beta_5 \times \mathrm{OUTDIT} \\ & + \beta_6 \times \mathrm{OUTDIT} \times \mathrm{ULTIMSTR} + \beta_7 \times \mathrm{BMEET} \\ & + \beta_8 \times \mathrm{BMEET} \times \mathrm{ULTIMSTR} + \beta_9 \mathrm{ROA} + \beta_{10} \mathrm{DEBT} \\ & + \beta_{11} \mathrm{SIZE} + \beta_{12} \mathrm{LIQU} + \sum_{i=13}^{16} \mathrm{YEAR} + \sum_{i=17}^{28} \mathrm{INDU},\end{aligned} \tag{34.1}$$

P expresses the probability of DISQ $= 1$ (that is, the disclosure quality rating is divided into "good", the possibility of a "good"). In actual regression analysis, considering the multicollinearity, we introduce respectively FAMLY, CR, SR into the model to replace ULTIMSTR; β_0 is for the Intercept and $\beta_1 - \beta_{28}$ is for the coefficients.

34.4 Results and Discussion

34.4.1 Descriptive Statistics

From the descriptive statistics of main variables, the statistical results is omitted owing to the limited text, we can see that the average value of information disclosure quality in excellent and good is 63% in the sample companies. It shows that the quality of information disclosure of Chinese Listed Companies is gradually improving in recent years. We can see that there is a big difference between Chinese Listed Companies from the duality of board leadership, the board size, the board independence and the number of board meetings. The average of family controlled listed company achieves 33%, it shows that the number of family controlled listed companies is gradually increasing in recent years. The average value of the listed companies' cash flow rights is 30.68%. The average value of the separation of cash flow right and control rights is 78.38%, and it is much more varied.

34.4.2 Regression Analysis

The Table 34.1 shows the regression result of efficiency of the board and quality of information disclosure, and the efficiency of board which is affected by the ultimate nature of property rights and the quality of information disclosure. We can see from model (1) $\sim$ (4) that there is significantly negative correlations between the duality of board leadership, the number of board meetings and the quality of information disclosure. It confirms most of the H1 and H4, the duality of board leadership and the greater the number of board meetings, the company lower the quality of information disclosure. There is a significantly positive correlation between board size and quality of information disclosure which confirms Hypothesis H2. It shows that large board is helpful to improve the quality of corporate disclosure. Board independence has a positive impact on quality of information disclosure but not significantly. Hypothesis H3 is not proved by any empirical evidence.

We can see from model that (1) that there is not significant correlation between the duality of board leadership and the quality of information disclosure, but there is a negative correlation between the interaction and the quality of information disclosure, which is very significant at the 1% level. This indicates that the duality of board leadership make it easier to disclose low-quality information through strengthening the control of the board in family controlled listed companies. We can see from model (2) that there is a significantly positive correlation between the board size and the quality of information disclosure, but there is a negative correlation between the interaction and the quality of information disclosure, which is very significant at the 10% level. This indicates that family controlling shareholders inhibit effective function of the board size in order to extract private benefits from the listed company, which result in Result in a lower quality of information disclosure. We can see from model (3) that there is not significant correlation between board independence and quality of information disclosure, but there is a negative correlation between the interaction and the quality of information disclosure, which is very significant at the 10% level. This indicates that independent directors affected by the families controlled shareholder and serve them, which makes the quality of information disclosure low in family controlled listed companies. We can see from model (4) that there is a significantly negative correlation between the number of board meetings and the quality of information disclosure, but there is a non-significantly negative correlation between the interaction and the quality of information disclosure. This indicates that family controlled shareholders didn't control the board by increasing the number of the board meeting, and which did not affect quality of information disclosure accordingly. Through the above analysis, it verify basically Hypothesis H5, the efficiency of board and quality of information disclosure affected by the ultimate nature of property rights.

Table 34.2 shows the regression result of efficiency of the board and quality of information disclosure, and that of efficiency of board which is affected by cash flow right and quality of information disclosure. Table 34.3 shows the regression result of efficiency of board and quality of information disclosure, and that of efficiency of board which is affected by the separation of cash flow right from control right and quality of information disclosure. We can see from model (5) $\sim$ (8) in Table 34.2 and model (9) $\sim$ (12) in Table 34.3, there is a significantly negative correlations between the duality of board leadership, the number of board meetings and the quality of information disclosure. There is a significantly positive correlation between board size and quality of information disclosure. There is a positive correlation between board independence and quality of information disclosure, which is not significant. The research conclusion is the same with that of Table 34.1 generally. Hypothesis H1, Hypothesis H2, and Hypothesis H4 is proved by further empirical evidence. Hypothesis H3 is not supported by empirical data.

From model (5) of Table 34.2 and model (9) of Table 34.3, we can see that there is a significantly negative correlation between the duality of board leadership and the quality of information disclosure. But there are positive correlations between the interaction and the quality of information disclosure, which is significant at the 1% level. It suggests that the greater cash flow rights are, the smaller the separation of cash flow rights and control rights is, and the more the cost that the ultimate controlling shareholders take advantage of the board to obtain private benefits of control is, which to some extent suppresses the unfavorable influence of the duality of board leadership on the quality of information disclosure and improves the quality of information disclosure. From model (6) of Table 34.2 and model (10) of Table 34.3, we can see that there is a significantly positive correlation between the board size and the quality of information disclosure at the 5% level. However, there are significantly positive correlations between the interaction and the quality of information disclosure at the 1% level. It suggests that the greater the cash flow rights of ultimate controlling shareholders are, the smaller the separation of cash flow rights and control rights is, and the effectiveness of board size is further strengthened that improves the quality of information disclosure accordingly. From model (7) of Table 34.2 and

Table 34.1 The influence of the ultimate nature of property rights considered

	Model (1)	Model (2)	Model (3)	Model (4)
Variable	Coefficient	Coefficient	Coefficient	Coefficient
Intercept	−9.052***	−8.756***	−8.722***	−9.086***
	(0.000)	(0.000)	(0.000)	(0.000)
DUAL	0.085	−0.273*	−0.272*	−0.280**
	(0.650)	(0.051)	(0.052)	(0.046
FAMLY*DUAL	−0.815***			
	(0.002)			
BNUM	0.114***	0.118***	0.110***	0.113***
	(0.000)	(0.000)	(0.000)	(0.000)
FAMLY*BNUM		−0.023*		
		(0.061)		
OUTDIR	1.183	1.119	1.342	1.060
	(0.235)	(0.259)	(0.181)	(0.285)
FAMLY*OUTDIR			−0.592*	
			(0.061)	
BMEET	−0.079***	−0.079***	−0.079***	−0.077***
	(0.000)	(0.000)	(0.000)	(0.000)
FAMLY*BMEET				−0.009
				(0.457)
ROA	0.030	0.031	0.032	0.032
	(0.368)	(0.341)	(0.335)	(0.334)
DEBT	0.001	0.0003	0.0003	0.0004
	(0.905)	(0.957)	(0.954)	(0.947)
SIZE	0.397***	0.386***	0.384***	0.400***
	(0.000)	(0.000)	(0.000)	(0.000)
LIQU	0.120***	0.127***	0.128***	0.128***
	(0.003)	(0.002)	(0.002)	(0.001)
YEAR	YES	YES	YES	YES
INDU	YES	YES	YES	YES
N	1876	1876	1876	1876
2Log likelihood	2264.964	2271.200	2271.202	2274.140
Cox & Snell R2	0.105	0.102	0.102	0.100

P-values are provided in parentheses. The sign * expresses that the relationship is significant at the 0.1 level (two-tailed test). The sign ** expresses that the relationship is significant at the 0.05 level (two-tailed test). The sign *** expresses that the relationship is significant at the 0.01 level (two-tailed test). When taking the interaction into regression analysis together, we find that the VIF value of every interaction is greater than 10, which indicates existing serious multicollinearity problem in interactions. Therefore, in the regression model we only adopt stepwise regression analysis method to analyze interaction.

model (11) of Table 34.3, we can find that there is a non-significantly positive correlation between the board independence and the quality of information disclosure. But there are positive correlations between the interaction and the quality of information disclosure, which is significant at the 1% level. It suggests that the greater the cash flow rights of ultimate controlling shareholders are, the smaller the separation of cash flow rights and control rights is, and the role of independent directors is played which is conducive to improve the quality of information disclosure. From

Table 34.2 The cash flow right considered

	Model (5)	Model (6)	Model (7)	Model (8)
Variable	Coefficient	Coefficient	Coefficient	Coefficient
Intercept	−9.126***	−8.442***	−8.432***	−8.783***
	(0.000)	(0.000)	(0.000)	(0.000)
DUAL	−0.839***	−0.271*	−0.267*	−0.274**
	(0.001)	(0.053)	(0.057)	(0.050)
CR*DUAL	2.040***			
	(0.008)			
BNUM	0.116***	0.089***	0.118***	0.117***
	(0.000)	(0.003)	(0.000)	(0.000)
CR*BNUM		0.103***		
		(0.002)		
OUTDIR	1.167	1.096	0.369	1.079
	(0.241)	(0.270)	(0.716)	(0.277)
CR*OUTDIR			2.747***	
			(0.001)	
BMEET	−0.081***	−0.079***	−0.079***	−0.101***
	(0.000)	(0.000)	(0.000)	(0.000)
CR*BMEET				0.076**
				(0.021)
ROA	0.030	0.030	0.030	0.031
	(0.362)	(0.373)	(0.364)	(0.349)
DEBT	0.001	0.0002	0.0002	0.0003
	(0.893)	(0.972)	(0.975)	(0.955)
SIZE	0.400***	0.369***	0.368***	0.385***
	(0.000)	(0.000)	(0.000)	(0.000)
LIQU	0.123***	0.122***	0.122***	0.124***
	(0.002)	(0.002)	(0.002)	(0.002)
YEAR	YES	YES	YES	YES
INDU	YES	YES	YES	YES
N	1876	1876	1876	1876
2Log likelihood	2267.400	2264.674	2264.085	2269.311
Cox & Snell R2	0.104	0.105	0.105	0.103

model (8) of Table 34.2 and model (12) of Table 34.3, we can discover that there is a significantly negative correlation between the number of board meetings and the quality of information disclosure at the 1% level. But there are significantly positive correlations between the interaction and the quality of information disclosure at the 5% level. It indicates that the greater the cash flow rights of ultimate controlling shareholders are, the smaller the separation of cash flow rights and control rights is. It will help the board to carry out its function through board meetings, and then will improve the quality of information disclosure. In conclusion, based on the analysis of the relationship between the quality of information disclosure and efficiency of board of directors under the influence of cash flow rights, and the separation of cash flow rights and control rights, we verify basically the hypothesis H9, H10 of this paper.

Table 34.3 The separation of cash flow right and control right considered

	Model (9)	Model (10)	Model (11)	Model (12)
Variable	Coefficient	Coefficient	Coefficient	Coefficient
Intercept	−8.913***	−8.723***	−8.649***	−8.913***
	(0.000)	(0.000)	(0.000)	(0.000)
DUAL	−1.490***	−0.282**	−0.286**	−0.285**
	(0.000)	(0.043)	(0.041)	(0.041)
SR*DUAL	1.549***			
	(0.001)			
BNUM	0.117***	0.072**	0.112***	0.113***
	(0.000)	(0.028)	(0.000)	(0.000)
SR*BNUM		0.054***		
		(0.007)		
OUTDIR	0.994	1.021	−0.154	1.043
	(0.317)	(0.303)	(0.866)	(0.292)
SR*OUTDIR			1.538***	
			(0.004)	
BMEET	−0.082***	−0.079***	−0.080***	−0.114***
	(0.000)	(0.000)	(0.000)	(0.000)
SR* BMEET				0.044**
				(0.032)
ROA	0.030	0.029	0.029	0.030
	(0.370)	(0.376)	(0.380)	(0.362)
DEBT	0.001	0.0004	0.0004	0.0005
	(0.876)	(0.947)	(0.949)	(0.942)
SIZE	0.394***	0.385***	0.382***	0.393***
	(0.000)	(0.000)	(0.000)	(0.000)
LIQU	0.119***	0.124***	0.123***	0.126***
	(0.003)	(0.002)	(0.002)	(0.002)
YEAR	YES	YES	YES	YES
INDU	YES	YES	YES	YES
N	1876	1876	1876	1876
2Log likelihood	2262.411	2267.499	2266.362	2270.090
Cox & Snell R2	0.106	0.104	0.104	0.102

34.5 Research Conclusions

This paper empirically examines the relationships between efficiency of the board, the efficiency of board of directors under the influence of ultimate ownership structure and the quality of information disclosure. The results show that: (1) The duality of board leadership and the number of board meetings have significantly negative impact on the quality of information disclosure; the board size has significantly positive impact on the quality of information disclosure; the board independence has not significantly impact on the quality of information disclosure. (2) After considering the influence of the ultimate nature of property rights, we find that in the family holding company, the duality of board leadership and the number of board meetings have more significantly negative impact on the quality of information disclosure, and the board size and the board independence will have significantly negative impact on the quality of information disclosure; After considering the influence of cash flow rights, the study suggests that for the listed companies whose ultimate cash flow rights are greater, the board size and the board independence have more significantly positive impact on the quality of information disclosure, and the duality of board leadership structure and the number of annual board meetings also have significantly positive impact on the quality of information disclosure; After considering the influence of the separation of cash flow rights and control rights, we discovered that for the listed companies who have smaller separation of cash flow rights and control rights, the board size and the board independence have more significantly positive impact on the quality of information disclosure, and the duality of board leadership structure and the number of annual board meetings also have significantly positive impact on the quality of information disclosure.

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Chapter 35
An Evaluation of Evaluators: Multivariate Statistical Analysis of Journal Evaluation Indicators

Neil Desnoyers and Zongmin Li

Abstract Journal evaluation has blossomed over the past four decades. Not only the bibliometric indicators provided by the Journal Citation Reports (JCR), but alternatives such as Google Scholar, Scopus and many other recently-introduced indicators are becoming popular. However, high correlations between journal evaluation indicators indicate that the development of new variants of the indicators has resulted in hardly any additional empirical contribution, so the application of existing indicators is a more promising direction for future research. This paper attempts to show how to evaluate and classify journals using current journal evaluation indicators by various multivariate statistical analysis methods. Data were collected from all journals in the Operations Research & Management Science category of JCR (2012) and SCImago Journal & Country Rank (scimagojr.com). Analysis in other scholarly fields can be conducted using the same method but with different category data in JCR and SCImago Journal & Country Rank.

Keywords Journal evaluation · Bibliometric indicators · Multivariate statistical analysis

35.1 Introduction

Since the initial celebrated work by Garfield [1], Garfield and Merton [2] and Pinski and Narin [3] on the evaluation of the scientific impact of a scientific journal, a great

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body of research has emerged on the application of information processing methods for evaluating scientific publication venues. The journal citation reports (JCR) provided by the Institute for Scientific Information (ISI), instituted by the work of Garfield [2] are often the main source for these indicators to academic and research evaluation committees. Undoubtedly, in current academic practice, JCR is one of the most used sources for facilitating a researcher's access to high-quality, current research. At the same time, Google Scholar and Scopus are becoming popular [4, 5]. Moreover, as citation data have become more available, new formulae for analysis have been developed. The best known of the new formulae is the H index [6]. The definitions of some primary journal evaluation indicators are shown in Table 35.1.

Table 35.1 Definitions of some primary journal evaluation indicators

Indicator	Definition
SJR	SJR ranks scholarly journals based on citation weighting schemes and eigenvector centrality [7].
H index	Retrieving all source items of a given journal from a given year and sorting them by the number of "Times Cited", the H index is the highest rank number which is still lower than the corresponding "Times Cited" value [8].
Total Cites	Total number of citations garnered in a time period.
IF	Impact Factor of a journal is a measure reflecting the average number of citations to recent articles published in the journal [1, 9].
5-year IF	The 5-year journal Impact Factor is the average number of times articles from the journal published in the past five years have been cited in the JCR year. It is calculated by dividing the number of citations in the JCR year by the total number of articles published in the 5 previous years.
Immediacy	The Immediacy Index is the average number of times an article is cited in the year it is published [10].
Articles	The total number of articles published in the JCR year in all journals in the scholarly category [10].
Cited-half life	The median age of the articles that were cited in the JCR year. Half of cited articles were published more recently than the cited half-life [10].
Eigenfactor	The Eigenfactor Score calculation is based on the number of times articles from the journal published in the past five years have been cited in the JCR that year [10].
Article Influence	The Article Influence determines the average influence of a journal's articles over the first five years after publication [10].

Although all indicators are of significance for quantitative journal evaluation, every index does have problems [11]. Even the most widely accepted IF index has non-ignorable shortcomings [12]. Therefore, how to use these indicators appropriately becomes a critical question. In addition, high correlations between indicators indicate that the development of new variants of the index has resulted in hardly any empirical improvement [13]. This suggests that the application of existing indicators is a more promising direction for future research.

This paper attempts to show how to evaluate, analyze and identify journals using current journal evaluation indicators by employing various multivariate statistical analysis methods. The statistical package SPSS 19.0 is utilized for the analysis. We will answer the following critical questions in this paper: Which indicators should be adopted to describe the general performance of journals and what attributes are these indicators depicting? Do journals with different specialties have significantly different performance? How to identify top journal using current indicators? Data were collected from all journals in the Operations Research & Management Science category of JCR (2012). SJR and H index data were collected from SCImago Journal & Country Rank (scimagojr.com). Analysis in other scholarly fields can be conducted using the same method but with different category data in JCR.

35.2 Missing Data Analysis

As shown in Table 35.2, there are some missing data (journal evaluation indicators) among the data set. Especially, there are 33.8% missing data in the Cited-half life indicator. Considering that the data are from only 77 journals in the category of Operations Research & Management Science, we decide to predict missing data instead of simply deleting journals with missing data.

Table 35.2 Univariate statistics of journal evaluation indidcators

	N	Mean	Std. Deviation	Missing	
				Count	Percent
SJR	75	1.1206	0.9092	2	2.6
H index	75	34.3333	24.5425	2	2.6
Total Cites	77	2001.1688	3425.6897	0	0.0
2008 IF	73	0.8949	0.6921	4	5.2
2009 IF	73	1.1573	0.7368	4	5.2
2010 IF	73	1.1550	0.8285	4	5.2
2011 IF	77	1.0389	0.7545	0	0.0
08-10 aver IF	73	1.1072	0.6886	4	5.2
5-year IF	64	1.4653	0.9603	13	16.9
Immediacy	77	0.1601	0.1477	0	0.0
Articles	77	98.2987	200.9999	0	0.0
Cited-half life	51	6.4569	1.9165	26	33.8
Eigenfactor	77	0.0056	0.0088	0	0.0
Article Influence	64	0.7714	0.4926	13	16.9

We adopt the EM algorithm to predict missing data. The EM algorithm has been the object of considerable interest since the paper of Dempster et al [14]. It has proved a flexible tool for calculating maximum likelihood estimates in a variety of problems involving missing data or incomplete information. While the 33.8% missing data in the Cited-half life indicator is a moderately high level, the EM algorithm with 25 iterations (SPSS default) should provide acceptable efficiency [15].

35.3 Principal Component Analysis of Journal Evaluation Indicators

Empirical studies show that there are high correlation coefficients among those indicators, so it is redundant to use all these indicators because of the exclusiveness principle [19, 20]. However, which indicators should be adopted in journal evaluating and what attributes are these indicators depicting? To answer these questions, after predicting missing data, this paper conducts a principal component analysis of journal evaluation indicators listed in Table 35.1. To track more information, this paper considers the latest four years of IFs, and 2008-2010 average of IF for IF indicator at the same time.

As shown in Table 35.3, the value of the Kaiser-Meyer-Olkin (KMO) [16] is 0.816 and the significance probability for the χ^2 test in the Bartlett's Test is 0.000, indicating that these indicators are suitable for the principal component analysis. After the principal components extraction procedure, a rotated quartimax transformation is used in this paper as it has the best performance in making the component loadings incline to ± 1 or 0, therefore it is beneficial to explain the factors' practical meanings. The eigenvalue and total variance explained are shown in Table 35.4, and the quartimax rotated loading matrix is shown in Table 35.5.

Table 35.3 KMO and Bartlett's test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		0.816
Bartlett's Test of Sphericity	Approx.Chi-Square	1747.656
	df	91
	Sig.	0.000

Table 35.4 Total variance explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	9.040	64.572	64.572	9.040	64.572	64.572
2	1.781	12.720	77.292	1.781	12.720	77.292
3	1.398	9.986	87.278	1.398	9.986	87.278
4	0.490	3.502	90.780	0.490	3.502	90.780
5	0.369	2.639	93.419	0.369	2.639	93.419
6	0.339	2.423	95.842	0.339	2.423	95.842
7	0.224	1.601	97.444	0.224	1.601	97.444
8	0.148	1.054	98.498	0.148	1.054	98.498
9	0.073	0.522	99.020	0.073	0.522	99.020
10	0.048	0.340	99.360	0.048	0.340	99.360
11	0.040	0.283	99.643	0.040	0.283	99.643
12	0.028	0.201	99.845	0.028	0.201	99.845
13	0.016	0.111	99.956	0.016	0.111	99.956
14	0.006	0.044	100.000	0.006	0.044	100.000

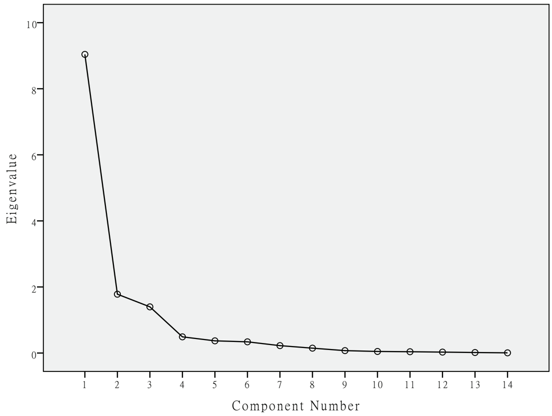

Fig. 35.1 Scree plot

In this paper, we choose four major components as the best solution for explaining the variability in the data. Although the eigenvalue of component 4 drops significantly from component 3 (as shown in the scree plot Fig. 35.1), and it is less than 1, we still include it. This is because component 4 represented by Articles is a very important aspect to depict journal's characteristics. It is also an important characteristic for authors to consider in choosing a journal to submit papers. All these 4 components extracted account for more than 90% of the total variance in the Initial Eigenvalues and the Extraction Sums of Squared Loadings, which is quite satisfactory.

Table 35.5 Quartimax rotated loading matrix for the 14 journal indicators with values above 0.7 given in bold face

	Component			
	1	2	3	4
SJR	**0.839**	0.094	0.112	−0.101
H index	**0.710**	0.499	0.354	0.100
Total Cites	0.506	**0.822**	0.160	0.166
2008IF	**0.883**	0.110	0.188	0.185
2009IF	**0.957**	0.067	−0.074	0.119
2010IF	**0.968**	0.016	−0.092	−0.059
2011IF	**0.953**	−0.018	−0.062	0.029
08-10averIF	**0.981**	0.066	−0.069	0.063
5yIF	**0.975**	0.028	0.066	−0.006
Immediacy	**0.802**	−0.069	0.006	−0.052
Articles	0.255	0.323	−0.135	**0.900**
Cited-halflife	0.260	0.156	**0.944**	−0.117
Eigenfactor	0.488	**0.843**	0.046	0.184
Article Influence	**0.729**	0.110	0.307	−0.178

Table 35.6 Pearson correlation coefficients table of journal evaluation indicators

	H index	Total Cites	2008IF	2009IF	2010IF	2011IF	08-10 averIF	5yIF	Imme-diacy	Articles	Cited-halflife	Eigen-factor	Article Influence
SJR	0.730	0.497	0.674	0.762	0.805	0.766	0.782	0.839	0.616	0.127	0.359	0.483	0.755
H index	1	0.831	0.729	0.695	0.658	0.652	0.699	0.734	0.494	0.391	0.575	0.791	0.575
Total Cites	0.831	1	0.594	0.538	0.480	0.464	0.551	0.534	0.350	0.521	0.392	0.966	0.492
2008IF	0.729	0.594	1	0.894	0.789	0.787	0.896	0.846	0.716	0.403	0.408	0.577	0.709
2009IF	0.695	0.538	0.894	1	0.904	0.887	0.971	0.906	0.746	0.384	0.175	0.550	0.657
2010IF	0.658	0.480	0.789	0.904	1	0.925	0.960	0.935	0.756	0.212	0.171	0.466	0.668
2011IF	0.652	0.464	0.787	0.887	0.925	1	0.914	0.952	0.788	0.275	0.178	0.444	0.607
08-10averIF	0.699	0.551	0.896	0.971	0.960	0.914	1	0.934	0.776	0.338	0.193	0.544	0.690
5yIF	0.734	0.534	0.846	0.906	0.935	0.952	0.934	1	0.743	0.243	0.321	0.494	0.739
Immediacy	0.494	0.350	0.716	0.746	0.756	0.788	0.776	0.743	1	0.127	0.211	0.309	0.550
Articles	0.391	0.521	0.403	0.384	0.212	0.275	0.338	0.243	0.127	1	−0.118	0.555	-0.006
Cited-halflife	0.575	0.392	0.408	0.175	0.171	0.178	0.193	0.321	0.211	−0.118	1	0.282	0.549
Eigenfactor	0.791	0.966	0.577	0.550	0.466	0.444	0.544	0.494	0.309	0.555	0.282	1	0.454
Article Influence	0.575	0.492	0.709	0.657	0.668	0.607	0.690	0.739	0.550	−0.006	0.549	0.454	1

In Table 35.5, choosing a threshold level of 0.7 leads to a clear interpretation. SJR, H index, all IF indicators, Immediacy and Article Influences fall into the first component; 2011-total cites and Eigenfactor fall into the second component; Cited-half life and Articles fall into the third and fourth component respectively. An interpretation of the components can be concluded as the following:

- The first component relates to journal impact, because the indicators that make up the first component all measure the impact.
- The second component relates to the total influence, since Eigenfactor score and Total Cites provide measures of the total influence that a journal provides, rather than measures of influence per article. The indicators in the first component, by contrast, measure the per-article influence of a given journal [17].
- The third component relates to the journal timeliness [18].
- The fourth component relates to the volume scale.

Correlation analysis shows that there are high correlation coefficients among indicators in each component (as shown in Table 35.6). Therefore, it is enough to choose one indicator in each component to describe journals' general performance. In this paper, we choose 2011IF for impact component, since it is the latest data and has more than 95% loading. We choose Eigenfactor for total influence component as it has clearly highest loading in this component. Similarly, we choose Cited-half life and Articles for journal timeliness and volume scale respectively. Therefore, to see the general performance of journals in Operations Research & Management Science category, we can examine their records in 2011IF, Eigenfactor, Cited-half life and Articles.

35.4 Specialty Analysis

Based on the report of Chinese Academy of Sciences, journals in the Operations Research & Management Science category can be further divided into four groups based on their specialty. Specifically, there are 37 journals specialized in management science, 29 in engineering technology, 10 in math and 1 in social science. To explore the performance difference in journals with different specialties, we conducted an multivariate analysis of variance.

As shown in Table 35.7, it is significant that journals with different specialties differ in performance. According to the results in Sect. 35.3, we compare 2011IF, Articles, Cited-half life and Eigenfactor of different specialties journals. As shown in Table 35.8, management science journals have the highest average IF in 2011 and Eigenfactor score. Engineering technology journals have the largest volume, which is nearly 3 times that of social science journals. Engineering technology journals also have the best cited-half life. In addition, it is worthwhile to note that there is a prominent fluctuation in the IF of management science journals.

Table 35.7 Multivariate tests

Effect		Value	F	Hypothesis df	Error df	Significance
Specialty	Pillai's Trace	1.653	3.168	56.000	252.000	0.000
	Wilks' Lambda	0.009	10.013	56.000	235.561	0.000
	Hotelling's Trace	52.014	54.336	56.000	234.000	0.000
	Roy's Largest Root	51.084	229.876	14.000	63.000	0.000

Table 35.8 Report

Specialty		2011IF	Articles	Cited-half life	Eigenfactor
Management science	Mean	1.14000	89.81	6.98	0.0069911
	N	37	37	37	37
	Std. Deviation	0.911096	98.610	2.447	0.01114973
	Range	4.162	444	14	0.06080
Engineering technology	Mean	0.95897	120.17	6.65	0.0042134
	N	29	29	29	29
	Std. Deviation	0.629784	309.254	2.463	0.00634066
	Range	2.606	1692	10	0.02821
Math	Mean	0.89860	72.70	8.32	0.0051140
	N	10	10	10	10
	Std. Deviation	0.410201	41.247	1.291	0.00425788
	Range	1.226	126	4	0.01328
Social science	Mean	1.01900	34.00	5.70	0.0016700
	N	1	1	1	1
	Std. Deviation	.	.	.	.
	Range	0.000	0	0	0.000
Total	Mean	1.03890	98.30	7.01	0.0056321
	N	77	77	77	77
	Std. Deviation	0.754497	201.000	2.359	0.00881786
	Range	4.162	1698	16	0.06094

35.5 Identifying the Top Journals

Identifying the top journals is a hot topic as it is close to scholars' promotion and tenure decision and there are various definitions and criterions for "top journals" [21].

This paper uses discriminant analysis to identify the top journals. First, we standardized data using "Zscore" which is a standard scores using the normal distribution. This is because indicators are not of the same scale (e.g., Articles indicator is in 10-1000 scale, but Eigenfactor is in 0.01-0.0001 scale), and the analysis results will be dominated by the larger scale data. Standardizing of the data can avoid the influence of dimension/scale on the accuracy of results and provide a better quality data structure. We use "1" to denote top journal and 0 denotes negative according to the journal list from the Chinese Academy of Sciences. After conducting discriminant analysis in SPSS 19.0, we obtain standardized canonical discriminant function coefficients. The standard canonical discriminant function of Zscores is as following:

$$\begin{aligned} \text{ZFun} = {} & 0.94\text{Zscore}(2011\text{IF}) - 0.721\text{Zscore}(\text{Articles}) - 0.474\text{Zscore}(\text{Cited-half life}) \\ & + 0.728\text{Zscore}(\text{Eigenfactor}). \end{aligned}$$

Table 35.9 Eigenvalues

Function	Eigenvalue	% of variance	Cumulative %	Canonical correlation
1	1.178	100.0	100.0	0.735

Table 35.10 Wilk's Lambda

Test of Function	Wilk's Lambda	Chi-square	df	Significance
1	0.459	56.825	4	0.000

As shown in Table 35.9 and Table 35.10, the canonical discriminant function achieve satisfactory canonical correlation and the function is significant. In this case, 97.4% of original grouped cases are correctly classified. Only Mathematical Programming is identified as a "non-top journal", but in fact it is a "top journal", and Transportation Research Part B-Methodological is identified as a "top journal", however, it is not.

35.6 Conclusion

We used various multivariate statistical analysis methods to show how to evaluate and classify journals using current journal evaluation indicators. Firstly, we predicted missing data using the EM algorithm. Then we conducted principal component analysis to get basic attribute groups of journal evaluation indicators and chose the most basic indicators in describing journals' general performance. After that, we conducted an multivariate analysis of variance of journals with different specialties. The results show that journals with different specialties have significantly different performance. Following this, we used discriminate analysis to identify the top journals. The canonical discriminant function shows the satisfactory performance of our method. We note that the results in this paper are only based on the Operations Research & Management Science category of JCR and they cannot be simply applied to journals in other categories. However, the methods are widely applicable. Future research include journal evaluation in different areas, application of other multivariate statistical analysis methods in journal evaluation.

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Chapter 36
Economic Determinants of Workers' Remittances in Pakistan

Asif Kamran, Sadaf Alam, Kaleem A. Ghias and Syed Nayyer Ali

Abstract Workers' remittances have become the second foremost source of monetary flows to developing countries. Pakistan has experienced fluctuations in economic indicators in the past that hindered the flow of workers' remittances in the country. According to World Bank data, Pakistan has become fifth largest remittances receiving developing country in 2011. This paper explores the economic determinants of workers' remittances of Pakistan using annual data spanning from 1990 to 2010. Research aims to analyze the extent to which multi variables impacts the flow of workers' remittances in Pakistan. The research is causal and explanatory in nature and follows quantitative research design. This study identifies empirically verified economic determinants of workers' remittances of Pakistan by using multiple regression. The quantitative substantiation of multiple regression analysis shows that FDI, exchange rate and GDP appeared to be important determinants of workers' remittances, other determinants of workers' remittances are inflation rate and interest rate. In particular, workers' remittances increased with the increase in GDP and FDI. Contrasting to this, rise in interest rate and fluctuation in inflation level lowers the inflows of workers' remittances in Pakistan, as greater insecurity in relation to price changes in future period and high inflation reduces the return on funds remitted.

Keywords Remittances (R) · Foreign Direct Investment (FDI) · Inflation Rate (IR) · Gross Domestic Product (GDP) · Real Interest Rate (RIR)

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36.1 Introduction

Worker's remittances are the segment of cross-border income that migrants send to residence country. Worker's remittances are considered as fundamental external source of investment for developing countries. Global transfers of remittances to developing countries have grown steadily in the last 10 years and exceed $100 billion worldwide [6]. Pakistan has also experienced same trend in the flow of workers' remittances like other developing countries. State Bank of Pakistan (SBP) data showed that workers' remittances recorded a substantial growth of 17.7 percent as compared to fiscal year 2010-11 and reached a record level of $13.186 billion.

Remittances do respond to staged changes in economic activity in recipient countries and overall price stability. Pakistan has experienced cycles in inflation and real economic activity in the history that has hindered the flow of worker's remittances in Pakistan. Remittances are not only the source of investment but play a fundamental role in poverty alleviation for the developing countries as it is a great source of income generation and employment. Increased income helps economies to provide individuals with numerous investment opportunities.

36.2 Literature Review

The relationship of remittances with many variables is well discussed in many research studies carried out all over the world. Russell [8], Burney [2, 3], Gupta [5] identified the economic determinants of remittances using technique of Ordinary Last Squares (OLS). By taking the data of different countries they all have tested the empirical relationship between workers' remittances and its economic determinants. El-Sakka [4] in his study considered the macroeconomic determinants of immigrants' remittances in Egypt by using data spanning from the period of 1967 to 1991. Study used Ordinary Least Square (OLS) regression technique. Wage rate of worker, domestic income, domestic price level, the domestic and world interest rates, and the official and black market exchange rates were the determinants of remittances.

According to the study difference in exchange rate and interest rate are imperative in directing the flow of remittance through authorized channels. Low interest rate in home country induces workers to send fewer remittances. High rate of inflation in home country reduces the income which forces them to migrate and therefore increases the remittances. The research also finds that with high income elasticity, when remittances are used to financed imports it has also the significant impact in attracting the flow of remittances in that nation.

Adams [7] studied the factors that influence the different level of remittances flowing in developing nations by using OLS regression. Study utilized data of 76 low- and middle-income developing countries.

Variables considered for the study were exchange rate, poverty, interest rate, level of per capita GDP and skills of migrants. The paper discovered that skills of migrants matter a lot in determining the flow of remittances. Remittance flow was higher in countries from where low skilled workers went abroad. Results also suggest that an inverted-U shaped curve subsists between the level of per capita GDP in a country and the receipt of remittances. Exchange rate and interest rate does matter in determining the flow of remittances whereas; poverty does not have significant impact on flow of remittances in developing countries.

36.3 Research Methodology

36.3.1 Hypothesis

This research tests this hypothesis:
H_0: $\beta_1 = \beta_1 = \beta_2 = \beta_3 = \beta_4 = \beta_5 = 0$. All slope coefficients are simultaneously zero.
H_1: $\beta_1 = \beta_1 = \beta_2 = \beta_3 = \beta_4 = \beta_5 \neq 0$. Not all slope coefficients are simultaneously zero.

36.4 Data and Construction of Variables

The main purpose of this study is to examine empirically the economic determinants of the price of workers' remittances in Pakistan.

To find out the determinants of remittances this equation was developed. Parenthesis shows expected signs of the coefficients.

$$\log(\mathrm{WR}) = \beta_0 + \overset{(+)}{\beta_1 \mathrm{GDP}} + \overset{(-)}{\beta_2 \mathrm{EXR}} + \overset{(-)}{\beta_3 \mathrm{INT}} + \overset{(-)}{\beta_4 \mathrm{INF}} + \overset{(+)}{\beta_5 \log(\mathrm{FDI})}. \quad (36.1)$$

Graph (a) of Fig. 36.1 shows trends in exchange rate of Pakistani rupee. From 1990 to 2010 Pakistani rupee has continued to depreciate, stability in exchange rate can be seen from 2001 to 2007 due to political and economic stability.

Graph (b) of Fig. 36.1 indicates trends in foreign direct investment. From 1990 to 1995 FDI has increased slightly. From 1996 to 2000 it has fallen from \$1 billion to \$0.332 billion due to political instability and economic sanctions that can also be observed in graph (a) where large fluctuation can be observed in currency depreciation. FDI has reached to \$5.41 billion in 2005 due to political stability and consistency in economic policies. One of the main reasons of this highest level of FDI was interest rate that was recorded at its lowest level in the same period.

Graph (c) of Fig. 36.1 shows the trends in GDP growth rate of Pakistan's economy. From 1990 to 2010 economy has faced unpredictability in economic growth rates. In 1990 GDP growth rate was 3.5 percent; in 1993 it fell to 2.3 percent due to political instability in the country. From 2002 to 2005 Pakistan's economy has

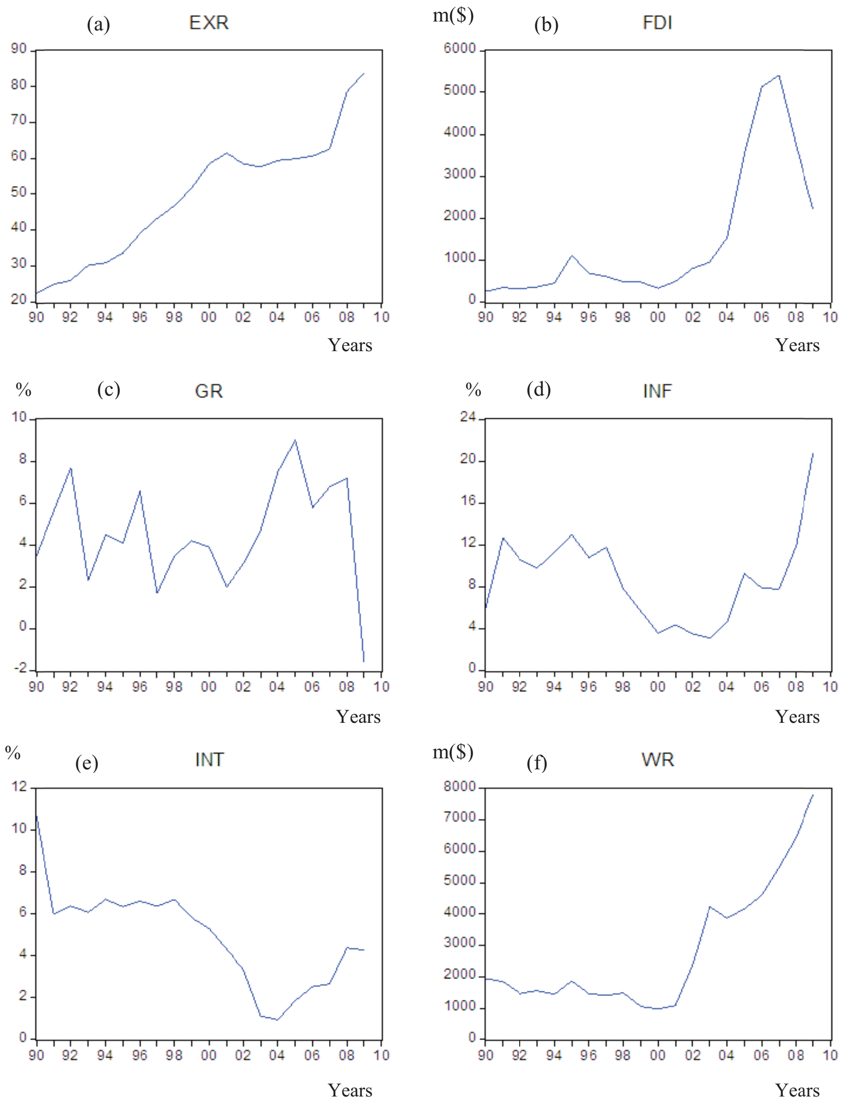

Fig. 36.1 Trends of dependant and independent variables

experienced very good economic conditions due to political stability and inflow of FDI.

It can be easily seen in graph (d) of Fig. 36.1 that in 1990 inflation rate was 6 percent; in 2002 it was at its lowest level of 3.1 percent as the monetary policy stance was towards increasing GDP. Large fluctuation in inflation rate can be observed in

2009 when inflation rate of 20.8 percent was recorded, the reasons for this increase were oil price shocks and after effects of bubble economy of previous regime.

Graph (e) of Fig. 36.1 shows the trends in interest rate in the economy. Highest interest rate of 10.66 percent was recorded in 1990. During the period of 2002-04 interest rates were low, indicating easy monetary policy stance of SBP.

Trends in workers' remittances can be observed from graph (f) of Fig. 36.1. During the early 1990s, the Gulf crisis declined the export of Pakistani workers to the Middle East. Precipitous decline in remittances can be observed in 1998 to 2000, when the foreign currency accounts of Pakistan were seized after nuclear explosion. From 2001 to 2004 workers remittances has increased remarkably and first time reached to \$4.23 billion in the comparable time period. One of the reasons is 911 incident and continuous depreciation of Pakistani rupee that has enforced people to take advantage of currency differences.

36.5 Empirical Results

Results of output of regression run in Eviews are presented as follows.

$$\log(\mathrm{WR}) = 7.651 - 0.008\mathrm{INF} + 0.160\log(\mathrm{FDI}) - 0.003\mathrm{EXR} - 0.069\mathrm{INT} \\ +0.000000243\mathrm{GP}.$$

Table 36.1 represents descriptive statistics of all variables taken into the regression equation. Statistics of skewness and kurtosis indicates that all variables are normally distributed except GDP and FDI. As values of skewness is close to zero and kurtosis near 3, fulfilling the criteria of normal distribution.

Table 36.1 Descriptive statistics

	EXR	FDI	GP	INF	INT	WR
Mean	51.22524	1489.871	4924913.	8.961905	4.893333	3121.491
Median	57.57000	682.1000	3778155.	9.300000	5.300000	1866.100
Maximum	86.64000	5410.200	15402783	20.80000	10.66000	8905.900
Minimum	22.42000	246.0000	892843.0	3.100000	0.950000	983.7300
Std. Dev.	19.01892	1616.914	4107906.	4.263622	2.303568	2362.939
Skewness	0.153479	1.391741	1.183814	0.734446	0.213387	1.138461
Kurtosis	2.158112	3.620242	3.483825	3.851548	3.250949	3.155463
Observations	21	21	21	21	21	21

The correlation matrix reveals pair-wise correlation. Results indicates that three variables including FDI, exchange rate and GDP are highly positively correlated with workers remittances as its values are 0.67, 0.78 and 0.95 respectively where as, two variables inflation rate and interest rate are moderately correlated with workers remittances as it can be observed from their values of 0.39 and 0.49 respectively.

Table 36.2 Correlation matrix

	EXR	FDI	GP	INF	INT	WR
EXR	1.000000	0.565793	0.917644	0.070599	−0.638862	0.788391
FDI	0.565793	1.000000	0.667524	0.145480	−0.563883	0.676894
GP	0.917644	0.667524	1.000000	0.308073	−0.528916	0.954089
INF	0.070599	0.145480	0.308073	1.000000	0.227503	0.391459
INT	−0.638862	−0.563883	−0.528916	0.227503	1.000000	−0.490431
WR	0.788391	0.676894	0.954089	0.391459	−0.490431	1.000000

36.5.1 Analysis of Results

(1) Coefficients and intercept

Coefficient corresponds to the regression equation between workers' remittances (dependent variable) and inflation rate, interest rate, FDI, exchange rate and GDP. The parameters signs are as expected. As it can be easily noticed, the relationship between workers' remittances and inflation rate, interest rate, FDI, exchange rate and GDP fulfill the criterion on coefficient signs, which implies a positive relationship between workers' remittances, GDP and FDI, and negative relationship between workers' remittances, inflation rate, interest rate and exchange rate thus correspond the theoretical model.

Results show that over the period of time 1990-2010, workers' remittances in Pakistan have increased very slightly about 0.000000243 percent for a percent increase in GDP. Workers' remittances have decreased about 0.033 percent, 0.069 percent and 0.008 percent for a percent increase in exchange rate, interest rate and inflation rate respectively. Workers' remittances in Pakistan for the same period have increased about 0.106 percent for a percent increase in FDI.

The intercept value of 7.65 percent shows that if the FDI, GDP, inflation rate, interest rate and exchange rate were zero on average, worker's remittances per year would have been 7.65 percent.

(2) R square and adjusted R^2

R squared measures the goodness of fit also called goodness of fit, its value of 0.911 means that about 91.1 percent variations in mean workers' remittances are explained by all variables (FDI, inflation rate, interest rate, exchange rate and GDP) incorporated in the model.

For multiple regressions adjusted R^2 gives true results as it is calculated after adjusting degree of freedom. Its value of 0.88 is indicating that 88.0 percent variation in mean workers' remittances is explained by all variables taken into the model.

(3) Sum squared residuals

Statistics for sum squared residuals in Table 36.3 shows that around 14 percent variation in workers' remittances is not explained by the model, whereas around 86 percent variation in the model is explained by all explanatory variables taken into regression.

Values of S.E regression 0.23 indicates that the average amount of error in predicting workers remittances is 0.23.

Table 36.3 Regression result

Dependent variable: log(WR)
Method: Least squares
Sample: 1990-2010
Included observations: 21

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	7.651830	0.936610	8.169707	0.0000
INF	−0.008152	0.016996	−0.479644	0.6384
log(FDI)	0.160107	0.107620	1.487703	0.1575
EXR	−0.033584	0.009152	−3.669564	0.0023
INT	-0.069935	0.040393	−1.731357	0.1039
GP	$2.43E-07$	$4.71E-08$	5.152285	0.0001
R-squared	0.911485	Mean dependent var		7.801966
Adjusted R-squared	0.881980	S.D. dependent var		0.698417
S.E. of regression	0.239935	Akaike info criterion		0.218057
Sum squared resid	0.863530	Schwarz criterion		0.516492
Log likelihood	3.710401	F-statistic		30.89245
Durbin-Watson stat	1.343185	Prob (F-statistic)		0.000000

36.5.2 Hypothesis Testing

(1) Hypothesis testing about regression coefficients

T-statistics: *T* calculated value for inflation rate is 0.47 which is greater than tabulated value of *t* at 5 percent confidence interval. *P* values are insignificant to reject null hypothesis. So, null hypothesis that $\beta_1 = 0$ can be rejected.

T calculated value for FDI is 1.48 which is less than tabulated value of *t* at 5 percent confidence interval. So, null hypothesis that $\beta_2 = 0$ can be rejected at 15 percent confidence level. *T* calculated value for exchange rate is 3.66 which is greater than tabulated value of *t* at 5 percent confidence interval. *P* values are also significant to reject null hypothesis. So, null hypothesis that $\beta_3 = 0$ can be rejected.

T calculated value for interest rate is 1.73 which is greater than tabulated value of t at 10 percent confidence interval. *P* values are also significant to reject null hypothesis. So, null hypothesis that $\beta_4 = 0$ can be rejected.

T calculated value for GDP is 5.15 which is greater than tabulated *t* value at 5 percent confidence interval. *P* values are also significant. Result of *t* statistics shows that *P* value of obtaining *t*-value of as much as or greater than 5.15 is very small, *P* values indicates that probability of committing a type I error is zero. So, null

hypothesis that $\beta_5 = 0$ can be rejected.
(2) Testing overall significance of multiple regression

F-statistics: F calculated value is 30.89 which is greater than tabulated value of $F.P$ value of F statistics is also significant to reject null hypothesis of $\beta_0 = \beta_1 = \beta_2 = \beta_3 = \beta_4 = \beta_5 = 0$.
(3) Findings

The quantitative evidence shows that GDP and FDI are positively related to workers' remittances during 1990 to 2010. A positive but negligible relationship between workers' remittances and GDP has been found, implying that although remittances are associated with higher economic growth but these inflows are affected by some other factors as compare to GDP. These results seem to support the proposition developed earlier that remittances had positively contributed to output growth in Pakistan during 1990 to 2010. Thus, the increase in GDP may not be an important prerequisite for the sustainable level of workers' remittances.

If money supply exceeds trend GDP levels, disequilibrium in the money and goods market will occur creating thus inflationary pressures. Inflation creates an unattractive environment for all forms of foreign capital, including remittances. The estimated coefficient of inflation shows a negative impact on workers' remittances as instability in the prices decrease the incentives to send money to the home country. Pakistan's economy is facing double digit inflation for last several years and this high inflation has an economic cost. It undermines the economy's ability to generate long-lasting gains in output, incomes, and employment. It also creates uncertainty for consumers, businesses, and investors, and erodes the value of incomes and savings. Therefore, decrease the worker's remittances.

A strong positive relationship between workers' remittances and FDI has been found, implying that remittances are associated with higher inflows of foreign investment that reflects the confidence of remitter on economic and political stability.

The investment return in Pakistan is highly significant, and with unpredicted signs indicating that remitters responded to increase in interest rate negatively in Pakistan. More depreciation in exchange rate of home country decreases the transfer of money. Less amount of money is required to spend on consumption as home country's exchange rate depreciation increases purchasing power of population working abroad. In Pakistan depreciation of exchange rate has slowed down the worker's remittances as household can consume more with the same amount of remittances.

36.6 Conclusions

This study identifies the economic determinants of workers' remittances of Pakistan by estimating multiple regression equation which is found empirically verified. The results are encouraging, as they show that the FDI, interest rate in Pakistan, inflation rate, exchange rates, and Pakistan's economic conditions all play a strong role in explaining remittances. Result shows that flow of remittances is not highly linked with the GDP. This signifies that GDP is not a very vital determinant of the inflow of remittances to Pakistan as compare to other factors.

Exchange rate (depreciation) is a strong incentive for workers' remittances to home state. Opposing to this, an increase in interest rate and fluctuation in inflation rate lowers the inflows of worker's remittances in Pakistan, as ambiguity about price changes in future periods and high inflation lower the return on money remitted. Negative relation has been observed between interest rate and worker's remittances in Pakistan that implies that being a Muslim country people are more concerned to other incentives rather than interest rate. Summing up the results, variables fulfilled the entire condition imposed on the model. The response of workers' remittances is also consistent with existing data on all independent variables. In response to currency depreciation, increase in inflation and increase in interest rate, workers' remittances decline, whereas FDI and GDP has the tendency to increase the flow of remittances.

36.7 Policy Implications

The findings of the study suggest that accurate policies can direct remittance flows into more prolific investment activities in the future. Keeping in view the multiplier effects and potential benefits of remittances on the economy, more wise policies can be formulated to encourage the remitters to send more remittances. As a policy matter, the government should provide striking investment opportunities to attract more remittance flows. These opportunities may include housing schemes, microenterprises and other kinds of development projects.

It has been observed during the study that an accurate record of numbers of workers is lacked that also influence the formulation of appropriate policy. Additional efforts are required to be made to send workers through legal recruitment procedures, which will not only help to maintain an accurate record of number of workers going abroad but would also help to rise the level of workers' remittances sent to the financial system of the country.

Foreign policy of Pakistan should be revised with neighboring countries to minimize the barrier from export of manpower in order to get sustainable flows of remittances.

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Appendix

Trend of GDP, inflation rate, real interest rate, FDI, workers' remittances, and exchange rate are shown in Table 36.4.

Table 36.4 Trend of GDP, inflation rate, real interest rate, FDI, workers' remittances, and exchange rate

Years	Inflation rate % INF	Interest rate % INT	FDI m$ FDI	WR m$ WR	Exchange rate (Rs = $1) EXR	GDP (Rs. million) GP
1990	6.0	10.66	246	1942.35	22.42	892843
1991	12.7	6.0	335.1	1848.29	24.84	1044508
1992	10.6	6.38	306.4	1467.48	25.95	1223922
1993	9.8	6.09	354.1	1562.24	30.16	1351589
1994	11.3	6.7	442.4	1445.56	30.85	1577085
1995	13	6.35	1101.7	1866.1	33.56	1879965
1996	10.8	6.62	682.1	1461.17	38.99	2113037
1997	11.8	6.38	601.3	1409.47	43.19	2408962
1998	7.8	6.69	472.3	1489.55	46.79	2653292
1999	5.7	5.82	469.9	1060.19	51.77	2912832
2000	3.6	5.3	322.5	983.73	58.43	3778155
2001	4.4	4.33	484.7	1086.57	61.42	4155391
2002	3.5	3.35	798	2389.05	58.49	4476319
2003	3.1	1.13	949.4	4236.85	57.57	5027460
2004	4.6	0.95	1524	3871.58	59.35	5765058
2005	9.3	1.86	3521	4168.79	59.85	6634243
2006	7.9	2.53	5139.6	4600.12	60.63	7773106
2007	7.8	2.66	5410.2	5493.65	62.54	8830640
2008	12	4.38	3719.9	6451.24	78.49	10451715
2009	20.8	4.29	2205.7	7811.43	83.8	13070268
2010	11.7	4.29	2201	8905.9	86.64	15402783

Source: SBP Handbook of statistics on Pakistan's economy 2010 and Statistical Supplements (2008-09) ministry of finance, Pakistan.

Chapter 37
The Fuzzy Time-cost-quality-environment Trade-off Analysis of Resource-constrained Multi-mode Construction Systems for Large-scale Hydroelectric Projects

Huan Zheng

Abstract This paper studies the fuzzy time-cost-quality-environment trade-off problem of construction project and establishes a decision making model with multiple modes under resource-constrained environment. The objective functions are to minimize the total project time, total resource cost, quality defect of all activities, and the environment impact. Furthermore, a fuzzy based adaptive-hybrid genetic algorithm is developed for finding feasible solutions. More specifically, our approach treats the uncertainty by using fuzzy expected value operator or fuzzy simulation. Finally, Jinping-II hydroelectric project was used as a practical example to demonstrate the practicality and efficiency of the method. Results and sensitivity analysis are presented to highlight the performances of our optimization method, which is very effective and efficient as compared with other algorithms.

Keywords Time-cost-quality-environment trade-off · Multi-mode · Construction project · Fuzzy · Genetic algorithm

37.1 Introduction

Time, cost, quality and environment of project delivery are among the crucial aspects of construction projects [1, 2]. Emergence of new situation that places an increasing pressure on minimizing the environment impact of projects while minimizing its duration, executive cost, and improve quality of all activities, requires the development of models considering environment in addition to time, cost and quality which has been modeled extensively. 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

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of projects. As the basal construction systems for large-scale hydroelectric projects plays an important role, it often has a great of impaction on our ecological environment. Therefore, construction managers need to develop a project management decision for directing and controlling the duration, budget, quality and environment in a construction projects in order to achieve management objectives. Furthermore, to ensure that these important projects are carried through with maximum efficiency, its efficient project management decision is especially important. Recognition should be given to the fact that in practice one project faces multiple objective to optimize. For instance, when faced with an urgent case, construction managers would increase the allocation of capital under certain limit to shorten the duration or improve quality of the project while minimizing the impaction on environment when it is necessarily. 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 resource 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 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. A multi-objective time-cost-quality-environment trade-off problem under fuzzy environment is described, and assumptions and notation for this problem are presented in Sect. 37.2. A multi-objective fuzzy optimization model is then proposed for this problem. Sect. 37.3 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. 37.4.

37.2 Problem Description and Mathematical Formulation Model

37.2.1 Problem Description

We consider the problem in large construction projects, especially in construction systems for large-scale hydroelectric projects. Assume there are I interrelated activities that must be executed in a certain order before the entire task can be completed. For many uncertain factors and uniqueness of construction project, it is hard to know the exact duration of each activity and difficult to give a strict function of them because of lack of data and strict definition. In real world, there are many non-probabilistic factors that affect a large-scale construction projects and they should not be dealt with probability approaches. And some research have assumed activity duration is characterized by a fuzzy number due to environmental variation [3]. 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 resource 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.

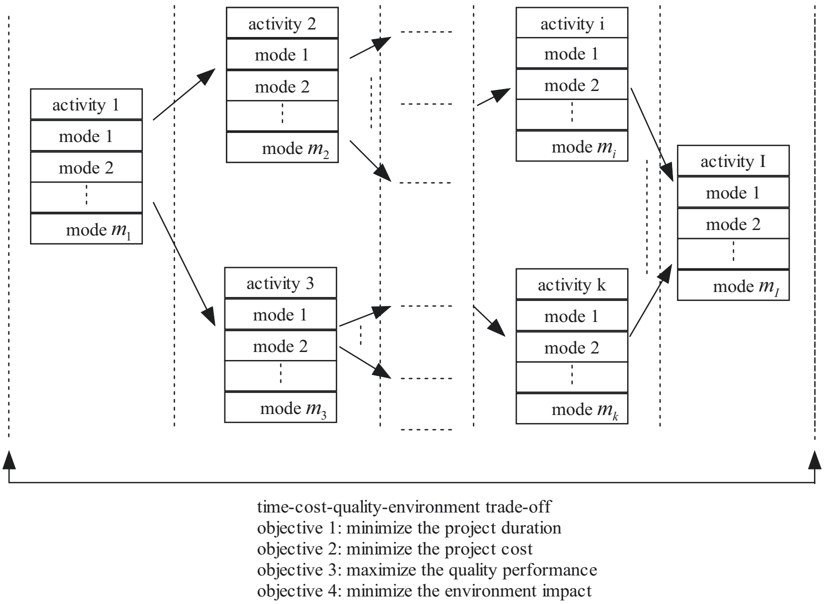

Fig. 37.1 The time-cost-quality-environment trade-off project

37.2.2 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, $p = 1, 2, \cdots, P_i$;
- q : renewable resource type index, $q = 1, 2, \cdots, Q$ (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;
- a_q : the unit price of resource q;
- r_{ijq} : Amount renewable resource q required per day when activity i is executed in mode j;
- R_q^M : maximum-limited resource q 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 bout 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_{irn} : the pondering coefficient which is assigned to each positive impact property n for positive environment impact r of activity i;
c_{ikf} : the pondering coefficient which is assigned to each negative impact property f for negative environment impact k of activity i;
$\tilde{p}_{ijrn}$: the positive environment impact property n for positive environment impact r in activity i of selected mode j;
$\tilde{p}_{ijkf}$: 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.

In order to transform these fuzzy variables into crisp numbers, we introduce the expected value operator for fuzzy measure *Me* Xu and Zhou [4] to deal with the uncertainty in the problem.

Due to all fuzzy variables are non-negative triangular fuzzy variable (Fig. 37.1 shows an example), so our problem belongs to the case of $E^{Me}[\xi] = \frac{(1-\lambda)r_1+r_2+\lambda r_3}{2}$.

Since all the fuzzy variables in the problem are triangular fuzzy numbers, the transformations are presented as follows,

$$\tilde{D}_{ij} \longrightarrow E[\tilde{D}_{ij}] = \frac{(1-\lambda)D_{ij1} + D_{ij2} + \lambda D_{ij3}}{2}.$$

37.2.3 Fuzzy Multi-objective Model

(1) Objective functions

The first objective is to minimize the resource cost. And activity cost is determined by the amount of resources consumed by the activity in a special mode. So the first objective is to minimize the total resource costs for the project. That is minimization the sum of the completion cost for all activities.

$$\min z_1 = \sum_{i=1}^{I} \sum_{q=1}^{Q} \sum_{j=1}^{m_i} \sum_{t=t_i^{EF}}^{t_i^{LF}} a_q r_{ijq} x_{ijt} E[\tilde{D}_{ij}]. \tag{37.1}$$

The second objective seeks to minimize the total project time. That is minimization the sum of the completion time for all activities.

$$\min z_2 = \sum_{j=1}^{m_I} \sum_{t=t_I^{EF}}^{t_I^{LF}} t x_{ijt}. \tag{37.2}$$

The third objective aims at minimizing project quality defect that is measured and quantified.

$$\min z_3 = \sum_{i=1}^{I} w_i \sum_{p=1}^{P_i} w_{i,p} \times Q_{i,p}^{j}. \tag{37.3}$$

The fourth objective is designed to minimize project environment impact that is measured and quantified.

The total $\overline{TV}$ is estimated by positive and negative environmental impacts $\overline{TV^+}$ and $\overline{TV^-}$. Pondering coefficients are assigned to each environmental factor to quantify the environmental significance of the factor, which can be estimated by convergence methods. These coefficients have to fulfil Equation (37.9).

$$\begin{aligned} \min z_4 = \quad & \overline{TV} = \overline{TV^+} - \overline{TV^-} = \sum_{i=1}^{I} y_i \left(\sum_{r=1}^{R} h_{ir} \overline{V_{ir}^+} - \sum_{k=1}^{K} h_{ik} \overline{V_{ik}^-} \right) \\ & = \sum_{i=1}^{I} y_i \left[\sum_{r=1}^{R} h_{ir} \sum_{n=1}^{N} c_{irn} \frac{\tilde{p}_{ijrn}^2}{100} - \sum_{k=1}^{K} h_{ik} \sum_{f=1}^{F} c_{ikf} \left(100 - \frac{\tilde{p}_{ijkf}^2}{100} \right) \right]. \end{aligned} \tag{37.4}$$

(2) Constraints

In project, precedence is the important basic term ensuring the rationality of the arrangement. Under this term, successive activities must be and can only be started with a certain mode when all the predecessors have already been completed with a certain mode.

$$\begin{aligned} & \sum_{j=1}^{m_e} \sum_{t=t_e^{EF}}^{t_e^{LF}} t x_{ejt} + \sum_{j=1}^{m_i} \sum_{t=t_i^{EF}}^{t_i^{LF}} E[\tilde{D}_{ej}] x_{ijt} \leq \sum_{j=1}^{m_i} \sum_{t=t_i^{EF}}^{t_i^{LF}} t x_{ijt}, \\ & i = 1, 2, \cdots, I, \; e \in Pre(i). \end{aligned} \tag{37.5}$$

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 as in Equation (37.6).

$$\sum_{j=1}^{m_i} \sum_{t=t_i^{EF}}^{t_i^{LF}} x_{ijt} = 1, \; i = 1, 2, \cdots, I. \tag{37.6}$$

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:

$$\sum_{i=1}^{I} w_i = 1. \tag{37.7}$$

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:

$$\sum_{p=1}^{P_i} w_{i,p} = 1,\ i = 1,2,\cdots,I. \tag{37.8}$$

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:

$$\sum_{i=1}^{I} y_i = 1. \tag{37.9}$$

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:

$$\sum_{r=1}^{R} h_{ir} + \sum_{k=1}^{K} h_{ik} = 1,\ i = 1,2,\cdots,I. \tag{37.10}$$

Pondering coefficients have to be assigned to each impact property to quantify the influence of each $\overline{v_i}$ on the value of the environmental impact V. They have to fulfil the following conditions:

$$\sum_{n=1}^{N} c_{irn} = 1,\ r = 1,2,\cdots,R,\ i = 1,2,\cdots,I, \tag{37.11}$$

$$\sum_{f=1}^{F} c_{ikf} = 1,\ k = 1,2,\cdots,K,\ i = 1,2,\cdots,I. \tag{37.12}$$

The total cost of all activities scheduled in time t cannot exceed the capital limit per period. In time-cost-quality-environment problem, we think capital used by all activities do not exceed limited quantities in any time period and the execution mode for all activity. The sum of the capital consumptions of all activities which are scheduled in a certain time period during the whole project duration, as well as in a certain mode in Equation (37.14).

$$\sum_{i=1}^{I}\sum_{j=1}^{m_i} r_{ijq} \sum_{s=t}^{t+E[\tilde{D_{ij}}]-1} x_{ijs} \leq R_q^M,\ t = 1,2\cdots,\lceil E[\tilde{T}_{I+1}]\rceil,\ q = 1,2\cdots,Q. \tag{37.13}$$

In order to describe some non-negative variables and 0-1 variables in the model for practical situation, the constraints in Equation (37.14) $\sim$ Equation (37.15) are presented. Non-negativity constraints on decision variable and its revelent variable

$$E[\tilde{D}_{ij}],\ E[\tilde{T}],\ t_i^{EF},\ t_i^{LF} \geq 0,\ i=1,2,\cdots,I,\ j=1,2,\cdots,m_i, \tag{37.14}$$

$$x_{ijt}=0 \text{ or } 1,\ i=1,2,\cdots,I,\ j=1,2,\cdots,m_i,\ t=1,2,\cdots,\lceil E[\tilde{T}_{I+1}]\rceil. \tag{37.15}$$

Constraints on project completion time. As is generally known, construction managers confirm an expected duration of the project beforehand to coordinate the whole project or other projects.

$$E[\tilde{T}_{I+1}] \leq E[\tilde{T}]. \tag{37.16}$$

37.3 Case Study: The Time-cost-environment Trade-off for Jinping-II Hydroelectric Project

This section is the practical application to a working procedure at a large-scale hydroelectric construction project. The procedure contains thirteen activities and two dummy activities (start and end activity). Each activity must be performed in one of m_i possible modes, where each activity-mode has fixed duration corresponding quality defect and environment impact, and requires a constant budget.

37.3.1 Presentation of the Case Problem

Jinping-II Hydroelectric Project is located on the large Jinping River Bend, and is the second of the five cascade projects on the river section from Kala down to the estuary. It is designed to cut the 150km river bend by a group of power tunnels to use the natural drop created by the bend. The project primarily consists of a headwork sluice dam, spillway structures, power tunnels and powerhouse complex. The dam is 7.5km downstream of Jinping-I dam. The catchment area upstream of the dam is 103,000 km^2, and the multi-year average inflow at the dam site is 1,220 m^3/s.

Jinping-II reservoir itself only has a capacity of daily regulation, but when jointly operated with Jinping-I, it also has the capacity of yearly regulation. The 4 power tunnels have an average length of 16.6 km and an excavated diameter of 13 m, which are among the world's longest and largest hydraulic tunnels. The powerhouse complex sits underground on the other side of the river bend. The project has a total installed capacity of 4,800 MW (8$\times$600 MW), which gives a multi-year average annual generation of 24.23 TWh.

The detailed corresponding data for each activity is as follows in Table 37.1 and Table 37.2.

Table 37.1 The number, mode, duration, budget, predecessor and two kinds of weight of each activity

I	II	III	IV	V	VI	VII	VIII
1	Dummy activity						
2	1	(2,3,4)	12	8	1	0.06	0.044
	2	(7,9,11)	10	6			
3	1	(0.5,1,1.5)	16	8	1	0.03	0.1
	2	(0.5,1,1.5)	14	6			
	3	(3,5,7)	12	8			
4	1	(2,5,8)	14	8	1	0.06	0.09
	2	(7,8,9)	12	6			
5	1	(3,6,9)	4	10	2	0.07	0.0875
6	1	(1,2,3)	4	4	3	0.15	0.056
	2	(2,6,10)	4	6			
7	1	(1,3,5)	10	10	2,3	0.12	0.11
	2	(7,8,9)	10	8			
8	1	(3,4,5)	12	8	6	0.1	0.0375
	2	(9,10,11)	6	4			
9	1	(1,2,3)	4	8	5	0.04	0.1
	2	(4,7,10)	2	6			
	3	(8,10,12)	2	4			
10	1	(0.5,1,1.5)	8	8	5,7	0.06	0.1
	2	(0.5,1,1.5)	10	4			
	3	(8,9,10)	8	12			
11	1	(4,6,8)	10	4	4,6,7	0.09	0.11
	2	(6,9,12)	6	2			
	3	(8,10,12)	12	2			
12	1	(9,11,13)	12	4	8,10	0.09	0.075
	2	(5,8,11)	14	8			
13	1	(4,5,6)	4	6	8,9,11	0.04	0.05
	2	(3,6,9)	6	6			
	3	(5,7,9)	8	4			
14	1	(2,4,6)	4	8	9	0.09	0.05
	2	(1,3,5)	6	10			
15				Dummy Activity			

Note: I: Activity i; II: Mode j; III: Duration (month) $\tilde{D}_{ij}$; IV: Resources consumption (r_{ij1}); V: Resources consumption (r_{ij2}); VI: Predecessor $(Pre(i))$; VII: Weight activity for quality (w_i); VIII: Weight activity for environment (y_i).

Based on the representation of the case problem, the proposed methods can be used to model it in Equation (37.13) and obtain the project scheduling model for our project.

Table 37.2 Activity mode option, their corresponding quality indicators and quality performance

I	II	IX	X	I	II	IX	X
2	1	43.5,38.54	0.63,0.37	9	1	71,76.97	0.33,0.67
	2	31,14.785	0.63,0.37		2	49,50.49	0.33,0.67
					3	41,35.775	0.33,0.67
3	1	77.5,85.605	0.28,0.72	10	1	34,33.022	0.32,0.68
	2	70.5,65.175	0.28,0.72		2	47.5,51.1765	0.32,0.68
	3	49,50.39	0.28,0.72		3	24,25.47	0.32,0.68
4	1	19,13.695	0.56,0.44	11	1	26,20.6	0.3,0.7
	2	43,39.965	0.56,0.44		2	18,16.07	0.3,0.7
					3	34.5,32.835	0.3,0.7
5	1	31.5,24.525	0.58,0.42	12	1	19.5,13.595	0.52,0.48
					2	29.5,26.01	0.52,0.48
6	1	28.5,25.54	0.38,0.62	13	1	59,82.335	0.85,0.15
	2	26,21.7	0.38,0.62		2	48.5,58.5	0.85,0.15
					3	43.5,3.5	0.85,0.15
7	1	44,40.41	0.35,0.65	14	1	21,10.16	0.6,0.4
	2	29.5,28.985	0.35,0.65		2	14,6.775	0.6,0.4
8	1	36,29.335	0.85,0.15				
	2	56,16	0.85,0.15				

Note: I: Activity i; II: Mode j; IX: Quality Performance $Q_{i,p}^{j}$; X: Weight of quality indicator $w_{i,p}$.

Other relevant data are as follows: total budget is 110000, maximum limited of resource is 30 unite for each period, project completion duration under normal condition 28 months and decision maker expected project completion duration below 30 months.

37.3.2 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 [5, 6] 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:

$$z_1 = 100100,\ z_2 = 27,\ z_3 = 33.5,\ z_4 = 35.5,$$

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 detailed results was shown in Table 37.3. The above strategy is offered for the project, that is: arrange the activities in the order proposed in Table 37.3, and choose the corresponding crash time in accordance with the required certain processing time and given budget which results in the decision-maker satisfied.

Table 37.3: Environmental impacts, impact properties and their pondering coefficients for each activity-mode

Activity i	Mode j	h_{ir}	c_{inr}	$p_{\tilde{ij}nr}$	h_{ik}	c_{ifk}	$p_{\tilde{ij}fk}$
2	1	0.2	0.7,0.3	99.5,86.9885	0.04	0.4,0.6	77.46,92.195
		0.5	0.55,0.45	99.5,98.38			
		0.2	0.72,0.28	94.34,56.45	0.06	0.8,0.2	90.55,94.154
	2	0.2	0.7,0.3	92.736,87.178	0.04	0.4,0.6	89.44,91.285
		0.5	0.55,0.45	90.55,85.5			
		0.2	0.72,0.28	88.32,96.06	0.06	0.8,0.2	60.83,96.77
3	1	0.2	0.7,0.3	85.44,40.41	0.04	0.4,0.6	91.1,94.69
		0.5	0.55,0.45	72.11,65.66			
		0.2	0.72,0.28	74.83,55.68	0.06	0.8,0.2	46.9,62.169
	2	0.2	0.7,0.3	85.44,40.41	0.04	0.4,0.6	91.1,94.69
		0.5	0.55,0.45	72.11,65.66			
		0.2	0.72,0.28	74.83,55.68	0.06	0.8,0.2	46.9,62.169
	3	0.2	0.7,0.3	76.16,64.29	0.04	0.4,0.6	76.16,86.41
		0.5	0.55,0.45	64.81,57.52			
		0.2	0.72,0.28	36.06,22.36	0.06	0.8,0.2	48.99,32.63
4	1	0.2	0.7,0.3	72.11.46.9	0.04	0.4,0.6	66.33,77.89
		0.5	0.55,0.45	69.282,66			
		0.2	0.72,0.28	56.57,37.6	0.06	0.8,0.2	84.85,77.14
	2	0.2	0.7,0.3	75.5,51.96	0.04	0.4,0.6	69.282,79.37
		0.5	0.55,0.45	76.16,70.08			
		0.2	0.72,0.28	56.57,37.6	0.06	0.8,0.2	85.44,96
5	1	0.2	0.7,0.3	85.44,40.41	0.04	0.4,0.6	91.1,94.69
		0.5	0.55,0.45	72.11,65.66			
		0.2	0.72,0.28	74.83,55.68	0.06	0.8,0.2	46.9,62.169

Table 37.3: Continued

6	1	0.2	0.7,0.3	70,50.67	0.04	0.4,0.6	89.44,93
		0.5	0.55,0.45	74.16,67.9			
		0.2	0.72,0.28	53.85,40.62	0.06	0.8,0.2	73.48,79.47
	2	0.2	0.7,0.3	44.72,31.62	0.04	0.4,0.6	88.3,91.1
		0.5	0.55,0.45	37.42,42.94			
		0.2	0.72,0.28	30,23.3	0.06	0.8,0.2	64.8,74.9
7	1	0.2	0.7,0.3	60,47.61	0.04	0.4,0.6	84.85,90.55
		0.5	0.55,0.45	52.9,50.77			
		0.2	0.72,0.28	61.64,33.48	0.06	0.8,0.2	80,66.96
	2	0.2	0.7,0.3	76.16,64.29	0.04	0.4,0.6	84.26,86.21
		0.5	0.55,0.45	78.74,71.33			
		0.2	0.72,0.28	64.81,82.9	0.06	0.8,0.2	73.48,88.4
8	1	0.2	0.7,0.3	55.68,42	0.04	0.4,0.6	74.83,77
		0.5	0.55,0.45	45,83,40.69			
		0.2	0.72,0.28	34.64,25.768	0.06	0.8,0.2	78.74,92.82
	2	0.2	0.7,0.3	85.44,40.41	0.04	0.4,0.6	91.1,94.69
		0.5	0.55,0.45	72.11,65.66			
		0.2	0.72,0.28	74.83,55.68	0.06	0.8,0.2	46.9,62.169
9	1	0.2	0.7,0.3	76.16,64.29	0.04	0.4,0.6	76.16,86.41
		0.5	0.55,0.45	64.81,57.52			
		0.2	0.72,0.28	36.06,22.36	0.06	0.8,0.2	48.99,32.63
	2	0.2	0.7,0.3	85.44,40.41	0.04	0.4,0.6	91.1,94.69
		0.5	0.55,0.45	72.11,65.66			
		0.2	0.72,0.28	74.83,55.68	0.06	0.8,0.2	46.9,62.169
	3	0.2	0.7,0.3	69.28,64.29	0.04	0.4,0.6	77.49,79.58
		0.5	0.55,0.45	64.03,69.04			
		0.2	0.72,0.28	64.81,70.1	0.06	0.8,0.2	64.03,67.82
10	1	0.2	0.7,0.3	69.28,52.92	0.04	0.4,0.6	42.43,38.3
		0.5	0.55,0.45	65.57,70.48			
		0.2	0.72,0.28	84.85,96.66	0.06	0.8,0.2	26.46,14.14
	2	0.2	0.7,0.3	85.44,40.41	0.04	0.4,0.6	91.1,94.69
		0.5	0.55,0.45	72.11,65.66			
		0.2	0.72,0.28	74.83,55.68	0.06	0.8,0.2	46.9,62.169
	3	0.2	0.7,0.3	76.16,64.29	0.04	0.4,0.6	76.16,86.41
		0.5	0.55,0.45	64.81,57.52			
		0.2	0.72,0.28	36.06,22.36	0.06	0.8,0.2	48.99,32.63
11	1	0.2	0.7,0.3	76.16,64.29	0.04	0.4,0.6	84.26,86.21
		0.5	0.55,0.45	78.74,71.33			
		0.2	0.72,0.28	64.81,82.9	0.06	0.8,0.2	73.48,88.4
	2	0.2	0.7,0.3	72.8,62.98	0.04	0.4,0.6	46.9,50.33
		0.5	0.55,0.45	76.16,66.84			
		0.2	0.72,0.28	66.56,79.28	0.06	0.8,0.2	78.74,90.09
	3	0.2	0.7,0.3	64.81,53.54	0.04	0.4,0.6	42.43,49.67
		0.5	0.55,0.45	67.82,57.16			
		0.2	0.72,0.28	64.03,66.76	0.06	0.8,0.2	88.88,97.8

Table 37.3: Continued

12	1	0.2 0.5 0.2	0.7,0.3 0.55,0.45 0.72,0.28	55.68,42 45,83,40.69 34.64,25.768	0.04 0.06	0.4,0.6 0.8,0.2	74.83,77 78.74,92.82
	2	0.2	0.7,0.3	85.44,40.41	0.04	0.4,0.6	91.1,94.69
		0.5	0.55,0.45	72.11,65.66			
		0.2	0.72,0.28	74.83,55.68	0.06	0.8,0.2	46.9,62.169
13	1	0.2	0.7,0.3	85.44,40.41	0.04	0.4,0.6	91.1,94.69
		0.5	0.55,0.45	72.11,65.66			
		0.2	0.72,0.28	74.83,55.68	0.06	0.8,0.2	46.9,62.169
	2	0.2	0.7,0.3	69.28,52.92	0.04	0.4,0.6	42.43,38.3
		0.5	0.55,0.45	65.57,70.48			
		0.2	0.72,0.28	84.85,96.66	0.06	0.8,0.2	26.46,14.14
	3	0.2	0.7,0.3	85.44,40.41	0.04	0.4,0.6	91.1,94.69
		0.5	0.55,0.45	72.11,65.66			
		0.2	0.72,0.28	74.83,55.68	0.06	0.8,0.2	46.9,62.169
14	1	0.2	0.7,0.3	85.44,40.41	0.04	0.4,0.6	91.1,94.69
		0.5	0.55,0.45	72.11,65.66			
		0.2	0.72,0.28	74.83,55.68	0.06	0.8,0.2	46.9,62.169
	2	0.2	0.7,0.3	69.28,52.92	0.04	0.4,0.6	42.43,38.3
		0.5	0.55,0.45	65.57,70.48			
		0.2	0.72,0.28	84.85,96.66	0.06	0.8,0.2	26.46,14.14

Considering a given budget, with regard to the number of activities and the corresponding executive mode and the project duration, total executive cost, quality and environment performance are often conflicting. The best way to handle multi-objective optimization is to keep dependent on the decision-maker's objective. Generally, the solution to this problem is a balance of multiple objectives.

37.4 Conclusion

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

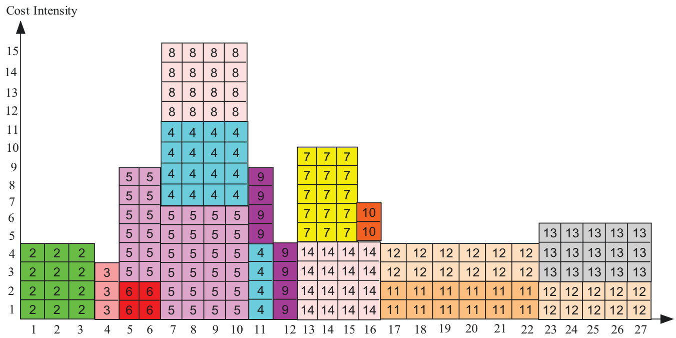

Fig. 37.2 Gantt chart for the construction project schedule

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 38
American Option Pricing with Time-Varying Parameters

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Abstract In this paper, we provide an explicit formula for American option pricing on a dividend-paying equity when the parameters in Black-Scholes equation are time dependent. By using a general transformation, the option value is shown as an explicit formula which is based on the value of American option with constant parameters. Finally, the optimal boundary of American option is given.

Keywords Option pricing · Time-varying parameters · American put option · Black-scholes equation

38.1 Introduction

Options have been traded on public exchanges since 1973. There are American and European options and a variety of exotic options in the market. American option entitles the holder to buy or sell, respectively, at any time prior to a specified expiration date. The existence of derivative securities leads to the mathematical question: *pricing*. Our paper presents the valuation of an American put option by solving the Black-Scholes partial differential equation (for short, PDE) with time dependent parameters. Since some investors do not want to corporate the market's view on the direction of the future behavior which the option price depends on, we concern on American option with time-varying parameters in order to give a mathematical model to handle the concrete affairs in practice.

By using the Feynman-Kac theorem [11], the popular method of matingale pricing for contingent claims (see [2, 3, 5–7]) is equivalent to the PDE technique. We

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shall only focus on the transformation of PDEs to obtain solutions to the valuation problems.

The original derivation of the Black-Scholes equation with time-varying parameters can be found in [8]. A method of reducing this PDE into the heat equation was described in [10] and an alternative approach to solving this PDE with time-varying parameters was given in [9]. In [10], it has to keep track of how the terminal condition and solve the problem based on the heat equation. In [9], Rodrigo and Mamon provided a simple derivation of an explicit formula for pricing a European option on a dividend-paying equity when the parameters in Black-Scholes PDE are time dependent. The approach of [9] is to transform the Black-Scholes equation with time-varying parameters directly into a Black-Scholes equation with time independent but arbitrary parameters.

Although Merton [8], Rodrigo and Mamon [9], Wilmott et al [10] introduced different approaches to solve the Black-Scholes equation with time-varying parameters, they only considered European option but not American option. American option is quite different with European option in that the buyer of an American option can opt, at any time of his choice, for a lump-sum settlement of the option. In [3] and [4], American option's price has been decomposed to a European option's price (see [1]) plus another part due to the extra premium required by early exercising the contract. In this paper, we show the price of American put option with time-varying parameters by using the approach of [9] and the decomposition of American option.

38.2 Preliminaries

Let S be the price of a stock, $V(S,t)$ be the value of an American option on a dividend-paying equity at time t and K be the exercise price or strike price in the contract. We assume that $\sigma(t)$ denotes the volatility of the equity at time t, $r(t)$ and $q(t)$ are riskless interest rate and dividend yield at time t, respectively. It is clear that $r(t)$, $q(t)$ and $\sigma(t)$ are time dependent parameters which are different with constant parameters. From [8], American put option satisfies the following equation:

$$\begin{cases} \min\{-\mathscr{L}V, V-g(S)\}=0, \\ V(S,t)=g(S), \end{cases} \tag{38.1}$$

where

$$\mathscr{L}V=\frac{\partial V}{\partial t}+\frac{\sigma^2(t)}{2}S^2\frac{\partial^2 V}{\partial S^2}+(r(t)-q(t))S\frac{\partial V}{\partial S}-r(t)V$$

and

$$g(S)=\begin{cases} (S-K)^+, & \text{call option,} \\ (K-S)^+, & \text{put option.} \end{cases} \tag{38.2}$$

Definition 38.1. In mathematical theory, American option pricing is a free boundary problem. The free boundary is a boundary curve (to be determined) which divides the domain $\{0 \leq S < \infty, 0 \leq t \leq T\}$ into two parts: the continuation region and the stopping region. To be specific, e.g., consider an American put option. The two sets of American put option are:

$$\begin{aligned}\Sigma_1 &= \{(S,t) \in \mathbb{R}^+ \times [0,T) | V(S,t) > (K-S)^+\} \\ &= \{(S,t) | S(t) \leq S < \infty, 0 \leq t \leq T\}, \\ \Sigma_2 &= \{(S,t) \in \mathbb{R}^+ \times [0,T) | V(S,t) = (K-S)^+\} \\ &= \{(S,t) | 0 \leq S \leq S(t), 0 \leq t \leq T\},\end{aligned}$$

where $S(t) < K$ for $0 \leq t < T$. It is called that Σ_1 is the continuation region which means it is possible to hold an American put option and find an exercise policy that gives riskless profits and Σ_2 is the stopping region which means it is possible to sell the American put option and can make riskless profits for every exercise policy option of the buyer. $\Gamma : S = S(t)$ is called the optimal exercise boundary and it must be determined simultaneously with the option price $V(S,t)$.

On the optimal exercise boundary Γ,

$$\begin{aligned}&V(S,t)\big|_{S=S(t)} = K - S(t), \\ &\lim_{S \to S(t)} \frac{\partial V(S,t)}{\partial S} = -1 = \frac{\partial (K-S)^+}{\partial S}\bigg|_{S=S(t)}.\end{aligned} \tag{38.3}$$

The free boundary condition (38.3) indicates the option price's derivative is continuous at crossing the optimal exercise boundary. This fact expresses the principle of American option pricing. In order to value an American put option, we should get $V(S,t) \in C^1_\Sigma$ where $\Sigma = \{(S,t) | 0 \leq S < \infty, 0 \leq t \leq T\} = \Sigma_1 \cup \Sigma_2 \cup \Gamma$.

Within the framework of constant risk-free rate r_c, constant dividend yield q_c and time independent volatility σ_c, the following definition and lemma are given.

Definition 38.2. $G(S,t;\xi,T)$ is called the **fundamental solution of the Black-Scholes equation**, if it satisfies the following terminal value problem to the Black-Scholes equation:

$$\begin{cases}\mathscr{L}V = \dfrac{\partial V}{\partial t} + \dfrac{\sigma_c^2}{2} S^2 \dfrac{\partial^2 V}{\partial S^2} + (r_c - q_c) S \dfrac{\partial V}{\partial S} - r_c V = 0, \\ V(S,t) = \delta(S - \xi),\end{cases}$$

where $0 < S < \infty$, $0 < \xi < \infty$, $0 < t < T$ and $\delta(x)$ is a Dirac function.

Lemma 38.1. *[4] Assume that the volatility of the equity, riskless interest rate and dividend rate are constant, the price of American put option $V_c(S,t)$ satisfies:*

$$V_c(S,t) = V_{Ec}(S,t) + e_c(S,t),$$

where $V_{Ec}(S,t)$ is the European put option price contract and $e_c(S,t)$ is the early exercise premium with constant parameters,

$$V_{Ec}(S,t) = Ke^{-r_c(T-t)}N(-d_2) - Se^{-q_c(T-t)}N(-d_1),$$
$$e_c(S,t) = \int_t^T d\eta \int_0^{S(\eta)} (Kr_c - \xi q_c)G(S,t;\xi,\eta)d\xi$$

and

$$\begin{cases} d_1 = \dfrac{\ln\frac{S}{K} + (r_c - q_c + \frac{\sigma_c^2}{2})(T-t)}{\sigma_c\sqrt{T-t}}, \\ d_2 = d_1 - \sigma_c\sqrt{T-t}. \end{cases}$$

38.3 American Put Option Pricing with Time-Varying Parameters

In this section, we investigate the American put option pricing problem with time varying parameters.

From Equations (38.1) and (38.2), we know that the price process of American put option $V(S,t)$ satisfies:

$$\begin{cases} \min\{-\mathscr{L}V, V - g(S)\} = 0, \\ V(S,t) = (K-S)^+. \end{cases}$$

Following the methodology of Lemma 38.1, we separate the variational inequality equation into a European put option and early exercise premium.

38.3.1 European Put Option with Time-Varying Parameters

At first, we investigate the price of the European put option which satisfies:

$$\begin{cases} \dfrac{\partial V}{\partial t} + \dfrac{\sigma^2(t)}{2}S^2\dfrac{\partial^2 V}{\partial S^2} + \big(r(t) - q(t)\big)S\dfrac{\partial V}{\partial S} - r(t)V = 0, \\ V(S,t) = (K-S)^+. \end{cases} \tag{38.4}$$

Within the framework of constant parameters which includes risk-free rate, constant dividend yield and time-independent volatility, the Black-Scholes PDE of the option pricing $\overline{V}(\overline{S},\overline{t})$ at time $\overline{t}$ is given by:

$$\begin{cases} \dfrac{\partial \overline{V}}{\partial \overline{t}} + \dfrac{\sigma_c^2}{2}\overline{S}^2\dfrac{\partial^2 \overline{V}}{\partial \overline{S}^2} + (r_c - q_c)\overline{S}\dfrac{\partial \overline{V}}{\partial \overline{S}} - r\overline{V} = 0, \\ \overline{V}(\overline{S},\overline{T}) = (\overline{K} - \overline{S})^+, \end{cases} \tag{38.5}$$

where $\overline{K}$ is the exercise price at time $\overline{T}$. The parameters σ_c, r_c, q_c and $\overline{K}$ are assumed to be positive. Following the methodology of [9], we transform Equation (38.4) into the Black-Scholes PDE with constant parameters Equation (38.5) directly. Therefore, $\bar{t} = \overline{T}$ when $t = T$.

Using the transformations:

$$V(S,t) = \varphi(t)\overline{V}(\overline{S},\bar{t}), \quad \overline{S} = \phi(t)S, \quad \bar{t} = \psi(t), \tag{38.6}$$

we can get the following equations by chain rule:

$$\begin{aligned}
\frac{\partial V}{\partial t} &= \varphi(t)\left(\frac{\partial \overline{V}}{\partial \overline{S}}\phi'(t)S + \psi'(t)\frac{\partial \overline{V}}{\partial \bar{t}}\right) + \varphi'(t)\overline{V}, \\
\frac{\partial V}{\partial S} &= \varphi(t)\phi(t)\frac{\partial \overline{V}}{\partial \overline{S}}, \frac{\partial^2 V}{\partial S^2} = \varphi(t)\phi(t)^2\frac{\partial^2 \overline{V}}{\partial \overline{S}^2}.
\end{aligned} \tag{38.7}$$

Substituting Equation (38.7) to (38.4), then regrouping and comparing it with Equation (38.5), we have:

$$\begin{aligned}
&\frac{\partial \overline{V}}{\partial \bar{t}} + \frac{\sigma^2(t)\phi^2(t)S^2}{2\psi'(t)}\frac{\partial^2 \overline{V}}{\partial \overline{S}^2} + \frac{\big(r(t) - q(t)\big)\phi(t)S + \phi'(t)S}{\psi'(t)}\frac{\partial \overline{V}}{\partial \overline{S}} \\
&\qquad + \frac{\varphi'(t) - r(t)\varphi(t)}{\varphi(t)\psi'(t)}\overline{V} = 0, \\
&\frac{\sigma^2(t)\phi^2(t)S^2}{2\psi'(t)} = \frac{\sigma_c^2}{2}\phi^2(t)S^2, \\
&\frac{\big(r(t) - q(t)\big)\phi(t)S + \phi'(t)S}{\psi'(t)} = (r_c - q_c)\phi(t)S, \\
&\frac{\varphi'(t) - r(t)\varphi(t)}{\varphi(t)\psi'(t)} = -r_c.
\end{aligned}$$

Integrating the above formulas, we can get $\varphi(t), \phi(t)$ and $\psi(t)$ as follows:

$$\begin{aligned}
\varphi(t) &= A\exp\left\{-\int_t^T \Big(r(\tau) - r_c\psi'(\tau)\Big)d\tau\right\}, \\
\phi(t) &= B\exp\left\{-\int_t^T \Big((r_c - q_c)\psi'(\tau) + q(\tau) - r(\tau)\Big)d\tau\right\}, \\
\psi(t) &= -\frac{1}{\sigma_c^2}\int_t^T \sigma^2(\tau)d\tau + C,
\end{aligned}$$

where A, B are positive constants and C is an arbitrary constant. From the terminal condition of Equations (38.4), (38.5) and the transformation Equation (38.6), we have:

$$(K - S)^+ = V(S,t) = \varphi(T)\overline{V}(\overline{S},\overline{T}) = \varphi(T)(\overline{K} - \overline{S})^+$$

$$= \varphi(T)\phi(T)\left(\frac{\overline{K}}{\phi(T)} - S\right)^{+}.$$

Thus, $\varphi(T)\phi(T) = 1$, $\frac{\overline{K}}{\phi(T)} = K$, $A = \varphi(T) = \frac{K}{\overline{K}}$, $B = \phi(T) = \frac{\overline{K}}{K}$, and $C = \psi(T) = \overline{T}$. Then, the price of the European put option with time-varying parameters Equation (38.4) is given as follows:

$$\begin{aligned}
V(S,t) &= \frac{K}{\overline{K}} \exp\left\{-\int_t^T \left(r(\tau) - r_c\frac{\sigma^2(\tau)}{\sigma_c^2}\right)d\tau\right\}\overline{V}(\overline{S},\overline{t}),\\
\overline{S} &= \frac{\overline{K}}{K}\exp\left\{-\int_t^T \left((r_c - q_c)\frac{\sigma^2(\tau)}{\sigma_c^2} + q(\tau) - r(\tau)\right)d\tau\right\}S,\\
\overline{t} &= -\frac{1}{\sigma_c^2}\int_t^T \sigma^2(\tau)d\tau + \overline{T},
\end{aligned}$$

where $\overline{V}(\overline{S},\overline{t})$ is the price of the classic European put option Equation (38.5) which is given by:

$$\overline{V}(\overline{S},\overline{t}) = \overline{K}\exp\{-r_c(\overline{T}-\overline{t})\}N(-\overline{d}_2) - \overline{S}\exp\{-q_c(\overline{T}-\overline{t})\}N(-\overline{d}_1),$$

with:

$$\begin{aligned}
\overline{d}_1 &= \frac{\ln\overline{S} - \ln\overline{K} + (r_c - q_c + \frac{\sigma_c^2}{2})(\overline{T}-\overline{t})}{\sigma_c\sqrt{\overline{T}-\overline{t}}},\\
\overline{d}_2 &= \overline{d}_1 - \sigma_c\sqrt{\overline{T}-\overline{t}}
\end{aligned} \tag{38.8}$$

and $N(x)$ is the cumulative distribution function of a standard normal variable.

38.3.2 Early Exercise Premium with Time-Varying Parameters

In order to get $e(S,t)$, we solve the fundamental solution of the following Black-Scholes equation first.

$$\begin{cases}
\mathscr{L}V = \dfrac{\partial V}{\partial t} + \dfrac{\sigma^2(t)}{2}S^2\dfrac{\partial^2 V}{\partial S^2} + \big(r(t) - q(t)\big)S\dfrac{\partial V}{\partial S} - r(t) = 0,\\
V(S,t) = \delta(S-\xi).
\end{cases} \tag{38.9}$$

Within the framework of constant parameters, the fundamental solution $\overline{G}(\overline{S},\overline{t};\overline{\xi},\overline{T})$ at time $\overline{t}$ is given by:

$$\begin{cases}
\dfrac{\partial \overline{V}}{\partial \overline{t}} + \dfrac{\sigma_c^2}{2}\overline{S}^2\dfrac{\partial^2 \overline{V}}{\partial \overline{S}^2} + (r_c - q_c)\overline{S}\dfrac{\partial \overline{V}}{\partial \overline{S}} - r_c\overline{V} = 0,\\
\overline{V}(\overline{S},\overline{T}) = \delta(\overline{S}-\overline{\xi}),
\end{cases} \tag{38.10}$$

where $0 < \overline{S} < \infty$, $0 < \overline{\xi} < \infty$, $0 < \bar{t} < \overline{T}$ and $\delta(x)$ is a Dirac function.

It is clear that the only difference between Equations (38.4) and (38.9) is the terminal condition. Thus, by Equation (38.6) and terminal conditions of Equations (38.9) and (38.10), we have:

$$\begin{aligned}\delta(S-\xi) = V(S,t) &= \varphi(T)\overline{V}(\overline{S},\overline{T}) = \varphi(T)\delta(\phi(T)S-\overline{\xi})\\ &= \frac{\varphi(T)}{\phi(T)}\delta\left(S-\frac{\overline{\xi}}{\phi(T)}\right).\end{aligned}$$

Therefore, $\frac{\varphi(T)}{\phi(T)} = 1$, $\frac{\overline{\xi}}{\phi(T)} = \xi, A = \varphi(T) = \frac{\overline{\xi}}{\xi}, B = \phi(T) = \frac{\overline{\xi}}{\xi}$ and $C = \psi(T) = \overline{T}$. Then, the fundamental solution of Equation (38.9) is:

$$\begin{aligned}G(S,t;\xi,T) &= \frac{\overline{\xi}}{\xi}\exp\left\{-\int_t^T\left(r(\tau)-r_c\frac{\sigma^2(\tau)}{\sigma_c^2}\right)d\tau\right\}\overline{G}(\overline{S},\bar{t};\overline{\xi},\overline{T}),\\ \overline{S} &= \frac{\overline{\xi}}{\xi}\exp\left\{-\int_t^T\left((r_c-q_c)\frac{\sigma^2(\tau)}{\sigma_c^2}+q(\tau)-r(\tau)\right)d\tau\right\}S, \quad (38.11)\\ \bar{t} &= -\frac{1}{\sigma_c^2}\int_t^T\sigma^2(\tau)d\tau+\overline{T}, \quad (38.12)\end{aligned}$$

where

$$\overline{G}(\overline{S},\bar{t};\overline{\xi},\overline{T}) = \frac{e^{-r_c(\overline{T}-\bar{t})}}{\overline{\xi}\sigma_c\sqrt{2\pi(\overline{T}-\bar{t})}} \exp\left\{-\frac{\left(\ln\frac{\overline{S}}{\overline{\xi}}+(r_c-q_c-\frac{\sigma_c^2}{2})(\overline{T}-\bar{t})\right)^2}{2\sigma_c^2(\overline{T}-\bar{t})}\right\} \quad (38.13)$$

is the fundamental solution of the classic Black-Sholes Equation (38.10).

Theorem 38.1. *If the fundamental solution $G(S,t;\xi,\eta)$ of Black-Scholes equation is regarded as a function of ξ,η, then it is the fundamental solution of the adjoint equation of the Black-Scholes equation. That is, let $\upsilon(\xi,\eta) = G(S,t;\xi,\eta)$, then $\upsilon(\xi,\eta)$ satisfies:*

$$\begin{cases}\mathscr{L}^*\upsilon = -\dfrac{\partial\upsilon}{\partial\eta}+\dfrac{\sigma^2(\eta)}{2}\dfrac{\partial^2(\xi^2\upsilon)}{\partial\xi^2}-\left(r(\eta)-q(\eta)\right)\dfrac{\partial(\xi\upsilon)}{\partial\xi}\\ \qquad -r(\eta)\upsilon = 0,\\ \upsilon(\xi,t) = \delta(\xi-S),\end{cases} \quad (38.14)$$

where $0 < \xi < \infty$, $0 < S < \infty$, $t < \eta$. If the fundamental solution of Equation (38.14) is $G^*(\xi,\eta;S,t)$, then $G(S,t;\xi,\eta) = G^*(\xi,\eta;S,t)$.

Proof. Consider the integral:

$$0 = \int_0^\infty \int_{t+\varepsilon}^{\eta-\varepsilon} \{G^*(x,y;S,t)\mathscr{L}G(x,y;\xi,\eta) - G(x,y;\xi,\eta)\mathscr{L}^*G^*(x,y;S,t)\}\,dxdy$$
$$= \int_0^\infty dx \int_{t+\varepsilon}^{\eta-\varepsilon} \left\{ \frac{\partial}{\partial y}(G^*G) + \frac{\sigma^2(y)}{2}\frac{\partial}{\partial x}\left(x^2G^*\frac{\partial G}{\partial x}\right) - \frac{\sigma^2(y)}{2}\frac{\partial}{\partial x}\left(G\frac{\partial}{\partial x}(x^2G^*)\right) + \Big(r(y)-q(y)\Big)\frac{\partial}{\partial x}(xGG^*)\right\} dy.$$

When $x \to 0$ and/or ∞, $x^2G^*\frac{\partial G}{\partial x} \to 0, G\frac{\partial}{\partial x}\left(x^2G^*\right) \to 0, xGG^* \to 0$. Thus

$$\int_0^\infty G^*(x,\eta-\varepsilon;S,t)G(x,\eta-\varepsilon;\xi,\eta)dx = \int_0^\infty G^*(x,t+\varepsilon;S,t)G(x,t+\varepsilon;\xi,\eta)dx.$$

Letting $\varepsilon \to 0$, from the initial conditions of Equations (38.9) and (38.14), we have:

$$\int_0^\infty G^*(x,\eta;S,t)\delta(x-\xi)dx = \int_0^\infty \delta(x-S)G(x,t;\xi,\eta)dx,$$

which implies $G^*(\xi,\eta;S,t) = G(S,t;\xi,\eta)$. This completes the proof. □

Theorem 38.2. *For time varying parameters, the value of an American put option $V(S,t)$ is:*

$$V(S,t) = V_E(S,t) + e(S,t), \tag{38.15}$$

where $V_E(S,t)$ is the value of the European put option and $e(S,t)$ is the early exercise premium of the American put option.

$$V_E(S,t) = \frac{K}{\overline{K}}\exp\left\{-\int_t^T \left(r(\tau) - r_c\frac{\sigma^2(\tau)}{\sigma_c^2}\right)d\tau\right\}\overline{V}_E(\overline{S},\overline{T}),$$
$$e(S,t) = \int_t^T d\eta \int_0^{S(\eta)} (Kr(\eta) - q(\eta)\xi)G(S,t;\xi,\eta)d\xi, \tag{38.16}$$

where $G(S,t;\xi,\eta)$ is the fundamental solution of the Black-Scholes equation with time-varying parameters,

$$\overline{V}_E(\overline{S},\overline{T}) = \overline{K}\exp[-r_c(\overline{T}-\bar{t})]N(-\bar{d}_2) - \overline{S}\exp[-q_c(\overline{T}-\bar{t})]N(-\bar{d}_1),$$
$$G(S,t;\xi,\eta) = \frac{\overline{\xi}}{\xi}\exp\left\{-\int_t^\eta \left(r(\tau) - r_c\frac{\sigma^2(\tau)}{\sigma_c^2}\right)d\tau\right\}\overline{G}(\overline{S},\bar{t};\overline{\xi},\overline{\eta}) \tag{38.17}$$

and $\bar{d}_1, \bar{d}_2$ are defined as Equation (38.8).

Proof. For American put option's domain $\Sigma = \{(S,t)|0 \le S < \infty, 0 \le t \le T\}$, $V(S,t)$ has continuous second derivative in each region. Thus $V(S,t)$ satisfies

$$-\mathscr{L}V(S,t) = \begin{cases} 0, & (S,t) \in \Sigma_1, \\ Kr(t) - q(t)S, & (S,t) \in \Sigma_2, \end{cases} \tag{38.18}$$

where $\mathscr{L}$ is the Black-Scholes operator.

Multiplying $G^*(\xi,\eta;S,t)$ to the both sides of Equation (38.18) and integrating it on domain $\{(\xi,\eta)|0 \le \xi < \infty, t+\varepsilon \le \eta \le T\}$, we have:

$$
\begin{aligned}
= -\int_{t+\varepsilon}^{T} d\eta \int_0^\infty &\left\{ \frac{\partial}{\partial \eta}(G^* V) + \frac{\sigma^2(\eta)}{2}\frac{\partial}{\partial \xi}\Big(\xi^2 G^* \frac{\partial V}{\partial \xi}\Big) \right. \\
&\left. -\frac{\sigma^2(\eta)}{2}\frac{\partial}{\partial \xi}\Big(V\frac{\partial}{\partial \xi}(\xi^2 G^*)\Big) + \Big(r(\eta)-q(\eta)\Big)\frac{\partial}{\partial \xi}(\xi V G^*)\right\} d\xi.
\end{aligned}
$$

When $\xi \to 0$ and/or ∞, $\xi^2 G^* \frac{\partial V}{\partial \xi} \to 0, V\frac{\partial}{\partial \xi}(\xi^2 G^*) \to 0, \xi V G^* \to 0$. Thus,

$$
\begin{aligned}
&\int_{t+\varepsilon}^{T} d\eta \int_0^{S(\eta)} \Big(Kr(\eta) - q(\eta)\xi\Big) G^*(\xi,\eta;S,t)d\xi \\
&= \int_0^\infty G^*(\xi,t+\varepsilon;S,t)V(\xi,t+\varepsilon)d\xi - \int_0^\infty G^*(\xi,T;S,t)V(\xi,T)d\xi.
\end{aligned}
$$

Letting $\varepsilon \to 0$, from Theorem 38.1 and the terminal condition of Equation (38.14), we have:

$$
\begin{aligned}
V(S,t) &= \int_0^\infty G(S,t;\xi,T)(K-\xi)^+ d\xi + \int_t^T d\eta \int_0^{S(\eta)} \Big(Kr(\eta)-q(\eta)\xi\Big) G(S,t;\xi,\eta)d\xi, \\
&= \frac{K}{\overline{\overline{K}}}\exp\left\{-\int_t^T \Big(r(\tau) - r_c\frac{\sigma^2(\tau)}{\sigma_c^2}\Big)d\tau\right\}\overline{V}_E(\overline{S},\overline{T}) \\
&\quad + \int_t^T d\eta \int_0^{S(\eta)} \Big(Kr(\eta)-q(\eta)\xi\Big)\cdot \frac{\overline{\overline{\xi}}}{\xi} \\
&\quad \cdot \exp\left\{-\int_t^\eta \Big(r(\tau) - r_c\frac{\sigma^2(\tau)}{\sigma_c^2}\Big)d\tau\right\}\overline{G}(\overline{S},\overline{t};\overline{\overline{\xi}},\overline{\eta})d\xi, \\
&= V_E(S,t) + e(S,t).
\end{aligned}
$$

This completes the proof. □

Theorem 38.3. *The optimal boundary of American put option $S = S(t)$ satisfies the following nonlinear integral equation:*

$$
\begin{aligned}
S(t) = K - &\frac{K}{\overline{\overline{K}}}\exp\left\{-\int_t^T \Big(r(\tau)-r_c\frac{\sigma^2(\tau)}{\sigma_c^2}\Big)d\tau\right\}\overline{V}(\overline{S}(t),\overline{t}) \\
&-K\int_t^T r(\eta)\exp\left\{-\int_t^\eta r(\tau)d\tau\right\}N\Big(-\tilde{d}_1|_{S=S(t)}\Big)d\eta \\
&+S(t)\int_t^T q(\eta)\exp\left\{\int_t^\eta -q(\tau)d\tau\right\}N\Big(-\tilde{d}_2|_{S=S(t)}\Big)d\eta, \quad (38.19)
\end{aligned}
$$

where

$$
\beta = \frac{r_c - q_c}{\sigma_c^2} - \frac{1}{2},
$$

$$\begin{aligned}
\tilde{d}_1 &= \frac{1}{\sqrt{\int_t^\eta \sigma^2(\tau)d\tau}}\left(\ln\frac{S}{S(\eta)}+\beta\int_t^\eta \sigma^2(\tau)d\tau\right.\\
&\quad \left.-\int_t^\eta \Big((r_c-q_c)\frac{\sigma^2(\tau)}{\sigma_c^2}+q(\tau)-r(\tau)\Big)d\tau\right),\\
\tilde{d}_2 &= \tilde{d}_1+\sqrt{\int_t^\eta \sigma^2(\tau)d\tau},\\
\overline{S}(t) &= \frac{\overline{\xi}}{\xi}\exp\left\{-\int_t^T \Big((r_c-q_c)\frac{\sigma^2(\tau)}{\sigma_c^2}+q(\tau)-r(\tau)\Big)d\tau\right\}S(t).
\end{aligned}$$

Proof. By Equations (38.11), (38.12), (38.13), (38.16) and (38.17), $e(S,t)$ can be expressed as:

$$\begin{aligned}
e(S,t) = &\int_t^T d\eta\int_0^{S(\eta)}\Big(Kr(\eta)-q(\eta)\xi\Big)\cdot\frac{1}{\xi}\cdot\frac{1}{\sqrt{2\pi\int_t^\eta \sigma^2(\tau)d\tau}}\\
&\cdot\exp\left\{-\int_t^\eta r(\tau)d\tau-\frac{1}{2\int_t^\eta \sigma^2(\tau)d\tau}\left(\ln\frac{S}{\xi}+\beta\int_t^\eta \sigma^2(\tau)d\tau\right.\right.\\
&\left.\left.-\int_t^\eta\Big((r_c-q_c)\frac{\sigma^2(\tau)}{\sigma_c^2}+q(\tau)-r(\tau)\Big)d\tau\right)^2\right\}d\xi. \qquad (38.20)
\end{aligned}$$

Changing the variable to:

$$\begin{aligned}
x = &\frac{1}{\sqrt{\int_t^\eta \sigma^2(\tau)d\tau}}\left(\ln\frac{S}{\xi}-\int_t^\eta\Big((r_c-q_c)\frac{\sigma^2(\tau)}{\sigma_c^2}+q(\tau)-r(\tau)\Big)d\tau\right.\\
&\left.+\beta\int_t^\eta \sigma^2(\tau)d\tau\right),\\
\xi = &S\cdot\exp\left\{-x\sqrt{\int_t^\eta \sigma^2(\tau)d\tau}-\int_t^\eta\Big((r_c-q_c)\frac{\sigma^2(\tau)}{\sigma_c^2}+q(\tau)-r(\tau)\Big)d\tau\right.\\
&\left.+\beta\int_t^\eta \sigma^2(\tau)d\tau\right\},\\
dx = &\frac{-d\xi}{\xi\sqrt{\int_t^\eta \sigma^2(\tau)d\tau}}.
\end{aligned}$$

Then, Equation (38.20) becomes:

$$\begin{aligned}
e(S,t) = &\frac{1}{\sqrt{2\pi}}\int_t^T\exp\left\{-\int_t^\eta r(\tau)d\tau\right\}d\eta\int_{\tilde{d}_1}^\infty\Big(Kr(\eta)-q(\eta)\xi\Big)e^{-\frac{x^2}{2}}dx,\\
= &K\int_t^T r(\eta)\exp\left\{-\int_t^\eta r(\tau)d\tau\right\}N\big(-\tilde{d}_1\big)d\eta
\end{aligned}$$

$$-S\int_t^T q(\eta)\exp\left\{\int_t^\eta -q(\tau)d\tau\right\}N\big(-\tilde{d}_2\big)d\eta. \tag{38.21}$$

Substituting Equation (38.21) into Equation (38.15), and taking into account:

$$V(S,t)\Big|_{S=S(t)} = V(S(t),t) = K - S(t),\ \lim_{S\to S(t)}\frac{\partial V(S,t)}{\partial S} = -1 = \frac{\partial (K-S)^+}{\partial S}\Big|_{S=S(t)},$$

we have:

$$\begin{aligned} V_E(S,t)+e(S,t)\Big|_{S=S(t)} &= V_E(S(t),t)+e(S(t),t) = K - S(t), \\ \lim_{S\to S(t)}\frac{\partial}{\partial S}\Big(V_E(S,t)+e(S,t)\Big) &= -1 = \frac{\partial (K-S)^+}{\partial S}\Big|_{S=S(t)} \end{aligned}$$

and

$$\begin{aligned} S(t) = &\ K - V_E(S(t),t) - e(S(t),t), \\ = &\ K - \frac{K}{\overline{K}}\exp\left\{-\int_t^T \Big(r(\tau) - r_c\frac{\sigma^2(\tau)}{\sigma_c^2}\Big)d\tau\right\}\overline{V}(\overline{S}(t),\overline{t}) \\ &-K\int_t^T r(\eta)\exp\left\{-\int_t^\eta r(\tau)d\tau\right\}N\Big(-\tilde{d}_1|_{S=S(t)}\Big)d\eta \\ &+S(t)\int_t^T q(\eta)\exp\left\{\int_t^\eta -q(\tau)d\tau\right\}N\Big(-\tilde{d}_1|_{S=S(t)}\Big)d\eta. \end{aligned}$$

This completes the proof. □

38.4 Conclusion

In this paper, we give an explicit formula for pricing an American put option on a dividend-paying equity when the parameters in Black-Scholes equation are time dependent. An alternative derivation of the solution is given through the use of a generalized change of variable technique. Our results show that the value of American put option with time-varying parameters can be expressed by that with constant parameters. Further, the optimal boundary of American put option is given. Although it is difficult to solve the nonlinear integral Equation (38.19), numerical methods which are similar to [3] can be employed to handle this problem.

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Chapter 39
Safety Evaluation of Special Equipment Based on Revolutionary AHP-FCE Method

Fumin Deng, Fan Zeng, Xuedong Liang and Jian Zhang

Abstract This paper divides special equipment safety evaluation factors into indirect factors (environment and management) and direct factors (human and equipment) combined with fishbone diagram based on the factors' features of diversity, fuzziness and interference effects between layers. AHP-FCE method and DEMATEL method are adopted to determine and modify factor weights to build a special equipment safety evaluation system. Finally, a practical case is proposed to examine the effectiveness of this system which is expected to provide a practical, objective and reasonable approach for the improvement of special equipment safety evaluation.

Keywords Special equipment · Safety evaluation · Revolutionary AHP-FCE Method · DEMATEL method · Fishbone diagram

39.1 Introduction

Special equipment is playing a more and more important role in the natural economy, and its security problem has become a key factor in its development. Compared to most industrial countries, special equipment management is started late in our country which leads to the relatively immature special equipment safety evaluation system [1, 2].

Factors of special equipment safety evaluation are diversified, uncertain and have interference effects between layers. Relatively a small number of domestic scholars study the safety evaluation of the special equipment, and mainly concentrate on

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the special equipment itself and its management. Shen et al [3] divided evaluation factors into daily operational management, the basis of important equipment, transmission, braking device, safety devices and electrical control device. Miao et al [4] divided evaluation factors into Enterprise security, equipment security and human security research. Yang et al [5] divided evaluation factors into source of the inherent danger, security system and management, device management status, status of personnel management and risk control. Tang et al [6] divided evaluation factors of passenger cableway into cableway qualification, security agencies, management system, safety training, safety inspections and incident handling research. There are two problems from these established special equipment safety evaluation system: (1) Most evaluation factors are constrained to equipment itself which did not reflect the systematic features of special equipment safety evaluation. Comprehensiveness and independence of factors can hardly be guaranteed in consideration of the diversity and complexity of evaluation factors. (2) Interference effects between layers of factors were ignored which influenced the objectiveness of factor weights.

Factors set of safety evaluation are established on the basis of fishbone diagram and AHP method. Evaluation factors are divided into indirect factors and direct factors, what's more, indirect factors are divided into environment and management while direct factors are divided into human and equipment. Then DEMATEL method is adopted to modify the interference effects between layers of factors and revise the factor weights. Finally, fuzzy comprehensive method is used to establish safety evaluation system and a practical case is presented to examine the effectiveness of this system.

39.2 Factors Set of Special Equipment Safety Evaluation

Factors set of special equipment safety evaluation are established on the basis of fishbone diagram and AHP method.

39.2.1 Factors Set

Factors set U are the sets of all related factors, $U = \{u_1, u_2, \cdots, u_n\}$. u_i $(i = 1, 2, \cdots, n)$ indicates the factor which influences special equipment safety evaluation system. Factors set are built by collecting relevant data, classifying master data and expert interviews, and fishbone diagram is drawn in Fig. 39.1.

Factors set of special equipment safety evaluation are established based on fishbone diagram analysis.

Factors set consist of direct and indirect factors.

Indirect factors include "environment" and "management" which represent indirect special equipment safety risks.

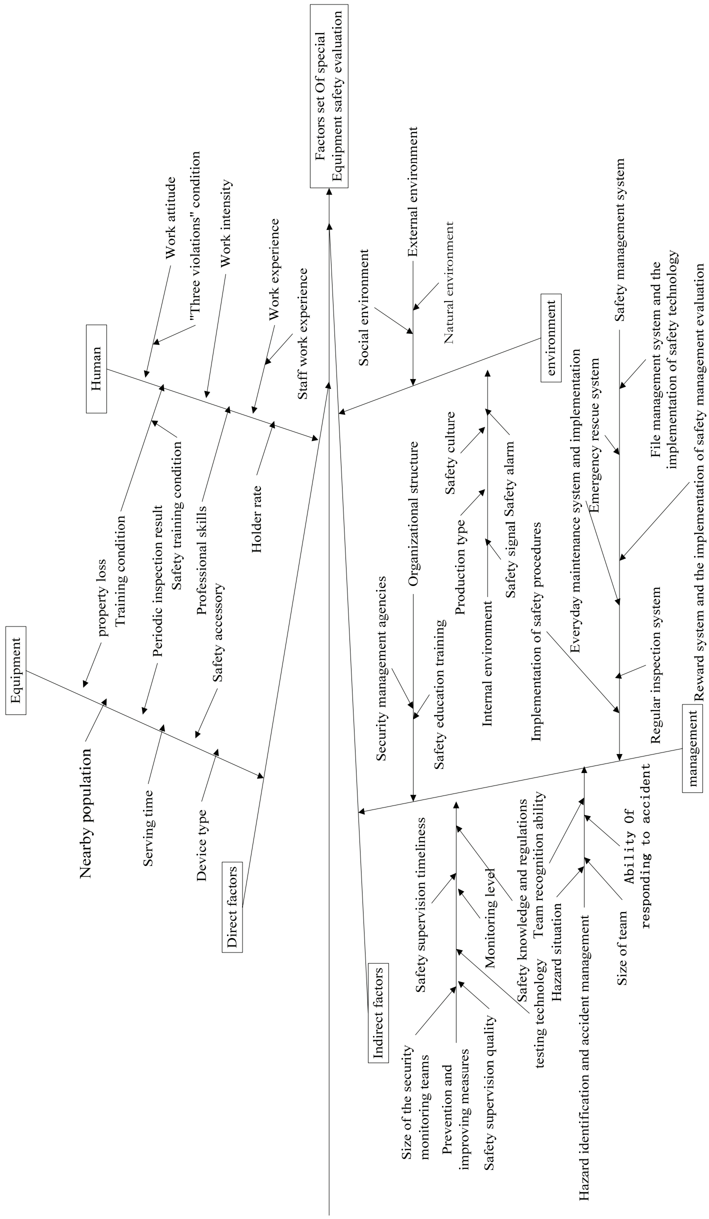

Fig. 39.1 Fishbone diagram of factors set of special equipment safety evaluation

Direct factors include "human" and "equipment" which represent indirect special equipment safety risks.

Indirect factors and direct factors are placed as criteria layer. External environment, internal environment, organizational structure, safety management system, prevention and improving measures, hazard identification and accident management, professional skills, working experience, training condition, work intensity, work attitude, device type, service life, safety accessory, periodic inspection result, headcount and property loss are placed as program layer (Fig. 39.2).

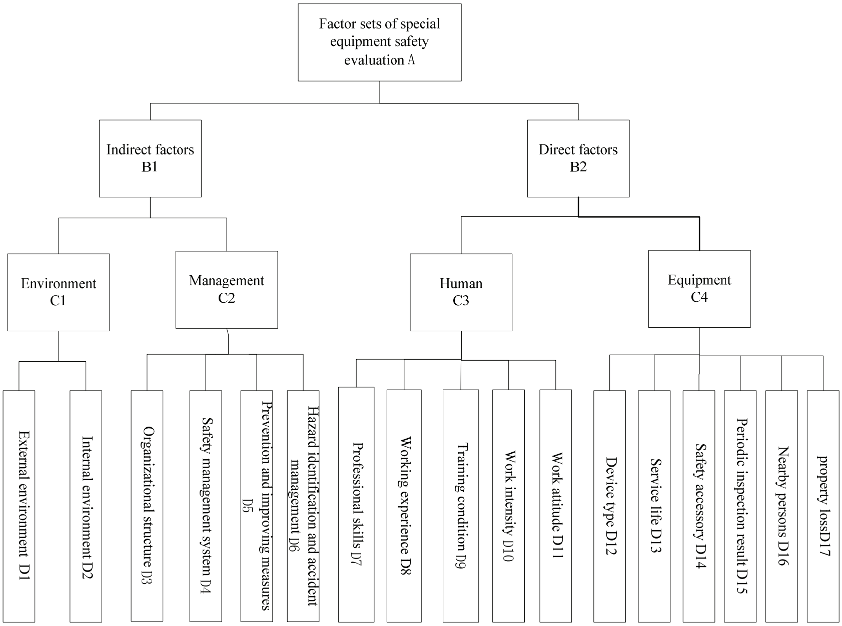

Fig. 39.2 factors set of special equipment safety evaluation

39.3 Revolutionary AHP-FCE Method

Revolutionary AHP-FCE method establishes evaluating factors set in a systematic and scientific way, which modifies factor weights between layers and builds evaluation system through fuzzy evaluation method.

39.3.1 Evaluation Set

Evaluation set V are sets of evaluation objects' possible evaluation results, $V = \{v_1, v_2, \cdots, v_n\}$. v_j $(j = 1, 2, \cdots, m)$ indicates the j-th level of special equipment safety evaluation. $V = v_j = \{90, 80, 70, 60, 50\}$ represents the degree of special equipment safety separately, the higher value means the safer level.

39.3.2 Evaluation Matrix

Every factor u_i $(i = 1, 2, \cdots, n)$ of factors set U is evaluated and membership degree R_i $(i = 1, 2, \cdots, n)$ of factors set is calculated, then all single factor from evaluation set U are constituted into a total evaluation set R:

$$R = \begin{pmatrix} r_{11} & r_{12} & \cdots & r_{1m} \\ r_{21} & r_{22} & \cdots & r_{2m} \\ \vdots & \vdots & \ddots & \vdots \\ r_{n1} & r_{n2} & \cdots & r_{nm} \end{pmatrix}. \tag{39.1}$$

39.3.3 Initial Weights W_a

(1) Judgment matrix

Judgment matrix is built through $1 \sim 9$ point system by expects' questionnaire survey method [7].

(2) Initial weight W_a

Maximum eigenvalues $\lambda_{\max}$ and eigenvectors are calculated through matlab and initial weights W_a are presented.

(3) Consistency test

CI (consistency index) [8] formula is proposed as follows: $\mathrm{CI} = \frac{\lambda_{\max} - n}{n-1}$, where CR (consistency ratio) is used to judge consistency, the formula is proposed as follows: $\mathrm{CR} = \mathrm{CI}/\mathrm{RI}$, where RI indicates average value of CI. Judgment matrix has satisfactory consistency if $\mathrm{CR} < 0.1$, or it has to be modified until it meets the demand [9].

39.3.4 DEMATEL Method to Modify Initial Weight [10]

(1) Direct impact matrix X

This paper defined $(0, 1, 2, 4)$ to indicate the degree of impact. The higher value means the higher direct impact.

$$X = \begin{pmatrix} 0 & x_{12} & \cdots & x_{1n} \\ r_{21} & 0 & \cdots & x_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ x_{n1} & x_{n2} & \cdots & 0 \end{pmatrix} = (x_{ij}),\ 1 \le i \le n,\ 1 \le j \le n, \tag{39.2}$$

where x_{ij} indicates the impact of factor i on factor j.
(2) G is the Standardization of direct impact matrix X.

$$G = X \Big/ \max_{1 \le i \le n} \sum_{j=1}^{n} x_{ij} = (g_i j),\ 1 \le i \le n,\ 1 \le j \le n. \tag{39.3}$$

(3) Combined effect matrix T and impact weight W_b

$$T = G + G^2 + \cdots + G^n = (t_{ij})_{n \times n}. \tag{39.4}$$

$T = G(1-G)^{-1}$ when n is sufficiently large.

$$W_b = \sum_{j=1}^{n} t_{ij} W_a \Big/ \sum_{i=1}^{n} \sum_{j=1}^{n} t_{ij} W_a,\ 1 \le i \le n,\ 1 \le j \le n. \tag{39.5}$$

(4) Final weights are concluded considering initial weight and impact weight.

$$W = (W_a + W_b)/2. \tag{39.6}$$

39.3.5 Fuzzy Comprehensive Evaluation

Proper operators are adopted in fuzzy comprehensive evaluation [11] and final evaluating conclusion is drawn.

$$B = W \cdot R = (w_1 w_2 \cdots w_n) \cdot \begin{bmatrix} r_{11} & r_{12} & \cdots & r_{1m} \\ r_{21} & r_{22} & \cdots & r_{2m} \\ \vdots & \vdots & \ddots & \vdots \\ r_{n1} & r_{n2} & \cdots & r_{nm} \end{bmatrix} = (b_1 b_2 \cdots b_m). \tag{39.7}$$

39.4 Case Study

A provincial chemical company is taken as an example. A large number of industrial boilers are used during production as it is one of the largest local chemical companies. Information combined with relevant experts' investigation was collected to establish a special equipment safety evaluation factor set. Revolutionary AHP-FCE

Table 39.1 Comparison matrix and the consistency test

Index	Comparison matrix B						Initial weight W_a	Consistency test
B1		1	1				0.4768	$\lambda_{\max} = 2.0000, \mathrm{CR} = \mathrm{CI}/\mathrm{RI} = 0.0000 < 0.10$
B2		1	1				0.5232	
C1	1	1/6	1/2	1/5			0.0708	$\lambda_{\max} = 2.0000, \mathrm{CR} = \mathrm{CI}/\mathrm{RI} = 0.0000 < 0.10$
C2	6	1	3	1			0.4060	
C3	2	1/3	1	1/3			0.1353	$\lambda_{\max} = 2.0000, \mathrm{CR} = \mathrm{CI}/\mathrm{RI} = 0.0000 < 0.10$
C4	5	1	3	1			0.3879	
D1		1	1/4				0.2	$\lambda_{\max} = 2.0000, \mathrm{CR} = \mathrm{CI}/\mathrm{RI} = 0.0000 < 0.10$
D2		4	1				0.8	
D3	1	1/7	1/4	1/2			0.0712	$\lambda_{\max} = 4.060, \mathrm{CR} = \mathrm{CI}/\mathrm{RI} = 0.0235 < 0.10$
D4	7	1	2	4			0.5331	
D5	4	1/2	1	2			0.2318	
D6	2	1/4	1/2	1			0.1639	
D7	1	1	1/2	3	2		0.2124	$\lambda_{\max} = 5.0173, \mathrm{CR} = \mathrm{CI}/\mathrm{RI} = 0.0039 < 0.10$
D8	1	1	1/2	3	2		0.2124	
D9	2	2	1	5	3		0.3867	
D10	1/3	1/3	1/5	1	1/2		0.0693	
D11	1/2	1/2	1/3	2	1		0.1192	
D12	1	2	1	1/2	1/2	3	0.1477	$\lambda_{\max} = 6.0599, \mathrm{CR} = \mathrm{CI}/\mathrm{RI} = 0.0095 < 0.10$
D13	1/2	1	1/2	1/4	1/3	1	0.0724	
D14	1	2	1	1/2	1/3	3	0.1380	
D15	2	4	2	1	1	6	0.2954	
D16	2	3	3	1	1	5	0.2922	
D17	1/3	1	1/3	1/6	1/5	1	0.0543	

is adopted in this paper to establish the industrial boiler safety evaluation system and to evaluate the security of the company.

39.4.1 Initial Weights W_a

Judgment matrix is proposed based on special equipment safety evaluation set, see Table 39.1.

39.4.2 DEMATEL Method of Modifying Initial Weight

The interference effects between layers of factors are analyzed through expert group survey and final weights are calculated (see Table 39.2).

Table 39.2 Revised calculation of the index weight

Index	Direct impact matrix X	Combined effect matrix T	W_a	W_b	W
B1	0 0	0 0	0.4768	0.4768	0.4768
B2	0 0	0 0	0.5232	0.5232	0.5232
C1	0 1 0 1	0.6875 0.8750 0.5625 1.1250	0.0708	0.0583	0.0646
C2	1 0 0 0	1.7500 0.8750 0.2500 1.1250	0.4060	0.4115	0.4088
C3	0 0 0 1	1.1250 0.2500 0.8750 1.7500	0.1353	0.1371	0.1362
C4	1 0 1 0	1.1250 0.5625 0.8750 1.4375	0.3879	0.3931	0.3905
D1	0 0	0 0	0.2006	0.2006	0.2006
D2	0 0	0 0	0.7994	0.7994	0.7994
D3	0 0 1 2	1.2532 0.871 1.7969 3.0785	0.0714	0.1186	0.0950
D4	0 0 1 1	0.7954 0.5491 1.0917 1.5640	0.5330	0.5060	0.5195
D5	1 1 0 1	0.9511 0.7278 0.7808 1.5398	0.2318	0.2202	0.2260
D6	2 1 1 0	1.0274 0.6254 0.9239 1.423	0.1638	0.0824	0.1231
D7	0 2 1 0 0	2 2 0.9999 0 0	0.2121	0.2360	0.2241
D8	1 0 0 0 0	3.0000 1.3334 0.6666 0 0	0.2121	0.2360	0.2241
D9	1 0 0 0 0	1 0 0 2 2	0.3865	0.4344	0.4105
D10	0 0 0 0 1	0 0 0 2 3	0.0694	0.0780	0.0737
D11	0 0 0 1 0	0 0 0 3 2	0.1190	0.0268	0.0729
D12	0 0 2 0 1 1	0.8321 0.6502 1.0765 1.1187 0.6924 1.6298	0.1477	0.1479	0.1478
D13	0 0 0 2 0 1	0.5208 0.9715 0.6091 1.7670 0.5793 1.4530	0.0724	0.0722	0.0723
D14	4 0 0 2 0 2	1.0765 0.7498 0.7455 1.3158 0.5116 1.6004	0.1379	0.1379	0.1379
D15	0 4 1 0 0 1	0.4971 1.2745 0.5847 1.4736 0.3972 1.7717	0.2954	0.2954	0.2954
D16	1 0 0 0 0 2	0.9231 0.7486 0.6821 1.1919 0.5379 1.9160	0.2911	0.2911	0.2911
D17	1 2 1 4 2 0	0.6519 1.0442 0.6401 1.5947 0.5748 1.4938	0.0544	0.0544	0.0544

39.4.3 Fuzzy Comprehensive Evaluation

Matrix of every membership degree is presented through fuzzy comprehensive evaluation:

$$R_1=\begin{pmatrix}0&1&0&0&0\\0&0&0&1&0\end{pmatrix},R_2=\begin{pmatrix}1&0&0&0&0\\0&0&1&0&0\\0&0&1&0&0\\0&0&0&0&1\end{pmatrix},R_3=\begin{pmatrix}0&0&1&0&0\\0&0.5&0.5&0&0\\0&0&1&0&0\\0&1&0&0&0\\0&1&0&0&0\end{pmatrix},R_4=\begin{pmatrix}0&0&0&1&0\\0&0&1&0&0\\0&0&0&0&1\\0&1&0&0&0\\0&0&0&1&0\\0&1&0&0&0\end{pmatrix}.$$

$W_1 = C_1 = (0.2006 \;\; 0.7994)$,
$W_2 = C_2 = (0.0950 \;\; 0.5195 \;\; 0.2260 \;\; 0.1231)$,
$W_3 = C_3 = (0.2241 \;\; 0.2241 \;\; 0.4105 \;\; 0.0737 \;\; 0.0729)$,
$W_4 = C_4 = (0.1477 \;\; 0.0724 \;\; 0.1379 \;\; 0.2954 \;\; 0.2911 \;\; 0.0544)$.

According to the formula: $B_i = w_i \cdot R_i$
$B_1 = (0.2006\ \ 0.7994\ \ 0)$,
$B_2 = (0.0950\ \ 0.5195\ \ 0.2260\ \ 0.1231)$,
$B_3 = (0.2241\ \ 0.2241\ \ 0.4105\ \ 0.0737\ \ 0.0729)$,
$B_4 = (0\ \ 0.3498\ \ 0.0724\ \ 0.4388\ \ 0.1379)$.

$$\begin{aligned} B = (w \cdot R) &= (0.4768\ \ 0.5232) \cdot \begin{pmatrix} 0.09 & 0.03 & 0.62 & 0.11 & 0.10 \\ 0 & 0.33 & 0.26 & 0.33 & 0.10 \end{pmatrix} \\ &= (0.04\ \ 0.19\ \ 0.43\ \ 0.22\ \ 0.10). \end{aligned} \tag{39.8}$$

The final evaluation result: $F = B \times V_T = (0.04\ 0.19\ 0.43\ 0.22\ 0.10) \times (90\ 80\ 70\ 60\ 50)^T = 60.50$.

According to the evaluation level, this unit belongs to the middle level.

Through revolutionary AHP-FCE method, the safety level of every factor is proposed and quick and effective information of special equipment safety management is provided. It is proposed that "hazard identification", "device type", "safety accessory" and "headcount" have security risks. Great attention should be drawn by relevant departments and effective measures should be taken to improve the safety condition of those factors.

39.5 Conclusions

Fishbone diagram is adopted in the classification of special equipment safety management and revolutionary AHP-FCE method is used to establish special equipment safety evaluation system. Here are the conclusions:

- In this paper, indirect and direct factors are classified in factors set of special equipment from the perspective of systematic and practical situation. Management and environment are divided in the indirect factors while human and equipment are divided in the direct factors to enhance systematization and integrality of factors set.
- In this paper, revolutionary AHP-FCE method is adopted to establish special equipment safety evaluation system. Multilevel fuzzy comprehensive evaluation method and DEMATEL method are adopted to reduce the subjective preferences of Analytic Hierarchy Process, and DEMATEL method is used to modify the weight of factors between layers to enhance the objectivity and scientific nature.
- In this paper, revolutionary AHP-FCE method is applied in specific cases to establish special equipment safety factors set and evaluation system. Weight is calculated and evaluation results are came. It reflects the practicality and effectiveness of the method.

Revolutionary AHP-FCE method is applied to build special equipment safety evaluation system; it reflects creativity and further improvement in the establishment of special equipment safety evaluation system.

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Chapter 40
The Macroeconomic Leading Indicators Analysis Based on the Method of K-L Information Content and Time Difference Correlation Coefficient

Bochi Cai and Yue He

Abstract It is common to have fluctuations of development and growth level in the process of economic development. Thusit is quite important to found a reasonable macro economic leading indicators to analyze the macro economy. First, we analyzed the composition of the proportion of GDP and chose the composite index of over scaled industry increasing value and total retail sales of social consumer goods which make up great amount of GDP as reference index. Then, we use K-L information content and time difference correlation coefficient to analyze the macro economic indicators, Through the method we chose the indicators which have the leading feature. Finally, by the help of composite index in the method of economic sentiment index, we had the leading indicators. The empirical analysis shows that the leading indicators for Chengdu can predict the trend of the macro economy in Chengdu in a way, so it can help the government to make decisions in advance.

Keywords Leading indicator · K-L information content · Time difference correlation coefficient · Composite index · Macro economy

40.1 Introduction

The macro economic fluctuation is a cyclical period during which the economy fluctuates from depression to recovery then to high. This fluctuation is presented by continuous evolution of various economic indicators in different economic process. If the fluctuation of a indicator do not agree with overall economic fluctuation in the peak and valley at the same time (the benchmark cycle represented by benchmark index), and is in a forward position in time axis, this index is called leading indicator. Xie et al [1] pointed out:this kind of economic indicators change before

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the whole national economic fluctuation and for the cyclical fluctuation of national economy, the indicators are ahead in time, and come up before overall economic growth and decline. In the book ≪ *Economic Cycle Research* ≫, Wang [2] analyzed external impact and internal conduction mechanism for China's economic cycle and provided theoretical basis for us to do qualitative analysis on economic leading indicators.

Currently, there are no fixed standards for analyzing macro economic leading indicators overseas. He et al [3] said every method should be suitable for its national condition. For example, American leading indicator system includes Labor, Finance, Equipment supplies, Consumption and Comprehensive class. Besides, The National Bureau of Economic Research, The Conference Board, The United States Institute of Business Cycles, The US Bureau of Economic Analysis use different leading indicators. For the leading indicators in the eurozone, finance class uses money supply index, Eonia, exchange rate index and EMU-11 stock index; Equipment supplies uses order position; Consumption class uses the number of new car registration; Comprehensiveness class uses OECD leading indicators. About its theoretical basis, Lahiri et al [4] came up with the new theory and concept about leading indicators in the book ≪ *Leading Economic Indicators: New Approaches and Forecasting Records*≫ and also mentioned a time series framework about leading indicators.

Our country have been studying establishing leading indicator system since 1980s. We can see from the former consequence, there are some achievements on the national level. But on the province or lower level, few work has been done. For example, Sachs [5] synthesized Goldman Sachs economic activity index and Goldman Sachs leading indicators to monitor China's macro economy. These two indicators were founded on national level. The first areal economic indicator in our country is Beijing's economic leading indicator which was imported from BEA by Ding [6] and it acted quite well in test run. For method, it was Zhang et al [7] who introduced gray correlation method, fuzzy nearness method and discriminant analysis method to select leading indicators; However the most popular method in our country includes peak and valley corresponding method, time difference correlation coefficient method, Stage Average of Reference Cycle and K-L Information Criteria. Li [8] introduced these methods about picking out leading indicators in 2002; Otrok et al [9] used Bayes theorem in establishing leading indicators. Anyway, breakthrough in method is still a big bottleneck of research. As for final research production, publications with depth and authority was little and most of them were about introducing indicators for western countries. For example, Stock et al [10] used leading indicators to predict the time that economy began to decline in last century; Banerjee et al [11] used mathematic methods to study the stability of leading indicators' predicting effect. This is a great help for us to pick out more accurate leading indicators of different data set. The existing researches are basically about the economic leading indicators on national level and few researches are on areal level. Besides, the existing researches usually use industrial increasing value as benchmark index and do not consider the characteristic of areal economy.

As for the above problems, this essay took Chengdu's characteristic into consideration and used K-L information content and time difference correlation coefficient to establish Chengdu's macro economic leading indicators. Besides, we chose the composite index of over scaled industry increasing value and total retail sales of social consumer goods as the benchmark index.

40.2 Methods of Constructing the Macro Economic Leading Indicators System

By the look of experience in development in different countries, the construction of economic indicator system include conforming benchmark index, selecting economic leading indicator system and establishing leading indicators in economic process.

40.2.1 Conforming Benchmark Index

The substance of selecting benchmark index (or indicator) is to determine reference system for the time difference, this is the foundation for constructing the overall economic leading indicator system. Countries with sophisticated statistical indicator system (such as America, some OECD members and Eurozone members) mostly use GDP as benchmark index. In our country, most institutions choose "industrial increasing value" as benchmark index, this include two reasons: (1) There are more time series data for industrial increasing value than GDP. GDP is recorded quarterly, industrial increasing value is recorded monthly; (2) industrial increasing value can reflect the actual changes in GDP better than total industrial output value. Yan et al [12] suggested as industry is the main part of secondary industry, industrial increasing value making up large proportion in GDP determines that it can replace GDP as benchmark index. Chengdu's GDP was recorded quarterly from the end of 2004 till now, So we consider using other monthly indicators as benchmark index. From the perspective of Chengdu's economic development, industry's average share in GDP is 34.4% from 1999 to 2006, it is quite a large proportion; However, tertiary industry's average share in GDP is 47.6%. As a result, we consider choosing the composite index of over scaled industrial increasing value and the important representative index for tertiary industry — total retail sales of social consumer goods as benchmark index.

Using the the composite index of over scaled industry increasing value and total retail sales of social consumer goods and GDP's quarterly Year-on-year data to do X-11 seasonal adjustment, then we have our graph. We can see that the composite index's trend is basically the same as the GDP's. So we choose the composite index of over scaled industry increasing value and total retail sales of social consumer goods as benchmark index, as shown in Fig. 40.1.

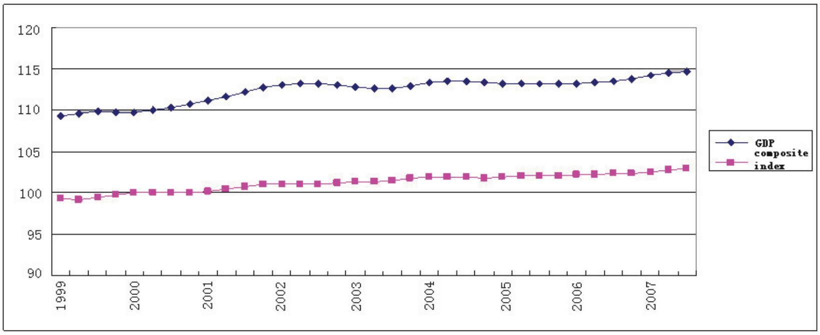

Fig. 40.1 The comparison between the trends of composite index and GDP

40.2.2 Selecting Leading Indicators

After confirming benchmark index, we can use suitable mathematical method to seriously calculate every index in basic index library (shown in Table 40.1) and pick out leading indicators with real ahead meanings. Here we use K-L information content method and time difference correlation coefficient to measure the correlativity between every indicator and benchmark index.

Table 40.1 Basic index library (1991.1 ∼ 2007.10)

Category	Indicators
Industry	Over scaled industry increasing value, the over scaled total industrial output value, cigarette production, cement output, the over scaled marketing rate on industrial output, steel production, Chinese patent medicine production
Fixed-asset investment	Total fixed asset investment value, Commodity House sales, renovation and reformation investment
Price	Consumer price index (CPI)
Finance	Local financial revenue, local financial expenditure
Banking	Deposit balances at a financial institution, deposits of enterprises, loans at a financial institution, industrial loan, financial institution's cash income, Financial institution's cash outlayresidents' deposit balance
Domestic trade	Total retail sales of consumer goods
Foreign trade	Total export-import volumetotal export, actual utilized foreign investment value
Transportation	Cargo volume, passenger traffic volume
People's livelihood	Per capita disposable income of urban residents, per capita living expenditures for consumption of urban residents

(1) K-L information content

For the occasional random phenomenon, it can usually be considered as realizations for random variables which obey certain probability distribution. If the probability distribution is already known, we need a measurement to estimate the chosen model's similar degree with real probability distribution, so we can tell the model is suitable or not, this is called Kullback-Leibler information content (K-L information content) which was came up with by Zhu et al [13].

Suppose that the probability distribution list for random (benchmark) variable is $\mathbf{p} = \{p_1, p_2, \cdots, p_m\}$, p_i is the event probability of w_i, restricted that $p_i > 0$, $\sum_{i=1}^{m} p_i = 1$.

Suppose that the probability distribution list for random (estimated) variable is $\mathbf{q} = \{q_1, q_2, \cdots, q_m\}$, $q_i > 0$ is the event probability of w_i, so define expectation $I(\mathbf{p}, \mathbf{q}) = \sum_{i=1}^{m} p_i \ln \frac{p_i}{q_i}$ as probability distribution list $\mathbf{q}$'s K-L information content related to probability distribution list $\mathbf{p}$. Assume that benchmark index is $\mathbf{y} = \{y_1, y_2, \cdots, y_n\}$. As sequence $\mathbf{p}$ which meet the needs of $p_i > 0, \sum p_i = 1$ can be considered as probability distribution list of certain random variable. So after standardized treatment for benchmark index, the sum of indicators is 1, $\mathbf{p}$ is the sequence that have been treated, then:

$$p_t = y_t \Bigg/ \left(\sum_{j=1}^{n} y_j \right), \ t = 1, \cdots, n \ (y_t > 0).$$

Suppose that the chosen indicator $\mathbf{x} = \{x_1, x_2, \cdots, x_n\}$ is also standardized and $\mathbf{q}$ is the final sequence, then:

$$q_t = x_t \Bigg/ \left(\sum_{j=1}^{n} x_j \right), \ t = 1, \cdots, n \ (x_t > 0).$$

By the equation $I(\mathbf{p}, \mathbf{q}) = \sum\limits_{i=1}^{m} p_i \ln \frac{p_i}{q_i}$, K-L information content can be calculated as:

$$k_l = \sum_{t=1}^{n_l} p_t \ln \left(p_t / q_{t+l} \right), \ t = 0, \pm 1, \cdots, \pm L.$$

In the equation, l represent the time ahead or behind. If l is negative it means ahead, positive means behind. l is called time difference or delayed number, L is the largest delayed number, n_i is number of data after been completed. When the $2L+1$ K-L information content have been calculated, the smallest value k_{ln} will be pick out as the K-L information content for the chosen indicator $\mathbf{x}$ related to benchmark index $\mathbf{y}$:

$$k_{l'} = \min_{-L \le l \le L} k_l,$$

where l' is the most appropriate months (quarter) that is ahead or behind. The smaller (more close to 0) K-L information content is, the closer indicator $\mathbf{x}$ is with benchmark indicator $\mathbf{y}$.

(2) Time difference correlation coefficient

Time difference correlation coefficient is a method use correlation index to confirm the relationship weather Economic time series is ahead, agreed or behind. Assume $\mathbf{y} = \{y_1, y_2, \cdots, y_n\}$ is benchmark index, $\mathbf{x} = \{x_1, x_2, \cdots, x_n\}$ is selected indicator, r is time difference correlation, then:

$$r_l = \frac{\sum_{t=1}^{n_l} (x_{t-l} - \bar{x})(y_t - \bar{y})}{\sqrt{\sum_{t=1}^{n_l} (x_{t-l} - \bar{x})^2 \sum_{t=1}^{n_l} (y_t - \bar{y})^2}}, \ t = 0, \pm 1, \pm 2, \cdots, \pm L.$$

In the equation, represent the time ahead or behind. If l is negative it means ahead, positive means behind. l is called time difference or delayed number, is the largest delayed number, n_l is number of data after been completed. When choosing the sentiment indicators, usually several time difference correlation for different delayed number are first calculated, then compare the results. The largest time difference correlation $r_{l'} = \max_{-L \le l \le L} r_l$ is considered to reflect the time difference correlation between selected indicator and benchmark index, delayed number l' represent the time ahead or behind. Dong et al [14] pointed out that we should pay attention to the following when estimating, choosing and classifying indicators:

- Indicators' time difference correlation usually do not larger than 0.5.
- Indicators' correlation coefficient sequences fluctuate a lot, they have obvious cyclical fluctuation feature.
- The size of time difference correlation do not restricted by sign.
- Time difference between ahead and behind indicators is usually more than three months.

40.2.3 Establishing Leading Indicators in Economic Process

Although economic booming trend can be observed and analyzed by fluctuations of various economic variables, comprehensive consideration on all variables's fluctuation should be take to observe overall process of macro economy's fluctuation. So, a comprehensive analysis method is needed to reflect macro economy's fluctuation in economic process, that is the method of economic sentiment index. It includes DI (Diffusion Index) and CI (Composite Index). DI regard indicators which are continuous increasing or decreasing as a process economic sentiment affect and permeate. It will be used to predict turning point of economic sentiment and grasp the process of effect; CI can be used to observe the degree that economic sentiment changes and provide quantitative descriptors. Meanwhile, it can also reflect the turning point of economic sentiment. The two indexes are both more reliable and authoritative than single index. The difference is that DI can not reflect the degree of increasing and decreasing but only can reflect the direction of change and the turning point; while

CI can not only predict the turning point of economic fluctuation but also can reflect the degree of economic cyclical variation in a way. Therefore, we adopt CI to deal with the selected leading indicator and finally get the leading indicators. Here, we use the mathematic method of synthetic index from OECD (Organization for Economic Cooperation and Development).

OECD uses the method of sentiment index to analyze and predict its members according to the concept of "cyclical increasing" from 1978. The method that OECD [15] uses to make synthetic index is quite easy and it is designed for leading synthetic index.

First, OECD decomposed the trend of indicators in leading indicator group (the sequence has been adjusted seasonally) by the stage average method and removed tendency in indicators. Then OCED got the cyclical elements sequence and assume it is $C_j(t)$ $(j = 1, 2, \cdots, m)$, m is the number of indicators. Meanwhile, benchmark index should be $X(t)$, it is also a cyclical element sequence obviously.
(1) Calculating the standard deviation SD_j of every indicators first:

$$SD_j = \left(\sum_{t=1}^{n} \left| C_j(t) - \bar{C}_j \right| \right) \Big/ n, \ j = 1, 2, \cdots, m,$$

$\bar{C}_j$ is the mean of j^{th} indicator.
(2) Calculating the average standardized sequence of leading indicators $S(t)$:

$$S(t) = \left(\sum_{j=1}^{m} \left(C_j(t) - \bar{C}_j \right) / SD_j \right) \Big/ m, \ t = 1, 2, \cdots, n.$$

(3) Calculating two adjustment factors k, d to make leading indicators go with benchmark index consistently and easy to compare by adjusting the range of the two factors.

$$k = \left(\sum_{t=1}^{n} |X(t) - \bar{X}| \right) \Big/ \left(\sum_{t=1}^{n} \left| S(t) - \bar{S} \right| \right),$$
$$d = \bar{X} - \bar{S},$$

where $X(t)$ is benchmark index, $\bar{X}$ is the mean of $X(t)$, $\bar{S}$ is the mean of $S(t)$.
(4) Calculating the leading synthetic index of cyclical increasing finally:

$$\mathrm{CI}(t) = k \times (S(t) + d), \ t = 1, 2, \cdots, n.$$

We can see that OECD uses cyclical increasing method to analyze cyclical element C's fluctuation. However, most developing countries use cyclical increasing rate method to analyze the fluctuation of cyclical element TC and secular trend in time series. Therefore, we choose TC's time series to calculate the leading composite index.

40.3 Empirical Analysis

Based on the methods above we can pick out leading indicators first. After using X-11 method to adjust 28 indicators, the two methods in Sect. 40.2.2 can be used to calculate K-L information content and time difference correlation of selected indicators and benchmark index. Through repeated comparison, 6 leading indicators were finally picked out, these indicators cover industry, investment, finance, banking and so on. As shown in Table 40.2.

Table 40.2 The leading indicator system established by the methods of K-L information content and Time difference correlation coefficient

Indictors	Time difference	K-L information content	Time difference correlation coefficient
The over scaled marketing rate on industrial output	−12	0.47	0.42
The over scaled total industrial output value	−12	11.04	0.94
fixed-asset investment	−9		0.71
Local fiscal revenues	−12	20.16	
Financial institution’s cash income	−10	24.25	
Financial institution’s cash outlay	−10	27.21	−0.46

Then, we can get the leading composite indicators for Chengdu by using the methods in Sect. 40.2.3. After comparing it with benchmark index we can see the tendency of leading composite indicators is similar with that of benchmark. As shown in Fig. 40.2.

Fig. 40.2 The comparison between trends of the leading composite indicator and benchmark index

The leading indicator is a synthetic index, the every number that consists it will affect the indicator. So it is very changeable and almost changes every month. According to a general rule, we should observe its trend. If the indicator has been increasing or decreasing for several months, it means new changes will be in the economic circulation. If the leading indicator keeps increasing for more than 8 months, benchmark index may have a return and GDP which have the similar fluctuation with benchmark index will climb up too. The duration of the recovery will be $3 \sim 7$ months behind in comparison with the leading indicator; Meanwhile, if the leading indicator has been decreasing for $5 \sim 12$ months, benchmark index will have a decline and GDP may also has the same fluctuation. The duration of the decline will be $3 \sim 9$ months behind the leading indicator. As shown in Tables 40.3 and 40.4. Besides, we can see from the analysis: Time difference between duration of the leading indicator keeps rising and duration of benchmark index's recovery is not obvious. The former is about $8 \sim 13$ months and the latter is about $11 \sim 14$ months; Time of the leading indicator's decreasing is about $7 \sim 12$ months which is longer than that of benchmark index's (about $5 \sim 7$ months).

Table 40.3 The comparison between the leading indicator and benchmark index in rising months

Duration of the leading indicator kept rising	The time the leading indicator began to rise	The time benchmark index began to rise	Duration of benchmark index kept rising	Rising period behind the leading indicator
13 months	2000.05	2000.12	14 months	7 months
12 months	2001.11	2002.05	11 months	6 months
9 months	2004.08	2005.01	11 months	4 months
8 months	2006.03	2006.06	17 months	3 months

Table 40.4 The comparison between the leading indicator and benchmark index in decreasing months

Duration of the leading indicator kept decreasing	The time the leading indicator began to decrease	The time benchmark index began to decrease	Duration of benchmark index kept decreasing	Decreasing period behind the leading indicator
7 months	1999.11	2000.08	5 months	9 months
9 months	2002.10	2003.04	5 months	6 months
5 months	2004.04	2004.07	7 months	3 months
12 months	2005.04	2005.11	5 months	7 months

40.4 Conclusions

In the essay, we chose the composite index of over scaled industry increasing value and total retail sales of social consumer goods as benchmark index to help us to pick out leading indicators for Chengdu with the quantitative method of K-L information content and time difference correlation coefficient. Then we analyzed the synthetic leading indicators and found the leading indicators can predict the trend of Chengdu's macro economy to help the government department make decisions in advance.

But due to the limitation of data sources, the essay is short of some indicators with important meanings. For example, the candidate indictor group lacks of indictors to reflect upstream economic movement (such as order for goods, survey index) and employment index etc. Therefore, the accuracy and comprehensiveness if affected in a way when choosing the indicators. After all, we should take steps to better the economic leading indicator system for Chengdu.

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Chapter 41
Research in Financial Governance Effect of Equity Structure of Listed Companies in China

Xiaoyan Hao, Dongfeng Song and Ye Wu

Abstract The outbreak of the financial crisis exposures many defects of financial governance that are caused by the defects of the ownership structure of the listed companies of in China. Ownership structure is the foundation of financial governance; its rationality has a decisive impact on the efficiency of financial governance of the company. This paper analyses the financial governance efficiency in the ownership structure in theory and demonstration. It analyzes the status of financial governance effect in ownership structure of China's listed companies, and finally putting forward suggestions and countermeasures which directly optimize the ownership structure and the financial governance efficiency in China's listed companies.

Keywords Ownership structure · Financial governance · Efficiency of financial governance · Value of the company

41.1 Introduction

Equity is the ownership of listed companies, stock ownership structure refers to the ownership structure of listed companies, including both what the owner, namely equity constitute, also include the proportion of each owner of shares, ownership concentration. In terms of composition of equity, listed companies' equity can be separate to state-owned shares, corporate shares, and outstanding shares. From the aspect of ownership concentration, the equity of the listed companies in China can be divided into highly concentrate (The company is the absolute shareholder), relative concentration (The controlling shareholder was shared by company and other substantial shareholders), and highly fragmented (Shareholders are small shareholders). Financial governance refers to institutional arrangements of financial power

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among various shareholders, via incentive and constraint mechanism, contingent governance, performance evaluation mechanism, and etc. achieving balanced financial power among all shareholders [1].

41.2 Analysis of Financial Governance Effect in Ownership Structure

Although ownership structure is the fundamental for financial governance, posing substantial effects on governance performance and reflecting from company value, the company value is not depended on ownership structure. In fact, the ownership structure affects the financial governance performance through its influence of incentive and constraint mechanism, which formed by financial power allocation [2].

41.2.1 Financial Governance Effect of Equity Constitution

Shareholders will set themselves assets to the company to operate, from the aspect of making the benefits maximize, shareholders of different characters should have different incentive and restriction mechanism to company's operators, shareholders of different shareholding ratio should have different driving power to encourage and restrain managers to have hard work to improve the value of the company.

There is a fact that the company involving highly proportion of state-owned shares fail to execute incentive with great dynamics. The reason to this point is that the majority of these listed companies are transformed from state-owned enterprises. Therefore, the major shareholders of the company are state-owned stocks. However, benefit conflicts among state-owned subjects along with the special character of the government give rise to the government's "super control" on the administrative aspect and the "super weak control" on the property subject. As a result, the government pays for the consequence of managers' high interests behaviors. In such occasion, companies with high state-owned proportion do not form effective incentive and constraint mechanism to managers. In contrast, they indulge corrupt practices, reducing the company value.

Major shareholders include corporate shares and largest individual shareholder. They believe that the effort of operators directly associate with their own vital interests, hence paying attention to companies' condition with great enthusiasm and dynamics. On the one hand, they use the method of voting-by-hand, transferring managers, exert pressures on operators; on the other hand, they instigate managers to work hard for the privilege of companies' interests, thus promoting the company value.

With limited range of professional knowledge, the majority of external investments of minority shareholders have blindness, leading to asymmetric costs and benefits of participation in corporate governance. So they do not have the capacity nor the will to concern over actual governance. What their main criteria to select the investment orientation is to follow the trend, therefore, to some extent, consolidating the influence of large shareholders. And finally incur the leverage effect of large shareholders investment on the operator's incentive and restraint.

Shares in the operator holding will increase the company's value within certain limits. If a manager holds company's stock, then the operator is the shareholder. Thence, the share proportion of internal shareholders poses positive effects on company value. However, the high ratio of manager's share may cause the procrastination, hence degrading the corporate governance mechanism. When the share proportion is too high to have pressure of being taken place, facing the balance of working consumption and company value, managers tend to abandon long-term interests of the company in favor of the personal enjoyment, reducing the company value [3].

41.2.2 Financial Governance Effect of Ownership Concentration

The research has shown that relative concentration of ownership structure can strengthen financial governance effect, in the view of the existence of large shareholder. In such condition, the large shareholder has the ability as well as dynamics to incentive, constraint, and monitor operators by the way of voting by hand. On the contrary, when equity dispersed, each minority shareholder has no access to incentive and constraint managers, making operators become enterprise's control. What's more, considering the interest conflicts between operators and shareholders, operators will sacrifice benefits of shareholders for the privilege of personal consumption and benefits, eventually reducing the company value [4].

41.3 Empirical Analysis in Financial Governance Effect of Equity Structure of Listed Companies in China

41.3.1 Sample Selection

This study samples come from all 2010 financial data in A-share listed companies in Shenzhen and Shanghai Stock Market in China. Considering variations among general business, we exclude observational value of corporations in financial, securities, and insurance realms. We also remove observational value of ST unit, S*ST unit, and PT unit. What's more, we reject some observational values in unavailable sample, extreme values and exception values, which are not suitable for calculations. After above filter processing, we get 1135 samples as final observational values. All transactions in the relevant financial data and market data come from CSMAR system (CSMAR21211).

41.3.2 Variable Selection

Basing on references study, considering present situation of listed companies in China along with the features of selected data, we chose the following variables as study on indicator. As shown in Table 41.1.

Table 41.1 Empirical analysis of financial governance effect of ownership structure indicators selected

Type		Symbol	Name	Variable definition
Dependent variable	Company value	ROE	Rate of Return on Common Stockholders' Equity	NOPAT/N.A.∗100%
Independent variables	Equity constitutes	GYG	The proportion of state-owned shares	State-owned shares/Total equity
		FRG	Proportion of corporate shares	Corporate shares/Total equity
		LTG	Proportion of outstanding shares	Outstanding shares/Total equity
	Ownership concentration	A1	Largest shareholder ratio	Number of largest shareholder/Total equity
		A10	The proportion of Top 10 shareholders	Total of top 10 shareholders/Total equity
	Capital structure	DAR	Debt Asset ratio	Total liabilities/Total assets

The explanatory variables are the company's marketing value, and we chose ROE as indicator to measure the value of the company. ROE, regarded as one of the most representative indicators, with high capacity, can reflect shareholder capital efficiency comprehensively (exclude the influence of bonus share) and be a vehicle for financial governance efficiency.

There are five explanatory variables: GYG, FRG, LTG, Al, and A10.

The control variable is the capital structure. According to relative researches, capital structure is one of the indicators that shareholders concern, because under the established framework structure, the capital structure is a basis for corporate financial governance structure. Thus, the corporate financial governance structure is a manifestation of the capital structure, which, by and large, determines the level of corporate financial governance efficiency.

41.3.3 Research Hypothesis

It is the state-owned shares in equity constituted investment that lead to the absence of investment subjects. In such condition, instead of considering the company's long-term benefits and company value, operators make decision in view of their own advantages, deteriorating the corporate governance performance. Institutional shareholders have strong supervisory capacity, posing great positive effects on company value. However, it by no means the larger the proportion the better the condition. In view of state-owned corporate shares belonging to the government, high proportion institutional shareholders may impact the stock liquidity, thereby reducing the company value. It is the fact that outstanding shares are public units. Thus, stimulating by maximizing profits, operators could be encouraged by outstanding shares. However, with the expansion of corporate scale, increasing number of shareholders, and decentralization of ownership structure, shareholders is insufficient to govern companies by virtue of personal ability. Taking this problem into consideration, individual shareholders may "thumb a ride" or "vote by feet", reducing the manager's risk of taking place. Consequently, outstanding shareholders monitor and incentive corporate operation and management with little effectiveness. After all, managers holding shares in certain range, shareholders are able to increase incentives for operators, thereby promoting the company value.

Research shows that ownership concentration has great effects on company value, influenced by the cost of risk and treatment costs. The higher these two costs are, the lower the ownership concentration, and vice versa. That is to say: these two costs have minimum value, under which the ownership concentration is the best equity ratio. According to the western research, there is a best value for ownership concentration which gives rise to the most efficient corporate financial governance. It is proved by "U" type theory that the benefit condition for raising company value lies in the existence of the controlling shareholder and other large shareholders [5].

According to the theories and illustration above, we can come up with following assumptions:

- The proportion of State-owned shares is in inversely proportional to the company value, which means negative correlation, namely, that decreasing the proportion of state-owned shares exerts positive influence on expanding the company value.
- In certain range, the proportion of corporate shares and the value of the company is relevant.
- Other conditions being equal, proportion of shares and corporate value have no significant relationship.
- Equity relative concentration is directly proportional to company value, which means positive correlation, namely, that the concentration of equity could bolster the efficiency of financial governance, but by no means highly concentrated equity can be always better.

41.3.4 The Reasonableness of the Data and Variable Detection

(1) The detection in the rationality of data

Using the filtered data to make statistical analysis and detecting the data rationality, we get more universal empirical results, making great difference. As shown in Table 41.2.

Table 41.2 Descriptive statistics of variables

Variable	Average	Medium	Standard deviation	Minimum	Maximum	Number of samples
GYG	0.179	0.051	0.219	0	0.802	1135
FRG	0.093	0	0.162	0	0.782	1135
LTG	0.674	0.692	0.229	0.041	0.999	1135
A1	0.363	0.342	0.150	0.051	0.849	1135
A10	0.534	0.531	0.151	0.151	0.932	1135
ROE	0.105	0.090	0.075	0.001	1.167	1135
DAR	0.515	0.531	0.192	0.010	0.944	1135

According to the Table 41.2, the average of ROE equals to 10.5%, greater than 0 and having higher proportion, which indicates that the company provides better safeguards so as to reimburse the debt and pay for the interest. The average of GYG is 17.9%; the average of FRG equals to 9.3% and the average of LTG is 67.4%, suggesting the effectiveness of restricted shares lifted in our country. The average of A10 is 54%, indicating that the Chinese listed company ownership concentration is high.

(2) The detection in the rationality of variables

To examine the rationality of the variables selected, we have to check every effect of variables on ROE, thereby analyzing regression analysis of each variable and ROE in the following table. As shown in Table 41.3.

Table 41.3 Correlation analysis of variables and ROE

Statistics variables	C	Coefficient	T-statistic	Prob	R
GYG	0.1066	−0.485	−0.6476	0.0175	0.6235
FRG	0.1002	0.535	3.0565	0.0023	0.7153
LTG	0.1285	−0.347	−2.7936	0.0544	0.6113
A1	0.0834	−0.362	−3.1523	0.0017	0.9144
A10	0.0307	0.714	7.6488	0.0000	0.9705
DAR	0.0901	0.292	1.9642	0.0499	0.8562

According to the Table 41.3, the selected variables and explained variables, the ROE, have certain correlation, especially under the level 5 percent (except for outstanding shares). In that correlation, the GYG is in inversely proportional to the

ROE, and the A1 is directly proportional to the DAR. However, the FRG, A10, and DAR are inversely proportional to the ROE. Outstanding shares are significant test.

41.3.5 Model Establishment

According to above analysis and basing on the suitability, we need to study the comprehensive impact of these variables on the company value. The regression model (β is the constant term, ε is the random perturbation, i stands for company) is:

$$\mathrm{ROE} = \beta_0 + \beta_1 \mathrm{GYG}_i + \beta_2 \mathrm{FRG}_i + \beta_3 \mathrm{LTG}_i + \beta \mathrm{A1}_i + \beta_5 \mathrm{A10}_i + \beta_6 \mathrm{DAR}_i + \varepsilon_i,$$
$$i = 1, 2, 3, \cdots, 1135.$$

41.3.6 Empirical Analysis

Taking the influence of multicollinearity into account, we select listed company information in 2010 and put the model in statistical software (Eviews 6.0) so as to make regression analysis on indicators of ownership concentration and equity construction. The results shown in the table below: As shown in Table 41.4.

Table 41.4 Please write your table caption here

	GYG	FRG	LTG	A1	A10
GYG	−0.2030				
FRG		0.0937			
LTG			−0.1042		
A1				−0.5047	
A10					0.3084
DAR	−2.3193	2.1507	1.7583	−0.4072	14.1138
β_0	227.2554	−201.5345	−361.2835	4.2797	−14.1714
Amended R2	0.9987	0.9547	0.7940	0.5324	0.9682
F	132.9586	6.2615	18.9388	74.6270	37.9627
T statistical value	−3.6403	5.4273	−2.7812	−1.8971	8.0736

Data above are all significant under the level of 5 percent (except for outstanding shares). By analyzing the data in this table, we find that equation is tested by F and random disturbance term does not exist between autocorrelation, indicating that model designed reasonably. The results show that state-owned shares are in inversely proportional to ROE, namely, that the higher GYG is, the less increasing company value, testifying assumption 1. Corporate shares positively correlated with value of the company, justifying assumption 2. Outstanding shares of value of the company fail to pass the test of significance, suggesting that outstanding shares and the company performance have no significant relations, consistent with previous described, testifying assumption 3. A1 is inversely proportional to the company value, illustrating that reducing the stake in largest shareholder can increase the value of the company. However, considering that A10 positively correlated with value of the company, in terms of A10, high concentration of ownership contributes to enhancing the value of the company. Comprehensive analysis shows that relative concentration of equity benefits to the improvement of ROE, testifying assumption 4. DAR and ROE are related, that is liabilities operators, to some extent, pose positive effects on company value, but not DAR as high as possible. This indicator's level and reasonable degree are impacted by various factors, hoping to continue research.

41.4 Status of Financial Governance Effect of Listed Companies in China

The special ownership structure and the poor-developed external market bring about the ineffectiveness and weakness of the financial governance. Along with the theoretical and empirical analysis, we summarize the status of financial governance effect of listed companies in China as following:
(1) Unreasonable ownership structure leads to the improper arrangement of the shareholders' remaining financial power

Due to the concentration of shareholding, the company's financial decision-making power is concentrated in the hands of a few large shareholders. The state-owned shares accounting for a larger proportion of equity structure in our nation. Thus, the dislocation of investment subject of state-owned shares results in the inconsistence in rest financial power involving "residual financial claims" and "the remaining financial control", which controlled by state-owned assets management departments and business managers, hence causing the imbalance among responsibilities, rights and interests. What's worse, incentives for managers dwarf the executive financial power; small shareholders and internal staff have inadequate power to exercise supervisory powers, leading to less strong financial supervisory powers.
(2) Unreasonable internal financial power allocation results in nominal board of directors

As the company's strategic leader and the core of the financial governance, the board of directors could represent the interests of all shareholders only by maintaining the high level of independence. Nevertheless, in China's listed companies, the board, by and large, is controlled by a few major shareholders or government officials, without substantive effect. Moreover, the majority of listed companies are CEO Duality, which suggests that most people in the board of directors are management personnel, forming the situation of inside dominant directors.
(3) Lacking effective incentive, restraint, and supervisory mechanisms

China's listed companies are prone to make equity financing, which unfortunately have less power of supervisory and restraint than bond financing. Yet, over equity financing will weaken the company's restraints. China's listed companies executive monologues incentives to operators, which primarily include short-term incentives and cash incentives, lacking enough incentive intensity and having less correlation degree with corporate performance. Even worse, the lose-making company makes huge contrast with their high salaries of executives. External managers slowly developing, operators have less pressure. Ineffective incentives and less restriction instigate the managers' behavior of consumption and seeking personal benefits. Even existing board of supervisors, most China's listed companies select members of the board of supervisors within internal companies, less independent and prestige, thereby wanting the real supervisory role. On the other hand, members of the board of supervisors have less professional knowledge and abilities than members of the board, thence failing to find out and deal with some indispensable faults and subjective morality mistakes of managers [6].

(4) Lacking efforts to protect the government's public financial supervision rules

Lacking efforts to protect the Government's public financial supervision rules give rise to limited development of external markets, affecting the establishment and perfection of the governance mechanisms of listed companies in China. Too much government intervention suppresses free game behavior of market subjects artificially along with the powerful control in companies' financial, forming the vicious circle, where the government manipulates whole process of "Market - company - market" artificially. What's worse, the manager market does not act the effect of initiative and manager selection mechanism is not perfect. Entitled by the government or government officials directly, a great number of managers cannot voted by multilevel administrative system, lacking constraints and restrictions. They are selected by leaders of company, without normal and fair electoral process.

41.5 Countermeasures of Financial Governance Effect to Strengthen the Shareholding Structure of China's Listed Companies

41.5.1 Optimize the Ownership Structure and Rationalize the Allocation of Financial Management Right

The reduction of state-owned shares is essentially to the adjustment of property rights, in which companies give part of the original state-owned financial authority to other investment subjects. This paper argues that by limiting the highest stake of state-owned shares in sub-industry and by changing state-owned share subjects and introducing other investment subjects to achieve the reduction of state-owned shares. Optimizing the securities market information disclosure mechanism, increasing the liquidity of the securities markets, improving investor protection legislation, and strengthening judicial execution efficiency, we can strengthen the protection of small investors, therefore decreasing the stake of the largest shareholders. According to earlier conclusions, we make adjustment in the shareholding structure of listed companies in China. Albeit the adjustment, there is a foothold. China's stock market is not very developed, and thus over dispersed shareholding structure is not suitable for our country. The equity structure of listed companies should be moderately concentrated, namely, that relative controlling shareholder exists and other large shareholders develop in a balance direction.

Promoting the shareholding structure of the financial strategy cause decision-making power concentrated in the hands of the shareholders meeting and the Board. The financial tactical decision-making power and the company's daily operation and management rights are concentrated in the hands of managers. In addition, the financial supervisory authority is dispersed in the company's internal and external. Hence, clearing the rights, responsibilities and interests in shareholders, board of directors and managers can establish pleasant checks and balances among them. Making cumulative voting rights system and small shareholder litigation system, the system protecting small and medium investors, we can strengthen the role of small and medium investors in the listed companies' financial governance structure. When the interests of the company are infringed by stakeholders, minority shareholders will no longer rely on the law to prosecute board of directors. Instead, they will sue the relevant personnel on behalf of the company actively, therefore protecting their own benefits [7].

41.5.2 Improve Financial Governance Mechanism

The separation of ownership leads to a conflict of interest. Only improving the performance evaluation mechanism, can investors understand the effort degree of operators objectively, thence taking appropriate incentive and restrictive measures and developing "creditors-satisfied" performance appraisal systems. Because of the imperfect external market, when making financial stimulated constraints system, we should note the selection of the incentives and source of operators. In China's listed companies, especially state-owned listed companies, most operators, not our incentive target, are entitled administratively. According to the incentives, long-term incentives than the short-term incentive enjoy more advantages to the improvement the company value. In view of present in our country, stock options are not ideal rewards for operators. However, with the elevation of various systems and market, stock options will be good long-term incentives. Moreover, we can introduce indicators such as EVA and MVA, allocating residual claim properly, operating appropriately, and taking measures like establishing long-term contractual relationships with professional managers, finally enhancing the company's incentive and restraint mechanisms and performance evaluation mechanism. Eventually, we should perfect the financial contingent governance mechanism. When the debtor fails to debt service punctually, creditors have rights to have control of the company, and external stakeholders have the right to safeguard their legitimate rights and interests via adopting the appropriate measures [8].

41.5.3 Standardize Financial Governance

Construct a hierarchical financial decision-making mechanism, so that Layers of financial subjects exercise their own financial decision-making authority, coordination, fully devoting, and without overriding. Give operators the limited borrowing power, within certain range of DAR. Managers' decisions on financing projects should be reviewed and registered. More importantly, give operators limited inward investment decision-making power, and parts exceeding the limits of investment project must approved by the shareholders. At last, give operators appropriate income distribution rights and avoid adverse selection. Using accountant designation, comprehensive budget management, contingent governance, and reporting system on significant events, we can eventually standardize financial oversight.

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Chapter 42
The Evaluation of College Students' Comprehensive Quality Based on Rough and ANN Methods

Xiaofeng Li and Lingyuan Liu

Abstract The risk measure for enterprise technology innovation is a hotspot problem and the forward position of enterprise management, is a much subject overlapping edge research program, it is very difficult to research this problem. In this paper, based on Rough set theory and ANN method, Rough-ANN model for dynamic risk measure of enterprise technological innovation is established. It takes the advantages of the informational reduction principle of rough set theories and ANN predominance which has stronger concurrent processing, approach advantage and sort study capability. Thus the model may simulate the mankind's abstracting logic thinking and image intuitive thought to measure enterprise technological innovation risk. This model can identify the main attributes of technological innovation risk, reduce the information accumulate cost of risk measure, improve the efficiency of risk measure, make the sophisticated problem of technological innovation risk measure simplified. Therefore, this model has better practice operability. Theoretical analysis and experimental results show the feasibility and validity of the model. The research work supplies a new way for dynamic risk measure for technological innovation.

Keywords Comprehensive quality · Evaluation · Rough set · BP artificial neural network

42.1 Introduction

Nowadays colleges and universities endeavor to train talents with innovative mind, who are urgently needed with the development of our society. At present, push higher education forward to the quality-oriented education, practice work already

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enters a new dimension, but college students' character adjudication, especially comprehensive quality's evaluation are relatively weak [1–3]. Nowadays, College students' comprehensive quality evaluation patterns are almost produced by past exam-oriented education environment,have existed many shortage in evaluation aim, evaluation content and evaluation method,they are as follows: analysis and research almost focus on qualitative, pay little attention to quantitative analysis and existing evaluation index system is out-of-date. Those comprehensive quality,particularly moral and capacity quality required in existing evaluation index system can not meet the quickly developing demand, this problem already become a "bottleneck" [4–7], which has a further affect on strengthening and improving of quality-oriented education. Therefore, build a scientific, achievable college students' comprehensive quality evaluation system already become an important subject of quality-oriented education's theory and practice. Through the study of the current society, especially employer's requirement for college students, we design the college students' comprehensive quality evaluation index system, and build college students' comprehensive quality evaluation's Rough-ANN model. This model not only can avoid disturbance of human factors, but also can recover college student comprehensive quality's major feature attribute, reduce the costs during gather information for college students' comprehensive quality evaluation, and improve the efficiency, simplify the complexity college students' comprehensive quality evaluation task.

42.2 Establish College Students' Comprehensive Quality Evaluation Index System

College students' comprehensive quality evaluation is using scientific systematic method to make the judgment and evaluation of college students' comprehensive quality, on the basis of carefully analyze about the condition and developing state of college students' moral quality, professional ability, practical capability, physical and psychological quality. Therefore, before evaluating college students' comprehensive quality, we must build college students' comprehensive quality evaluation index system.

42.2.1 The Principle for Establishing the Evaluation Index System

There are many factors which influence college students' comprehensive quality, and the relationships of them are complex. Therefore, In process of building college students' comprehensive quality evaluation system, we must follow these principles below.

- Guiding principle. Evaluation index system should reflect quality-oriented education's basic requirement on college students, can guide students' cultivate and develop all-round quality, and has been good for encouraging all-around personal development morally, intellectually, physically and esthetically.
- Comprehensiveness principle. Evaluation index system should reflect related important content of quality-oriented education as far as possible, describe college students' comprehensive quality intension and feature from different levels and points, so that it could guarantee the evaluation accurately feeds back college students' comprehensive quality and quality-oriented education's effect.
- Level principle. We should set the index system according to progressive arrangement, compose a united whole which has a clear, connected, reasonable structure. And lower levels' specific evaluation index should analyze and explain to upper levels.
- Independence principle. Evaluation index should be relatively independent, that reflect one respect of student, there is no cross and similar phenomena involved between each index. And try to avoid duplication of information to take advantage of the evaluate effect of different indexes.
- Practicability principle. We could not be further from reality when designing the evaluation system, those evaluation indexes can obtain enough information in education practice, can quantified describe the state of evaluation object in education programmers, at the same time, try to simplify evaluation system.

42.2.2 The Way to Establish the Evaluation Index System

Based on the new requirements of employers and college students' feature, college students' comprehensive quality can be fall into five categories: moral quality, professional quality, humanistic quality, physical and psychological quality, capability quality. We can treat these five categories as the first-class index of college students' comprehensive quality evaluation. Then, according to the principle of establishing college students' comprehensive quality evaluation system, and reference relative literatures at home and abroad [8–11], we gradually decompose first-class indexes, and initially build the framework of college students' comprehensive quality evaluation index system, which include 5 first-class indexes, 11 second-class indexes and 54 third-class indexes. Then, we design questionnaire, ask interviewee (relative field expert, manager) to assess every evaluation index. Combined with expert opinions, the 11 third class indexes are canceled. At last, we build college students' comprehensive quality evaluation index system, which are shown in Table 42.1.

Table 42.1 The college students' comprehensive quality evaluation index system

First-class index	Second-class index	Third-class index
Moral quality	Politics quality	Politics theory level Politics attitude Scientific world outlook Experience as students leader
	Ethics quality	Ethics character Civilization accomplishment Study attitude Attitude toward manual labor
	Law and Discipline quality	Legal knowledge Law concept Abidance by law Abidance by the school rules
Professional quality	Professional theory	Public required course score Specialized course score
	Professional skill	Practical foreign language competence Computer application ability Literature search and data access quality Professional design quality
Humanistic quality	Humanistic theory quality	Social sciences knowledge Natural science knowledge Humanity quality train knowledge
	Humanistic practice quality	Social work Social practices Art competition award Self-cultivation
Physical and psychological quality	Physical quality	Fitness condition Sports score Participation in sports activities
	Psychological quality	Mental health condition Social adaptation Emotional coordination and control capacity
Capacity quality	General capacity	Written capacity Oral communication capacity Analysis & judgment capability Independent problem solving capacity Hands-on capacity Self-study capacity
	Special capacity	Interpersonal communication capacity Teamwork capacity Organization and management capacity Academic research capacity Technological innovation capacity Art innovation capacity

42.3 Rough-ANN Model of College Student Comprehensive Quality Evaluation

42.3.1 Overview of Rough Set Knowledge Reduction Method

Rough set theory is a mathematical theory analysis of data first proposed in the early 1980s by Polish mathematician Pawlak [12]. It is a new tool which deal with fuzzy and uncertainty knowledge of mathematical. Rough set theory has been widely applied in machine learning, knowledge discovery from the database, decision support and analysis. The main idea is under the premise of maintaining the same classification ability, export the decision-making and classification rules of problem by knowledge reduction. Knowledge reduction method is the kernel of the rough set theory. In knowledge base knowledge (attributes) are not equally important, even some of the knowledge is redundant [13]. The so-called knowledge reduction is to keep the same conditions of the known training library classification ability, delete irrelevant or unimportant knowledge.

Let $K = (U, R)$ is an information system where $U = \{u_1, u_2, \cdots, u_n\}$ is a finite non-empty individual Complete Works, $R = \{r_1, \cdots, r_m\}$ is a finite set of attributes, set $r \in R$ is an attribute on the U, the equivalence class of the Complete Works of U on the elements on the properties of r can be denoted by $[x]_r$, where $x \in U$.

Let $P \subseteq R$, $P \neq \varphi$, $P = r_{i1}, \cdots, r_{ik}$, all equivalence relation of P is $\cap P = \cap_{j=1}^{k} r_{ij}$, then $\cap P$ is an equivalence relation, denoted by $\mathrm{IND}(P)$, says this intersection is no clear relationship.

Let $r \in R$, if $\mathrm{IND}(R) =$ the $\mathrm{IND}(R - r)$, claimed that r is a reduction properties of R, otherwise r is an irreducible property of R. If $\forall r \in R$ are not reduction, called the set R is an independent set, otherwise the set R is related.

Q, R is independent and $\mathrm{IND}(Q) = \mathrm{IND}(P)$, claimed that the Q is simplified of the P. The collection of all non-Province attribute of P is called P nuclear, recorded as core (P). Detailed Rough set algorithms for reduction of knowledge please refer to Literature [14].

42.3.2 BP Artificial Network Architecture and Algorithm

A standard back propagation neural network is shown in Fig. 42.1. The first layer consists of n input units. Each of the n input units is connect to each of the r units in the hidden layer. The r output units of the hidden layer are all connected to each of the m unit in the output layer.

BP is a supervised learning algorithm for multilayer networks [15, 16]. The algorithm aims at minimizing the MSE between the actual output of the network and the desired output. Gradient descent search is user in BP. In BP learning, a set of patterns of the form $< x_1, \cdots, x_n, y_1, \cdots, y_m >$, where $x_1, \cdots, x_n$ are the components

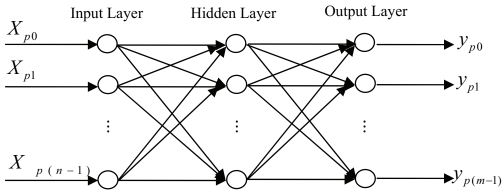

Fig. 42.1 The standard BP artificial neural network

of the input vector and $y_1, \cdots, y_m$ are the components of the desired output vector, is repeatedly given to the network until the learning of weights converges.

If the BP neural network has N units in each layer, The transfer function is the sigmoid function, $f(x) = \frac{1}{1+e^{-x}}$, the training samples involve M different patterns (X_p, Y_p), $P = 1, 2, \cdots, M$. Corresponding the Input sample P, let net_{pj} represents the input total of unit j, let O_{pj} represents the output value, that is:

$$\mathrm{net}_{pj} = \sum_{j=0}^{N} W_{ji} O_{pj}, O_{pj} = f(\mathrm{net}_{pj}).$$

The error between input values and output values is as following:

$$E = \sum E_p = \left(\sum (d_{pj} - O_{pj})^2\right)/2.$$

The revise connection weights of BP neural network are as following:

$$W_{ji} = W_{ji}(t) + \eta \delta_{pj} O_{pj} + \alpha (W_{ji}(t) - W_{ji}(t-1)),$$

$$\delta_{pj} = \begin{cases} f(\mathrm{net}_{pj})(d_{pj} - O_{pj}), & \text{corresponding the output units,} \\ f(\mathrm{net}_{pj}) \sum \delta_{pk} W_{kj}, & \text{corresponding the output units,} \end{cases}$$

where η represents the learning rate, it can increase convergence in speed, α represents the momentum coefficient. The value of a is *a* constant, it affects the connection weights of next step. Details of the traditional BP neural network algorithm can be found in the original paper by Tian and Gao [17].

42.3.3 The Basic Principles of Rough-ANN Model Construction

From Table 42.1, we know that many factors affect college students' comprehensive quality indicators. Correlation may exist between the data of these indexes, if regarding all of them as artificial neural network input variables will obviously increase the complexity of the network, reduce network performance, greatly increase the calculation of running time, and affect the accuracy of the calculation. Knowledge reduction in Rough set theory provides a good idea to solve this problem, we can reduce the expression of information attribute index, remove the redundant information and indicators, simplify the neural network training set, reduce the complexity and training time of neural network system by Rough set theory. First compress third-level indicators of college students' comprehensive quality evaluation with the knowledge of reduction in the Rough Set Theory. Next, use the three level indicators as input variables of the BP network, and then study by the improved BP algorithm. The idea to do so is that, Rough set theory can start from the relevance of data x and found the data pattern to extract data rules, reduce data variable, but does not exist advantage in knowledge inference and prediction. However, neural network's earning ability, reasoning ability and classification ability are strong, also is good at extracting rules and information from large amounts of data, and has a good dynamic prediction function. Therefore, we would organically combine the two methods through learning from each other, in order to improve capabilities of artificial neural network to deal with complex issues, non-linear problems.

42.3.4 Design the Rough-ANN Model

During designing college students' comprehensive quality evaluation's Rough-ANN model, we firstly determine the comment level of college students' comprehensive quality comment. Then determine the assignment method of the third-class evaluation indexes. At last, build Rough-ANN model's three layers network structure.

(1) Confirm college students' comprehensive quality comment level

Let $V=\{v_1,v_2,\cdots,v_n\}$ represent the evaluation levels of college students' comprehensive quality. In this paper, set $n=5$, establish 5 kinds of evaluation levels. Comment sets consist of evaluation levels is $V=\{v_1,v_2,\cdots,v_5\}=\{\text{excellent}, \text{fine}, \text{medium}, \text{passing}, \text{bad}\}$.

(2) Assignment method to evaluation indexes

In order to reflect objectivity and comprehensiveness of college students' comprehensive quality evaluation, avoid one-sidedness, during quantizing the third-class indexes of college students' comprehensive quality evaluation indicator system, we should combine students' self assessment, mutual evaluation and teachers' evaluation. At first, organize a assessment team, this group is made up of student, delegation of schoolmates, counselor and teachers. Then, ask the group member to assess the third-class indexes of evaluation object. Evaluation standard is as follows.

Suppose one group member considers the evaluation index x_i is "bad", then its score will be u_1 $(u_1 \in [0,1])$; considers the evaluation index x_i is "passing", then its score will be u_1 $(u_1 \in [0,1])$; and so on.

Suppose the group has f members, the member a $(a=1,2,\cdots,f)$ gives u_a score to index x_i $(i=1,2,\cdots,43)$, then the evaluation value xv_i of index x_i is:

$$xv_i=\frac{1}{f}\sum_{a=1}^{f}u_a.$$

(3) Rough-ANN model structure

According to the traditional BP neural network structure, we divide Rough-ANN model for college students' comprehensive quality evaluation into three layers:

- Input layer: Firstly, give values to three layers indicators of college students' comprehensive quality evaluation index system. Then, use the knowledge reduction method in Rough Set Theory to remove redundant indicators, take the three layers indicators as input variables of neural network.
- Hidden layer: As for the selection of the hidden layer, please refer to literature [18] that have mentioned-BP neural network dynamically adjusted learning algorithms, firstly, set up hidden layer nodes large, let network self-regulated learn, and finally get the right size of hidden layer nodes.
- Output layer: College students' comprehensive quality is divided to: excellent, fine, medium, passing, bad. So, in artificial neural networks, respectively, we use the output vector $(1,0,0,0,0), (0,1,0,0,0), (0,0,1,0,0), (0,0,0,1,0), (0,0,0,0,1)$ to describe. Therefore, the neural network's output layer nodes are 5.

42.3.5 Basic Algorithm of Rough-ANN Model

Combine Rough Set Theory with ANN method, we establish college students' comprehensive quality Rough-ANN model, the basic algorithm procedure is as follows:
Step 1. According to the college students' comprehensive quality comment set, combined with the assignment way of evaluation index give values to three indicators of college students' comprehensive quality evaluation, then, use knowledge reduction method in Rough Set Theory to remove redundant indicators, and take the three layers indicators as input variables of the neural network.
Step 2. Set neural network output layer node as 5, and initialize other parameters of network (including a given study accuracy ε, the provisions of the iterative step number M_0, hidden nodes limit r, learning parameters b. The initial hidden nodes should be appropriate to take a large number).
Step 3. Enter the learning sample, make the sample parameter values into the $[0,1]$.
Step 4. Random values between $[-1,1]$ are assigned to the initial weight matrix.
Step 5. Use dynamically adjusted algorithm to train BP neural network, in order to ensure weight matrix between each layers.
Step 6. Judge whether the number of iterations exceed the prescribed number of steps or meet the learning accuracy requirements or not. If yes, terminate the algorithm; if no, return to Step 5 and keep learning.
Step 7. Give values to the evaluation object's comprehensive quality three layers evaluation index, process the data and make it into $[0,1]$.
Step 8. Input processed data to the trained BP neural network and calculate the output.
Step 9. According to the output results, combined with college students' comprehensive quality evaluation set, make the evaluation of the object's comprehensive quality condition.

42.4 Empirical Research

We use Rough-ANN model built in this paper to evaluate college students' comprehensive quality. We randomly select 16 students from management engineering major of Sichuan University, they are: student S_1, student S_2 student $S_3, \cdots$, student S_{16}. Previous 12 students are taken as a training sample of the Rough-ANN model, and the after 4 students as forecast sample.

42.4.1 Knowledge Reduction of College Students' Comprehensive Quality Evaluation Index

Use the method which is introduced in Sect. 42.3.4 of this paper, we get the estimated values of evaluation index x_i $(i = 1, 2, \cdots, 43)$ of previous 12 students (student S_1, student S_2, student $S_3, \cdots$, student S_{12}).

In order to simplify evaluation index x_i $(i = 1, 2, \cdots, 43)$ by Rough method, we should transform estimated value of each index, the standard of transform is as follows: when the estimated value of index x_i is in $[0, 1]$, the score of x_i will be 1, when the estimated value of index x_i is in $(1, 2]$, the score of x_i will be 2. And so on, when the estimated value of index x_i is in $(4, 5]$, the score of x_i will be 5.

Then, according to Rough theory knowledge simplify algorithm, we can clear away redundant information and indexes in the evaluation system. This process contains two steps: first, remains only one index between the evaluation indexes which have the same value; then calculate the evaluation indexes nuclear, delete redundant indexes according to the indexes nuclear, find the smallest simplification of the indexes. From the final reduction results can be seen, the original 43 third-class indexes, be reduction for 28 third-class indexes. They are as follows: politics theory level, scientific world outlook, ethics character, study attitude, work attitude, abidance by the school rules, public required course score, specialized course score, practical foreign language competence, computer application ability, social sciences knowledge, social work, social practices, art competition award, participation in sports activities, mental health condition, social adaptation, emotional coordination and control capacity, written capacity, oral communication capacity, independent problem solving capacity, hands-on capacity, self-study capacity, interpersonal communication capacity, teamwork capacity, organization and management capacity, technological innovation capacity.

42.4.2 Rough-ANN Model

According to result of index knowledge reduction, neural network use 28 input variables (i.e. input layer take 28 nodes), and the middle hidden layer take bigger, here we take 65 nodes, the output layer for 5 nodes, the network structure is 28-65-5. Then, initialize the network (take the error limit $\varepsilon = 0.0002$, learning rate $b = 0.5$, iteration steps $M_0 = 20000$), Next, convert 28 indexes (the remaining indexes after knowledge reduction) of the 12 students (student S_1, student S_2, student $S_3, \cdots$, student S_{12}) to $[0,1]$ (each estimated value should be divided by 10). Then input processed data as the study sample data to the neural network, train the network by the improved BP algorithm, the network structure is automatically adjusted to 28-37-5 (28 input layer nodes, 37 hidden layer nodes, 5 output layer nodes) after training, at the same time we get optimize network weights matrix. The inference results (output) of the network study sample are shown in Table 42.2.

It can be seen from the Table 42.2, network inference results of the study sample and the actual results are exactly the same, which indicates the feasibility and effectiveness of the Rough-ANN model for college students' comprehensive quality evaluation.

Table 42.2 Network inference output

Student	Comprehensive quality condition	Sample output	Network inference output	Network evaluation result
Student 1	excellent	(1,0,0,0,0)	(0.9997,0.0223,0.0926,0.0659,0.0057)	excellent
Student 2	fine	(0,1,0,0,0)	(0.0023,0.9896,0.0069,0.0258,0.0045)	fine
Student 3	medium	(0,0,1,0,0)	(0.0023,0.9896,0.0069,0.0258,0.0045)	medium
Student 4	medium	(0,0,1,0,0)	(0.0156,0.2133,0.9324,0.0854,0.0576)	medium
Student 5	passing	(0,0,0,1,0)	(0.0037,0.0052,0.0029,0.9998,0.1462)	passing
Student 6	excellent	(1,0,0,0,0)	(0.9339,0.0085,0.0879,0.0562,0.0021)	excellent
Student 7	passing	(0,0,0,1,0)	(0.025,0.3451,0.0385,1.007,0.0032)	passing
Student 8	bad	(0,0,0,0,1)	(0.0461,0.0867,0.0346,0.0086,0.9358)	bad
Student 9	excellent	(1,0,0,0,0)	(1.0073,0.0521,0.0024,0.0745,0.0125)	excellent
Student 10	fine	(0,1,0,0,0)	(0.0471,1.0035,0.0239,0.1456,0.0086)	fine
Student 11	bad	(0,0,0,0,1)	(0.4667,0.3568,0.0051,0.0022,1.0001)	bad
Student 12	fine	(0,1,0,0,0)	(0.0643,0.0035,0.0142,0.0094,1.0021)	fine
Student 13	Measuring degree		(0.9967,0.0262,0.0013,0.0037,0.0126)	excellent
Student 14	Measuring degree		(0.0013,0.0337,1.0016,0.0069,0.0052)	medium
Student 15	Measuring degree		(0.0067,1.0021,0.0037,0.0591,0.0011)	fine
Student 16	Measuring degree		(0.0723,0.9915,0.0137,0.0031,0.0346)	fine

42.4.3 Evaluation of College Students' Comprehensive Quality

With the trained neural network, we evaluate the comprehensive quality of the students $(S_{13}, S_{14}, S_{15}, S_{16})$ of Sichuan University.

Use the method which is introduced in Sect. 42.3.4 of this paper, we get the estimated values of 28 third-class indexes(remaining index after knowledge simplify) of these students (student S_{13}, student S_{14}, student S_{15}, student S_{16}).

Then, convert these estimated values of 28 third-class indexes to $[0,1]$ (each estimated value is divided by 10), put the processed data into neural network calculating, the output has been shown in the last 4 lines of Table 42.2. According to the maximum membership degree principle, and combined with college students' comprehensive quality comment set, we can find this 4 students' evaluation results are excellent, excellent, fine, fine. The results are in accord with the real condition.

42.5 Conclusion

With the analysis of requirement for college students' quality in this quickly developing society, and According to these principles of guiding, comprehensiveness, level, independence, practicability, a set of college students' comprehensive quality evaluation index system has been established. This index system reflects college students' comprehensive quality condition, and their difference in moral quality, intellectual quality, physical and esthetical quality, also it generally shows all the important content relative with quality-oriented education. On this basis, combined with Rough Set theory and ANN, we have established Rough-ANN model of college students' comprehensive quality evaluation, this model not only acquires the major feature attributes of college students' comprehensive quality, but also cancels redundancy information and reduces the costs of gather comprehensive quality evaluation information. At the same time, it reduces neural network's complicacy and train time, improves neural network learning ability, reasoning ability and classification ability, achieves a dynamic evaluation for overall level of comprehensive quality of students. The experimental results show that the model is feasible and effective, provides a new way for early dynamic warning of the risk of technological innovation. The experimental results indicates, the evaluation method established in this paper is scientific and effective, it can reflect college students' comprehensive quality correctly, and has considerable practical value.

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Chapter 43
Partner Selecting, Partnership and Alliance Performance in Alliance Development Process

Yan Guo, Yuerong Liu and Bin Guo

Abstract There are many successful researches about alliance performance; however most of them are silent about alliance development processes. In this article we aim to examine the relationship between partner selecting, partnership and alliance performance in the alliance development process. We present a theoretical model for forecasting alliance performance through the determinations of selecting partner and partnership, using the alliance conditions as intermediate variable. We submit that alliance performance is strongly influenced by factors of partner selecting and partnership. The determinations of partner selecting involve strategy fit, capability fit and resource fit; and the factors of partnership are commitment, trust, communication, and resolutions of interpartner conflicts. We discuss the various linkages between the factors and alliance performance, and develop a number of propositions; we also use a case study to test them. Our research facilitates empirical testing of our framework, and indicates implications for future research and managerial practice.

Keywords Partner selecting · Partnership · Alliance performance · Alliance development process

43.1 Introduction

With the development of technology and economic globalizationmore and more firms are engaged in strategic alliances to learn partner's technology, gain resources, facilitate market entry, so as to sustain their competitive advantages [1, 2]. However,

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scholars argued that the high failure rate [3, 4] is along with strategic alliances' popularity. Anne and Geraed [5] suggested that the failure of strategic alliances mainly comes from the problem of choosing alliancing partner and relationship between partners, where the two factors account for 30 and 70 per cent respectively. In this respect, examining the issues of partner selecting and partnership is significantly important to the success of alliances.

Many studies have researched alliance performance since 1990s, and they divide antecedences of alliance performance into two categories: relational capital and exchange climate [6–8]. Most of researchers focus their attention on commitment, trust [9, 10], communication [11], conflict resolution [12], cooperation [13]. Others, like Das and Teng [14] examine the relationship between partner analysis and alliance performance, where the partner analysis involves market and resource characteristics and resource alignment. All of these studies, however, are hardly related to alliance development process. We will examine alliance performance with regarding it as a process, from the partner selecting in formation stage to partnership in operation stage and eventual performance evaluated at outcome stage, combined with alliance conditions closely related to alliance dynamics.

This paper falls into five sections. In the first section, we review the studies about alliance development process, three alliance conditions which are closely associated with dynamics of alliance, predictors of alliance performance, and the relationship between the alliance conditions and alliance performance. In section two and three, we propose the theoretical model which regards the partner selecting and partnership as the determinations of alliance performance, and a number of propositions. In the fourth section, we adopt Gas Sales where the data is collected by Pieter and Jeltje [2] through their interview with the managers of the alliance and partner firms as we study case. At last, we discuss the implications of the case research for the theoretical model, and suggest areas for future research.

43.2 Alliance Development, Alliance Conditions and Alliance Performance

43.2.1 Alliance Development Process

Nowadays, many studies suggest that alliances are dynamic over time of its life cycle [15]. There are many researchers to examine the stage-models of alliance development process. Successful studies of alliance development process involve Ring and Van de Ven [16], and Das and Teng [17]. In this article, we use the three-stage model of alliance development process which is divided into formation, operation, and outcome stage on the base of those studies.

In the formation stage, alliancing firms commit themselves in analyzing and educating, selecting alliance strategy and partners, negotiating with prospective ones, planning and signing contracts. In the operation stage, alliance partners are engaged in managing and operating the alliance. In this stage, they exchange information and communicate with each other frequently as to smooth the operation; and they may decide whether to commit to extra investment. In the outcome stage, they contribute themselves to evaluating and modifying the performance, thus then deciding whether to continue or exit the alliance.

43.2.2 Alliance Performance

Alliance performance has attracted considerable researchers to examine, due to evaluating the strategy in terms of its success. However, among the significant number of studies, the measures of alliance performance are hardly consistent. While some researchers prefer perceived satisfaction, others use objective measures such as profitability [14]. In this paper, we suggest satisfaction, strategic objectives and financial index as predictors of alliance performance. The trust among partners, commitment, and communication may reflect the satisfaction indirectly. Strategic objectives always mean indicate the purpose to form the alliance; sometimes, they are similar to financial objectives in some extent, and for example market share of the alliance. The financial index mainly involves sales growth and market share of the alliance, ROE and ROI.

43.2.3 Alliance Conditions

Alliance conditions are the characteristics of an alliance at any given moment in the life cycle of it. Das and Teng [17] have a reviewed a mount of the literatures, and propose that alliance conditions involve the following three key factors-collective strengths, interpartner conflicts, and interdependencies. The collective strengths of an alliance are the combined resource from partner firms that facilitate to pursue specific strategic objectives and exploit opportunities. Interpartner conflicts refer to the degree of divergence in partners' preferences, interests, and practices in an alliance [19]. Interdependencies refer to a condition in which both parties benefit from dealing with each other [20].

In the formation stage, collective strengths and interdependencies are relatively high, because partners form an alliance to attain some certain strategic objectives. And the level of interpartner conflicts is perceived low by partners in this stage. Alliancing partners would not form an alliance with the partner that they do not trust. In the operation stage, the size of alliance will grow significantly. The collective strength may continue to go up with a relatively slower pace, as a result of seeking the best ways of cooperation eventually. Also it may take a turndown in the end of this stage, owing to an exhaustion of resources and commitments [17]. The interpartner conflicts may quickly change in this stage. Having accomplished their objective of learning know-how, partner may not depend on their cooperators any more; in this sense, interdependencies between partners may sharply go down. Thus then, the alliance will either to be reformed or terminated. The interdependencies may also keep consistent with before, or go up gradually, for the steady need of each other. As to interpartner conflicts, it may emerge at first of this stage, and then gradually go down during the stage. In the outcome stage, the conditions of alliance will show a stability pattern and alliance performance will be tangible enough to measure. The collective strengths may continue to climb, and interdependencies and interpartner conflicts may reach a relatively low level.

Learners have examined the relationship between alliance conditions and alliance performance in both theoretical and empirical perspective [12, 14]. They conclude that both collective strength [21] and interdependencies [18] are positive to alliance performance; interpartner conflict is negative to alliance performance [22].

43.3 Partner Selecting and Alliance Performance in Formation Stage

In this section and next section, we will submit a theoretical model (see Fig. 43.1), examine how partner selecting and partnership affect alliance performance, regarding alliance conditions as intermediate variable, see Table 43.1, and suggest some propositions.

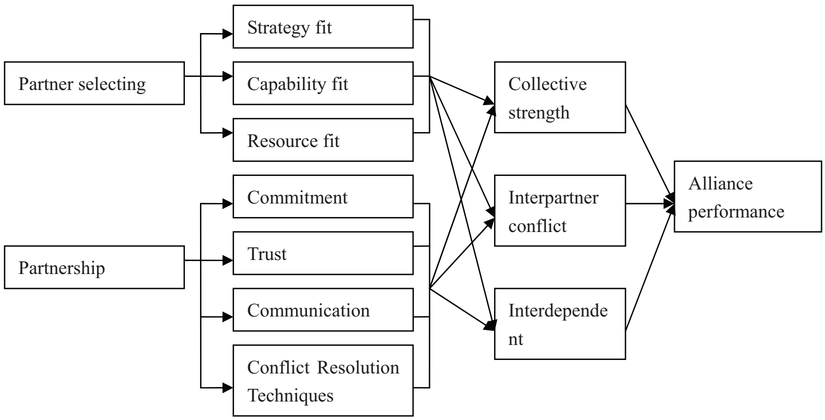

Fig. 43.1 The theoretical model of the paper

Table 43.1 The effects of determinations and factors on alliance conditions

		Collective strength	Interpartner conflict	Interdependencies
Strategic fit		−−	↘	↗
Capability fit		−−	↘	−−
Resource fit	Supplementary	↗	↘	↗
	Surplus	−−	↘	↘
	Complementary	↗	−−	↗
	Waste	−−	↗	↘
Commitment		↗	↘	−−
Communication	Quality	↗	↘	−−
	Share information	↗	↘	−−
	Participation	↗	↘	↗
Trust		↗	↘	−−
Conflict	Constructive	↗	↘	−−
Resolutions	Destructive	↘	↗	↘

Note: "−−" means no effect or the effect is depend on situations; "↗" means increasing; and "↘" means decreasing.

43.3.1 The Determinations of Partner Selecting

Strategic fit, capability fit and resource fit are three key determinations of choosing a partner to form an alliance [1, 2]. Strategic fit refers the degree to which partners have compatible goals in the alliance [1]. Capability fit means that partner firms' scales match with each other, and their contribution to the alliance will be equally important. Resource fit means the combination of both partners' resource facilitates to create value effectively [1].

Usually, alliance partner firms have different objectives, which are divided into same or very similar objectives, compatible objectives and conflicting ones. Strategy fit refers to that the partner firms' objectives are same or very similar, or compatible. Same or similar objectives are associated with each other at large extent and are therefore most likely to be achieved without hammering the partner's and alliance's interest. Compatibles objectives are those ones that can be achieved simultaneously, though they are not similar.

Capability fit is significantly important for alliance. The partners' capabilities determine their bargaining power in the alliance [2]. The more important of one's contribution to the alliance, the stronger of its bargaining power it is. The partner with strong bargaining power may easily change to be dominant to control the alliance, and therefore the alliance would be instable which is harmful for alliance performance.

Based on the two dimensions of resource similarity and resource utilization, Das and Teng [23] propose four resource. Supplementary and complementarity resource alignment are the similar and dissimilar resources respectively contributed by partner firms are performing in the alliance. When partner firms contribute similar resources that are not utilized fully in an alliance, the alignment is called surplus. And wasteful alignment is that different resources are not compatible or not used fully in the alliance. We illustrate the four interpartner resource alignments in Table 43.2.

Table 43.2 A typology of interpartner resource alignments

Resource similarity	Resource utilization	
	Performing	Nonperforming
Similar	Supplementary	Surplus
Dissimilar	Complementary	Wasteful

Source: the table is quoted from Das and Teng [23] pp. 49.

43.3.2 Partner Selecting and Alliance Performance

Strategy fit means that partner firms know each other's real objectives in an alliance, and form the alliance with the feeling of that their objectives can be attained with the cooperation. Knowing the real purpose of each other, partner firms will be likely to perceive relatively low level of interpartner conflicts. As the result of their need of each other to achieve objectives, partner firms with strategy fit have a high level of interdependencies. So, we conclude:

P1a: Strategy fit is negatively related to interpartner conflicts, and positively related to interdependencies.

P1b: Strategy fit has no significant effects on collective strengths.

P1c: The strategy fit is positively related to alliance performance.

Capability fit ensures the balance of partners' bargaining power which can reduce the interpartner conflicts. Therefore, the capability fit partner firms may perceive low level of interpartner conflicts. The interdependency is high when the capabilities are about different fields, for the ability to develop new product and new market. On the other hand, the partner will perceive low level of interdependencies. Both strategy fit and capability fit have no significant effect on collective strengths. So we suggest:

P2a: Capability fit is negatively related to interpartner conflicts.

P2b: Capability fit has no significant influence on both collective strengths and interdependencies.

P2c: The capability fit is positively related to alliance performance.

As for resource fit, we adopt the standpoints of the study of Das and Teng [14]: supplementary and complementary resource alignments are positively related to alliance performance; wasteful alignment is negatively related to alliance performance.

43.4 Partnership and Alliance Performance in Operation Stage

43.4.1 The Factors of Partnership

After forming the alliance, partner firms begin to operate alliance and implement signed agreements. And the partnership which is defined as purposive strategic relationships between independent firms who share compatible goals, strive for mutual benefit, and acknowledge a high level of mutual interdependent [18] as already established. And based on some successful studies, we summarize that the factors of partnership involves commitment [18], communication [24], trust [25], and conflict resolution techniques [26].

Commitment is the willingness of alliance partners to exert effort on behalf of the relationship [27]. It is a future orientation to the alliance and partnership of partners; and they will try their best to operate alliance whatever happened or whether they can weather unanticipated problems. High level of commitment will decrease the possibility of partners' opportunism, thus then smooth the relationship between partners.

Communication is needed in the life cycle of alliance from the negotiation in formation stage, to the exchanging information in operation and outcome stage. What's more, communication processes underlie most aspects of organizational functioning, so it is critical to the alliance and partnership [28]. Communication behavior mainly involves three aspects: communication quality, the extent of information sharing between partners, and participation in planning and goal setting [18]. Quality involves the accuracy, timeliness, adequacy, and credibility of information [29]. Information sharing refers to the extent of critical information exchanged between partners, and participation is to the extent to which partners engage jointly in planning and goal setting [18]. Effective communication help partners know each others' real purposes, decrease discrepancies, joint solve problems. Partners are more likely to satisfy with alliance and partnership with effective communication.

Trust is the belief on the others' capability, personality and so on. Trust is a multilevel phenomenon that exists at the personal, organizational, interorganizational, and even international levels [30]. Williamson [31] states that, other things being equal, exchange relationships featuring trust will be able to manage greater stress and will display greater adaptability. And trust leads to low risk perception without doing anything about the partner. Trust can help partners reduce their aspiration to opportunistic behaviours and gain a high level of relational capital.

Interpartner conflicts exist in both inter- and intra-organization level [32, 33]. In this paper, interpartner conflicts are the degree of divergence in partners' preference, interests. Conflict resolution techniques mainly include joint problem solving, persuasion, domination, harsh words. The two former of them are called productive resolution technique, and the others are destructive ones. Higher frequency of using constructive resolution techniques, such as joint problem solving and persuasion, partners may gain successful partnership.

43.4.2 Partnership and Alliance Performance

Partners always contribute themselves to the alliance with their commitment to alliance and partnership, though the alliance is in the corner. Thus, the commitment facilitates them to take advantage of opportunities to create value, therefore increase alliance collective strengths. Similarly, the commitment to partnership makes partners perceive relative low level of interpartner conflicts. Though commitment smoothes the partnership, it may have no effect on interdependencies, because the commitment can not change their need of each other, which is mainly determined by the resources.

P5a: Commitment is positively related to collective strengths and negatively related to interpartner conflicts; and it has no significant effect on interdependencies.

P5b: Commitment is positively related to alliance performance.

Communication quality, the extent of information sharing between partners, and participation of communication behaviours are all good for alliance collective strengths. Partners know each other's real objectives and even critical information, such as technology with high quality communication and large extent of information sharing. This enhances alliance collective strengths with no doubt, because partners can commit themselves to create value without wasting energy on suspecting partner or misappropriating partner's know-how. However, this may also lessen interdependencies for having attained needed knowledge, for example in learning alliance. What's more, all of three reduce interpartner conflicts for effective communication which helps reduce the discrepancies between partners. The participation in planning and goal setting will enhance interdependencies, because their plans and goal are most joint ones. Sometimes quality and sharing information increase interdependencies, as a result of frequent interaction.

P6a: Communication quality, extent of sharing information and participation of communication behaviours are all positively related to collective strengths and negatively to interpartner conflicts.

P6b: Participation is positively related to interdependencies; both communication quality and extent of sharing information have no effect on interdependencies.

P6c: All three aspects of communication are positively related to alliance performance.

Trust can increase alliance collective strengths. According with the study of Zaheer et al [34], we suggest that trust can reduces negotiation costs, which add to collective strengths. What's more, trust leads to low level of perceived relational risk [30], which is closely associated with interpartner conflicts. We propose that trust reduces interpartner conflicts in alliance. Similar with commitment with commitment, trust has on significant on partners' need of each other, thus then has little effect on interdependencies.

P7a: Trust is positively related to collective strengths and negatively related to interpartner conflicts; and it has no significant effect on interdependencies.

P7b: Trust is positively related to alliance performance.

Constructive conflict resolutions such as joint problem solving and persuasion can always smooth interpartner conflicts. On the other hand, destructive conflict resolutions like dominant and harsh words usually deteriorate interpartner conflicts. In the process of solving conflicts, constructive ones gain more opportunities of creating value, thus then enhance collective strengths. The constructive ones may enhance interdependencies for new fields that need partners' cooperative after having solved conflicts; or the interdependencies may be consistent, or decrease gradually with accomplishment of initial objectives. As for destructive conflict resolutions, because the conflicts are unsolved, both collective strengths and interdependencies may decrease.

P8a: Constructive conflict resolutions are positively related to collective strengths and negatively related to interpartner conflicts. They have no significant effect on interdependencies.

P8b: Destructive conflict resolutions are positively related to collective strengths and interdependencies negatively related to interpartner conflicts.

P8c: Constructive conflict resolutions are positively related to alliance performance; destructive ones are negatively related to alliance performance.

43.5 Case Study

In this section, we have adopted a case study with a view to finding out whether we can understand alliance performance in practice by means of our theoretical model. The case comes from the study of Pieter and Jeltje [2].

43.5.1 The Formation Stage of Gas Sales

Gas Sales was a joint venture dealing with the marketing and sale of gas on the British market. The parents were Electricity Corp., an English electricity supplier, and American Corp., an American utility company. It was set up in the early 1990s, when the British gas market was deregulated and business companies were permitted to acquire licenses to sell gas. Electricity Corp. considered the sale of gas as a lucrative new business, as its experience on the electricity market with respect to marketing, billing customers, and collecting debts on the electricity was easily applicable to the gas market. Moreover, it had access to a large group of potential customers. However, it did not have gas and experience with gas activities. It was American Corp. or more specifically its British subsidiary α Gas, which had expertise with respect to gas activities and managed to gain access to the gas of the gas producers. However, American Corp. did not have customers. Thus, both parties saw the opportunity of combining their assets and they decided to bring them together into a new joint venture. The two alliancing firms' capabilities are fit, and their resource fit is complementary fit, which is benefit of alliance performance as we suggested.

43.5.2 The Operation Stage of Gas Sales

There were various types of meetings. What's more, the trust went beyond contractual and competence trust. There was a good fit between the managers of α Gas and the managers appointed by Electricity Corp. They got along very well. Goodwill trust was often demonstrated. Examples of that from α Gas were the waiving of penalties in the case of incorrect gas volume forecasts and its assistance during the "beach price collapse" in 1995. Within 6 weeks, the gas price fell drastically thereby causing problems for all gas suppliers, especially those who had gone "upstream" and were under long-term purchasing obligations. On the advice of α Gas, Gas Sales had avoided upstream activities. Therefore, Gas Sales' gas purchasing commitments were not excessive. However, it did have some purchasing obligations. Contractually, α Gas would have been in the position to have Gas Sales adhere to its gas purchases. However, instead of keeping the joint venture to its contractual obligations and exercising its power, α Gas was willing to help the joint venture and adopt a long-term view. So, α Gas helped by postponing part of Gas Sales' purchase obligations to the future.

The communication between two partners is effective, owing to frequent and detailed meetings. And both partners trust each other and have high level of commitment to the alliance and partnership. When the alliance or one partner suffers problems, other partner will try their best to solve problems, and both of them prefer to joint problem solving resolution.

43.5.3 The Performance of Alliance Gas Sale

The Gas Sales alliance has attained its strategic objective: it entered the British gas market successfully. And both partners are satisfied with alliance and partnership. Above all, the Gas Sales alliance performance is relatively high.

43.6 Conclusions and Future Work

We conclude that strategy fit, capability fit and resource fit (supplementary and complementary) in formation stage of alliance are positive related to alliance performance. When selecting a partner firm in practice, managers should choose a partner with high level of the fit. And in operation stage, managers of partners should trust each other and commit themselves to the alliance. When communicate with each other, managers are better to exchange real and critical information, and take part in planning and goals setting. What's more, partners should be better to choose constructive conflict resolutions, such as joint problem solving and persuasion, to solve the problems.

In this paper, we propose a series of propositions and a theoretical framework of partner selecting, partnership and alliance performance. However, our empirical effort is relatively less, in the future researches we will collect more data about alliances to test our theoretical framework through analyzing these data. What's more, we can research more concretely, such as which predictors that strategic fit affect most significantly.

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Chapter 44
A Fusion Based Approach for Group Decision Making Based on Different Uncertain Preference Relations

Zhibin Wu and Zhimiao Tao

Abstract Many decision making problems such as personnel promotion and investment selection in organizations are often dealt by multiple experts in uncertain situation. The aim of this paper is to develop an approach to solve group decision making problems where the preference information provided by experts is in the form of interval multiplicative preference relations, interval fuzzy preference relations and interval linguistic preference relations. Firstly, taking interval linguistic preference relation as base representation element, non-homogenous information is unified by transformation functions. Then, an optimization model is established to obtain the maximum consensus level among the group by searching the weights of the experts. Next, the aggregation process and the selection process are carried out to find the best alternative(s). The entire procedure of the proposed approach is given. Finally, an example of the manager selection for a company is provided to show the effectiveness of the proposed approach.

Keywords Group decision making · Uncertain preference relation · Linguistic variable · Consensus · Alternative selection

44.1 Introduction

Decision making problems that address choosing the most appropriate option have been widely studied in the last decade [3, 6, 14]. For example, selecting a suitable advanced manufacturing technology is an important issue in operations managers when making capital investment decisions to improve their manufacturing performance [3]. In practice, because of the increasing complexity of the social-economic environment nowadays, many organizations have moved from a single

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decision maker or expert to a group of experts to accomplish the given tasks successfully.

In decision making problems with multiple experts as group decision making (GDM) problems, each expert expresses his/her preferences depending on the nature of the alternatives and on his/her own knowledge over them [10]. Preference relations are a popular and powerful tool used by experts to provide their preference information in the decision process. The use of preference relations facilitates experts when expressing their preferences. Alternative selection problems are mainly related to qualitative aspects which make it difficult to qualify them using precise values. To capture the uncertainty contained in these problems, various types of uncertain preference relations have been investigated in the literature, including interval multiplicative preference relations e.g. [17], interval fuzzy preference relations e.g. [20], and interval linguistic preference relations e.g. [5].

In GDM, it is quite natural that different experts who may have different background and knowledge will provide their preferences by different kinds of preference relations [7]. The use of non-homogenous information in decision problems is not an unusual situation [4, 10]. In this paper, we will assume a GDM model in which the preferences can be provided in any of the uncertain preference relations: interval multiplicative preference relations, interval fuzzy preference relations, and interval linguistic preference relations with multi-granularity. The main problem to deal with non-homogenous contexts is how to aggregate the information assessed in these contexts. Different methods have been proposed to unify the input information [4, 7, 8, 10, 13, 21].

Prior studies have made significant contributions to the GDM with diverse nature. However, there is no sufficient information to model the GDM problem with uncertain preference relations. The aim of this paper is to present a model for GDM with different uncertain preference relations. To make the information uniform, we extended the transformation functions into uncertain situations. To obtain the maximum degree of consensus in the aggregation process, an optimization model is constructed. The rest of this the paper is organized as follows. Sect. 44.2 deals with the preliminaries necessary to develop our model. Sect. 44.3 presents the conceptual framework of the proposed model. Sect. 44.4 introduces the information fusion methods. Sect. 44.5 presents the optimization method to compute the maximum consensus level of the group. Finally, an example of the manager selection for a company is provided in Sect. 44.6 and some concluding remarks are included in Sect. 44.7.

44.2 Basic Concepts and Definitions

In this section, we briefly introduce the basic concepts of linguistic approaches, and then for the convenience of analysis, we give definitions of different preference relations.

The linguistic approach considers the variables which participate in the problem assessed by means of linguistic terms, that is, variables whose values are not numbers but words or sentences in a nature or artificial language [23]. The basic notations and operational laws of linguistic variables can be found in [9] and [19]. Suppose that $S = \{s_\alpha | \alpha = -t, \cdots, -1, 0, 1, \cdots, t\}$ be a linguistic term set whose cardinality value is an odd one, where s_α represents a possible value for a linguistic variable. The semantics of the terms is given by fuzzy numbers defined in the $[0,1]$ interval, which are usually described by membership functions.

It is usually required that s_i and s_j satisfy the following additional characteristics:
(1) The set is ordered: $s_i > s_j$, if $i > j$;
(2) There is a negation operator: $\text{neg}(s_i) = s_{-i}$, especially, $\text{neg}(s_0) = s_0$;

In the process of information aggregation, however, some results may not exactly match any linguistic labels in S. To preserve all the information, Xu [19] extend the discrete linguistic label set S to a continuous linguistic label set $\bar{S} = \{s_\alpha | s_{-q} \leq s_\alpha \leq s_q, \alpha \in [0,q]\}$, where s_α meets all the characteristics above and $q(q \geq t)$ is a sufficiently large positive integer. If $s_\alpha \in S$, s_α is called the original term, otherwise, s_α is called the virtual term. In general, the original term is used to evaluate alternatives, while the virtual term can only appear in operations.

Definition 44.1. Let $\tilde{s} = [s_\alpha, s_\beta]$, where $s_\alpha, s_\beta \in \overline{S}$, s_α and s_β are the lower and upper limits, respectively, then $\tilde{s}$ is called an uncertain linguistic variable.

Let $\tilde{S}$ be the set of all uncertain linguistic variables. Consider any three uncertain linguistic variables $\tilde{s} = [s_\alpha, s_\beta]$, $\tilde{s}_1 = [s_{\alpha_1}, s_{\beta_1}]$ and $\tilde{s}_2 = [s_{\alpha_2}, s_{\beta_2}]$, then their operational laws are defined as:
(1) $\tilde{s}_1 \oplus \tilde{s}_2 = [s_{\alpha_1}, s_{\beta_1}] \oplus [s_{\alpha_2}, s_{\beta_2}] = [s_{\alpha_1} \oplus s_{\alpha_2}, s_{\beta_1} \oplus s_{\beta_2}] = [s_{\alpha_1+\alpha_2}, s_{\beta_1+\beta_2}]$;
(2) $\tilde{s}_1 \oplus \tilde{s}_2 = \tilde{s}_2 \oplus \tilde{s}_1$;
(3) $\mu\tilde{s} = \mu[s_\alpha, s_\beta] = [\mu s_\alpha, \mu s_\beta] = [s_{\mu\alpha}, s_{\mu\beta}]$, where $\mu \in [0,1]$.

From the above descriptions, we can see that the operation on two linguistic terms can be converted to the operation on lower indices of the corresponding terms. Thus we denote $I(s)$ as the positive index of s in $\bar{S}$. For example, $I(s_\alpha) = \alpha$. The function I translates a linguistic term to a numerical one and has an inverse function noted as I^{-1} which translates a numerical value into a linguistic type.

In many practical cases, crisp values are inadequate to model real-life decision problems because of the inherent subjective nature of the human judgments. The experts may have vague knowledge about the preference degrees of one alternative over another, and can not estimate their preferences with exact values. It is suitable for the experts expressing their opinions with uncertain formats of preference relation. Different uncertain preference relations are stated as follows.

Definition 44.2. [15] An interval multiplicative preference relation on a set of alternatives X is represented by an interval matrix, $\tilde{A} = (\tilde{a}_{ij})_{n \times n}$, $\tilde{a}_{ij} = [a_{ij}^L, a_{ij}^U]$, $0 < a_{ij}^L \leq a_{ij}^U$, being $\tilde{a}_{ij}$ belonged to the Satty's $[1/9,\ 9]$ scale. The reciprocal property by assumption holds, i.e., $a_{ij}^L = 1/a_{ji}^U$, $a_{ij}^U = 1/a_{ji}^L$, $a_{ii}^L = a_{ii}^U = 1$, for all $i, j \in N$.

Definition 44.3. [21] An interval fuzzy preference relation on a set of alternatives X is represented by an interval matrix, $\tilde{P} = (\tilde{p}_{ij})_{n\times n}$, $\tilde{p}_{ij} = [p_{ij}^L, p_{ij}^U]$, $0 \le p_{ij}^L \le p_{ij}^U$, being $\tilde{p}_{ij}$ belonged to the $[0,\ 1]$ scale. The reciprocal property by assumption holds, i.e., $p_{ij}^L + p_{ji}^U = p_{ij}^U + p_{ji}^L = 1$, $p_{ii}^L = p_{ii}^U = 0.5$, for all $i, j \in N$.

Definition 44.4. [16] Let S_T be a linguistic terms set with granularity T. An interval linguistic preference relation on a set of alternatives X is represented by an interval matrix, $\tilde{L} = (\tilde{l}_{ij})_{n\times n}$, $\tilde{l}_{ij} = [l_{ij}^L, l_{ij}^U] \in \tilde{S}$, where the reciprocal property by assumption holds, i.e., $l_{ij}^L \oplus l_{ji}^U = l_{ij}^U \oplus l_{ji}^L = s_0$, $l_{ii}^L = l_{ii}^U = s_0$, for all $i, j \in N$.

44.3 A Conceptual Model Based on Uncertain Preference Relations

Let $X = \{x_1, x_2, \cdots, x_n\}$ be a finite set of alternatives. The alternatives will be classified from best to worst (ordinal ranking), using the information already known according to a finite set of purposes. Without loss of generality, suppose there are m experts $E = \{e_1, e_2, \cdots, e_m\}$ who provide their evaluations on alternatives with different preference relations. Let $\lambda = (\lambda_1, \lambda_2, \cdots, \lambda_m)^T$ be the weight vector of experts which is to be determined. Suppose m_1 experts give uncertain multiplicative preference relations $\{\tilde{A}_1, \tilde{A}_2, \cdots, \tilde{A}_{m_1}\}$, m_2 experts give uncertain fuzzy preference relations $\{\tilde{P}_1, \tilde{P}_2, \cdots, \tilde{P}_{m_2}\}$, and m_3 experts give uncertain linguistic preference relations $\{\tilde{L}_1, \tilde{L}_2, \cdots, \tilde{L}_{m_3}\}$, such that $m = m_1 + m_2 + m_3$. The problem addressed in this paper is how to rank alternatives or select desired alternatives in a rational way.

The proposed method for solving the above GDM problem with different kinds of uncertain preference relations is presented graphically in Fig. 44.1.

Although any one kind of uncertain preference relation can be used to manage the non-homogenous information, the linguistic type of preference relation is selected as the representation model for the convenience of computation. First, we use the transformation functions proposed in the next section to make the different uncertain preference relations uniform. Then, the decision model develops two steps to accomplish the selection process. The aggregation phase utilizes the uncertain linguistic weighted average operator $ULWA$ to aggregate information which guarantees that the collective preference relation is a reciprocal interval linguistic preference relation as well. A maximizing consensus method is introduced to determine the weights of the experts. Such weight vector is also used in the aggregation process. The exploitation phase consists of choosing the alternatives "best" acceptable to the group of individuals as a whole. To do so, the uncertain linguistic ordered weighted average operator $ULOWA$ acts over the collective linguistic preference relation to quantify the dominance of one alternative over all the others in a fuzzy majority sense. Finally, a ranking method could be used to obtain the rank order of the alternatives and the best option.

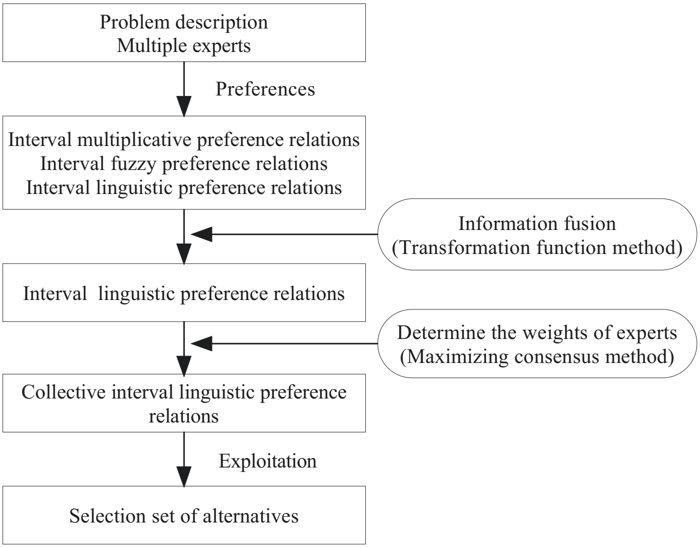

Fig. 44.1 The resolution process of the GDM problem

44.4 Fusions of Different Uncertain Preference Relations

In this section, we give different transformation functions to make the different scales uniform. Based on the work of [4] and [7], we get the following propositions.

Proposition 44.1. *Let S_{T_1} and S_{T_2} be two linguistic scales predefined as in Sect. 44.2. Their granularities are T_1 and T_2, respectively. Let, $l_1 \in S_{T_1}, l_2 \in S_{T_2}$. Then the transformation function from S_{T_1} to S_{T_2} is given as follows:*

$$l_2 = \frac{T_2 - 1}{T_1 - 1} l_1. \tag{44.1}$$

Proposition 44.2. *Let P be the $[0,1]$ fuzzy scale, and S_T be a linguistic scale with granularity T. Let $p \in P$ and $l \in S_T$. Then the corresponding transformation function from P to S_T is given as follows:*

$$l = I^{-1}((T-1)(p-0.5)). \tag{44.2}$$

Proposition 44.3. *Let A be the $[1/9, 9]$ scale, and S_T be a linguistic scale with granularity T. Let $a \in A$ and $l \in S_T$, then the corresponding transformation function from A to S_T is given as follows:*

$$l = I^{-1}\left(\frac{T-1}{2}\log_9 a\right). \tag{44.3}$$

In a situation, where different experts give different uncertain preference relations, to make the information uniform, we have the following transformation functions.

Proposition 44.4. *Let S_{T_1} and S_{T_2} are two linguistic scales predefined as in Sect. 44.2. Their granularities are T_1 and T_2, respectively. Let $\tilde{L}_1 = (\tilde{l}_{ij,1})_{n\times n}$ and $\tilde{L}_2 = (\tilde{l}_{ij,2})_{n\times n}$ be two interval linguistic preference relations, where $\tilde{l}_{ij,1} = [l^L_{ij,1}, l^U_{ij,1}]$, $l^L_{ij,1}$, $l^U_{ij,1} \in S_{T_1}$, $\tilde{l}_{ij,2} = [l^L_{ij,2}, l^U_{ij,2}]$, $l^L_{ij,2}, l^U_{ij,2} \in S_{T_2}$. Then the transformation function from $\tilde{L}^1$ to $\tilde{L}^2$ is given as follows:*

$$\tilde{l}_{ij,2} = \frac{T_2-1}{T_1-1}\tilde{l}_{ij,1}. \tag{44.4}$$

Proof. This proposition is a generalization of Proposition 44.1. We only need to verify that the preference relation after the transformation function (44.4) is in deed a reciprocal interval linguistic preference relation. Firstly, we have:

$$l^L_{ij,2} \oplus l^U_{ji,2} = \frac{T_2-1}{T_1-1} l^L_{ij,1} \oplus \frac{T_2-1}{T_1-1} l^U_{ji,1} = \frac{T_2-1}{T_1-1}(l^L_{ij,1} \oplus l^U_{ji,1}) = s_0. \tag{44.5}$$

In a similar way, we have $l^U_{ij,2} \oplus l^L_{ji,2} = s_0$. This completes the proof of Proposition 44.4. □

Proposition 44.5. *Let $\tilde{P} = (\tilde{p}_{ij})_{n\times n}$ be an interval fuzzy preference relation, and $\tilde{L} = (\tilde{l}_{ij})_{n\times n}$ be an interval linguistic preference relation with granularity T. Then the corresponding transformation function from $\tilde{P}$ to $\tilde{L}$ is given as follows:*

$$\tilde{l}_{ij} = I^{-1}((T-1)(\tilde{p}_{ij}-0.5)). \tag{44.6}$$

Proof. This proposition is a generalization of Proposition 44.2. We only need to verify the reciprocal property of $\tilde{L}$. According to the reciprocity of $\tilde{P} = (\tilde{p}_{ij})_{n\times n}$, we have

$$I(l^L_{ij})+I(l^U_{ji}) = (T-1)(p^L_{ij}-0.5))+(T-1)(p^U_{ji}-0.5)) = (T-1)((p^L_{ij}+p^U_{ji})-1) = 0. \tag{44.7}$$

From Equation (44.7), it follows that:

$$l^L_{ij} \oplus l^U_{ji} = s_0. \tag{44.8}$$

Similarly, we get $l^U_{ij} \oplus l^L_{ji} = s_0$. Thus $\tilde{L}$ is reciprocal, This completes the proof of Proposition 44.5. □

Proposition 44.6. *Let $\tilde{A} = (\tilde{a}_{ij})_{n\times n}$ be an interval multiplicative preference relation, and $\tilde{L} = (\tilde{l}_{ij})_{n\times n}$ be an interval linguistic preference relation with granularity T. Then the corresponding transformation function from $\tilde{A}$ to $\tilde{L}$ is given as follows:*

$$\tilde{l}_{ij} = I^{-1}\left(\frac{T-1}{2}\log_9 \tilde{a}_{ij}\right). \tag{44.9}$$

Proof. This proposition is a generalization of Proposition 44.3. Again, we verify the reciprocal property of $\tilde{L}$. According to the reciprocity of $\tilde{A} = (\tilde{a}_{ij})_{n\times n}$, we have:

$$I(l_{ij}^L) + I(l_{ji}^U) = \frac{T-1}{2}\log_9 a_{ij}^L + \frac{T-1}{2}\log_9 a_{ji}^U = \frac{T-1}{2}\log_9 a_{ij}^L a_{ji}^U = 0. \quad (44.10)$$

From Equation (44.10), it follows that:

$$l_{ij}^L \oplus l_{ji}^U = s_0. \quad (44.11)$$

Similarly, we get $l_{ij}^U \oplus l_{ji}^L = s_0$. Thus $\tilde{L}$ is reciprocal, This completes the proof of Proposition 44.6. □

In this section, we give propositions to make different uncertain preference relations uniform, given the interval linguistic preference relation as the basic representation structure. The transformations between different preference relations are the generalizations of the conversions between different judgement scales in essence.

44.5 Maximizing Consensus

The experts's judgements are somewhat subjective. It is possible that conflicts and contradicts may exist among the experts. Therefore, before the selection process, a consensus process is carried out to obtain a solution of maximum degree of agreement between the set of group members. Some researches have presented interesting results on consensus models based linguistic information e.g. [1, 2, 11, 19] or other information formats e.g. [12, 20]. Generally speaking, research progress in GDM with one kind of preference relation can benefit research in other kind preference relation. In the following, we introduce an optimization model to obtain the maximal consensus level among the experts for GDM with interval linguistic preference relations.

Definition 44.5. [5] Let $\tilde{s}_1 = [s_{\alpha_1}, s_{\beta_1}]$, $\tilde{s}_2 = [s_{\alpha_2}, s_{\beta_2}]$ be two uncertain linguistic variables, the distance between $\tilde{s}_1$ and $\tilde{s}_2$ is defined as:

$$d(\tilde{s}_1, \tilde{s}_2) = \frac{1}{2t}\left(|I(s_{\alpha_1}) - I(s_{\alpha_2})| + \left|I(s_{\beta_1}) - I(s_{\beta_2})\right|\right). \quad (44.12)$$

Definition 44.6. Let $\tilde{L}_1 = (\tilde{l}_{ij,1})_{n\times n}, \tilde{L}_2 = (\tilde{l}_{ij,2})_{n\times n}, \cdots, \tilde{L}_m = (\tilde{l}_{ij,m})_{n\times n}$ be m interval linguistic preference relations. Then their weighted combination $\tilde{L} = \lambda_1\tilde{L}_1 \oplus \lambda_2\tilde{L}_2 \oplus \cdots \oplus \lambda_m\tilde{L}_m$ by *ULWA* operator is the group interval linguistic preference relation, $\tilde{L} = (\tilde{l}_{ij})_{n\times n}$, where, $\tilde{l}_{ij} = \lambda_1\tilde{l}_{ij,1} \oplus \lambda_2\tilde{l}_{ij,2} \oplus \cdots \oplus \lambda_m\tilde{l}_{ij,m}$.

Definition 44.7. Let $\tilde{L}_1 = (\tilde{l}_{ij,1})_{n\times n}, \tilde{L}_2 = (\tilde{l}_{ij,2})_{n\times n}, \cdots, \tilde{L}_m = (\tilde{l}_{ij,m})_{n\times n}$ and $\tilde{L} = (\tilde{l}_{ij})_{n\times n}$ be m interval linguistic preference relations and the group interval linguistic preference relation, respectively. Then based on the distance function d, the group consensus index of $\tilde{L}_k$ is defined by:

$$\mathrm{GCI}(\tilde{L}_k) = \frac{2}{n(n-1)} \sum_{i=1}^{n-1} \sum_{j=i+1}^{n} d(\tilde{l}_{ij,k}, \tilde{l}_{ij}). \tag{44.13}$$

Let $e = (1, 1, \cdots, 1)^T$ be a m dimensional vector. Let $\lambda = (\lambda_1, \lambda_2, \cdots, \lambda_m)^T$ be the weight vector of experts such that $e^T\lambda = 1$, $\lambda_i \geq 0$. It is most desirable that the consensus indexes of every expert should be kept as small as possible, which leads to the following optimization model to be constructed.

$$\begin{aligned} &\min\ \mathrm{GCI}(\tilde{L}_k),\ k = 1, 2, \cdots, m, \\ &\text{s.t. } e^T\lambda = 1,\ \lambda \geq 0. \end{aligned}$$

Considering every single objective is of equal importance, the above model can be transformed into the following concrete programming:

$$\begin{aligned} &\min\ J = \tfrac{1}{t \times n \times (n-1)} \sum_{k=1}^{m} \sum_{i=1}^{n-1} \sum_{j=i+1}^{n} d(\tilde{l}_{ij,k}, \tilde{l}_{ij}), \\ &\text{s.t. } \sum_{k=1}^{m} \lambda_k = 1,\ \lambda_k \geq 0,\ k = 1, 2, \cdots, m. \end{aligned}$$

Letting

$$\varepsilon_{ij,k}^{+} = \frac{1}{2}(\varepsilon_{ij,k} + |\varepsilon_{ij,k}|) \quad \text{and} \quad \varepsilon_{ij,k}^{-} = \frac{1}{2}(-\varepsilon_{ij,k} + |\varepsilon_{ij,k}|), \tag{44.14}$$

$$\eta_{ij,k}^{+} = \frac{1}{2}(\eta_{ij,k} + |\eta_{ij,k}|) \quad \text{and} \quad \eta_{ij,k}^{-} = \frac{1}{2}(-\eta_{ij,k} + |\eta_{ij,k}|), \tag{44.15}$$

where

$$\varepsilon_{ij,k} = I(l_{ij,k}^{L}) - \sum_{h=1}^{m} \lambda_h I(l_{ij,h}^{L}) \quad \text{and} \quad \eta_{ij,k} = I(l_{ij,k}^{U}) - \sum_{h=1}^{m} \lambda_h I(l_{ij,h}^{U}). \tag{44.16}$$

We have:

$$|\varepsilon_{ij,k}| = \varepsilon_{ij,k}^{+} + \varepsilon_{ij,k}^{-} \quad \text{and} \quad |\eta_{ij,k}| = \eta_{ij,k}^{+} + \eta_{ij,k}^{-}. \tag{44.17}$$

Accordingly, the optimization model can be rewritten as the following linear programming model:

$$\min J = \frac{1}{t\times n\times(n-1)} \sum_{k=1}^{m}\sum_{i=1}^{n-1}\sum_{j=i+1}^{n} (\varepsilon_{ij,k}^{+} + \varepsilon_{ij,k}^{-} + \eta_{ij,k}^{+} + \eta_{ij,k}^{-}),$$
$$\text{s.t.} \begin{cases} I(l_{ij,k}^{L}) - \sum_{h=1}^{m} \lambda_h I(l_{ij,h}^{L}) - \varepsilon_{ij,k}^{+} + \varepsilon_{ij,k}^{-} = 0, \\ \quad i = 1,2,\cdots,n-1,\ j = i+1,\cdots,n,\ k = 1,2,\cdots,m, \\ I(l_{ij,k}^{U}) - \sum_{h=1}^{m} \lambda_h I(l_{ij,h}^{U}) - \eta_{ij,k}^{+} + \eta_{ij,k}^{-} = 0, \\ \quad i = 1,2,\cdots,n-1,\ j = i+1,\cdots,n,\ k = 1,2,\cdots,m, \\ \sum_{k=1}^{m} \lambda_k = 1, \quad \lambda_k \geq 0, \quad k = 1,2,\cdots,m. \end{cases} \tag{44.18}$$

The solution to the above problem could be easily found by Matlab software or Lingo software package. Thus, we obtain the weights of the experts by considering maximizing the consensus among the group.

In sum, a procedure for alternative selection in GDM with different formats of uncertain preference relations is given in the following.

Algorithm 1

Step 1. Form a committee of experts and identify the set of alternatives.
Step 2. Each expert provides preferences over the alternatives in the form of different uncertain preference relations.
Step 3. Making the information uniform. Utilize Proposition 44.6 to transform different uncertain preference relations into the same kind of interval linguistic preference relations.
Step 4. Aggregation. Utilize optimization model (44.18) to obtain the weight vector of the experts. Compute the collective interval linguistic preference relation by uncertain linguistic weighted average ($ULWA$) operator.
Step 5. Exploitation. Calculate the overall assessment value of each alternative by the uncertain linguistic ordered weighted average($ULOWA$) operator.
Step 6. Rank the overall assessment values. Choose the best alternative with the maximal ranking value.
Step 7. Return the result to the experts and the decision maker. If the result is convincing and the decision maker is satisfied with it, then terminate the decision procedure, otherwise start a new round of decision.

Remark 44.1. If the consensus level reached does not meet predefined requirements, a consensus reaching algorithm can be introduced to achieve the goal [18]. We only consider one preference relation given by each expert for the alternative selection problem in this paper. However, similar to the analytical hierarchy process (AHP), we may consider constructing a hierarchy structure based on uncertain preference relations and extended the proposed approach into this general case.

44.6 Application Example

In this section, an example is provided to demonstrate how the proposed approach works in practice. Suppose a company wants to employ a new manger to manage its new business. Four outstanding candidate $\{x_1, x_2, x_3, x_4\}$ entered the final round of competition. There are four experts, $\{e_1, e_2, e_3, e_4\}$ provide their evaluations over the candidates according to the general performance of each candidate. Concretely, expert e_1 constructs an interval multiplicative preference relation, $\tilde{A}$, using Saaty's $[1/9, 9]$ scale. Expert e_2 an interval fuzzy preference relation, $\tilde{P}$, using the $[0, 1]$ scale. Experts e_3 and e_4 provide interval linguistic preference relations $\tilde{L}_3, \tilde{L}_4$ with granularity 7 and 9, respectively. These data are shown as follows.

$$\tilde{A} = \begin{pmatrix} [1,1] & [1,2] & [6,8] & [3,5] \\ [1/2,1] & [1,1] & [5,7] & [3,4] \\ [1/8,1/6] & [1/7,1/5] & [1,1] & [1/3,1/2] \\ [1/5,1/3] & [1/4,1/3] & [2,3] & [1,1] \end{pmatrix},$$

$$\tilde{P} = \begin{pmatrix} [0.5,0.5] & [0.5,0.6] & [0.8,0.9] & [0.6,0.8] \\ [0.4,0.5] & [0.5,0.5] & [0.7,0.8] & [0.5,0.7] \\ [0.1,0.2] & [0.2,0.3] & [0.5,0.5] & [0.3,0.4] \\ [0.2,0.4] & [0.3,0.5] & [0.6,0.7] & [0.5,0.5] \end{pmatrix},$$

$$\tilde{L}_3 = \begin{pmatrix} [s_0,s_0] & [s_0,s_1] & [s_2,s_3] & [s_1,s_2] \\ [s_{-1},s_0] & [s_0,s_0] & [s_2,s_3] & [s_0,s_1] \\ [s_{-3},s_{-2}] & [s_{-3},s_{-2}] & [s_0,s_0] & [s_{-2},s_0] \\ [s_{-2},s_{-1}] & [s_{-1},s_0] & [s_0,s_2] & [s_0,s_0] \end{pmatrix},$$

$$\tilde{L}_4 = \begin{pmatrix} [s_0,s_0] & [s_1,s_2] & [s_3,s_4] & [s_1,s_2] \\ [s_{-2},s_{-1}] & [s_0,s_0] & [s_2,s_3] & [s_0,s_0] \\ [s_{-4},s_{-3}] & [s_{-3},s_{-2}] & [s_0,s_0] & [s_{-2},s_{-1}] \\ [s_{-2},s_{-1}] & [s_0,s_0] & [s_1,s_2] & [s_0,s_0] \end{pmatrix}.$$

On the basis of Algorithm 1 described in the last section, the resolution process for this problem is divided into the following stages.

Stage 1: Make the information uniform

According to the methods in Sect. 44.4, we transform $\tilde{A}, \tilde{P}, \tilde{L}_3$ into interval linguistic preference relations with granularity 9. The transformed linguistic preference relations for e_1 and e_2 are denoted as $\tilde{L}_1$, $\tilde{L}_2$, and for e_3, it is still denoted as $\tilde{L}_3$ for simplicity.

$$\tilde{L}_1 = \begin{pmatrix} [s_0,s_0] & [s_0,s_{1.3}] & [s_{3.3},s_{3.8}] & [s_1,s_2] \\ [s_{-1.3},s_0] & [s_0,s_0] & [s_{2.9},s_{3.5}] & [s_2,s_{2.5}] \\ [s_{-3.8},s_{-3.3}] & [s_{-3.5},s_{-2.9}] & [s_0,s_0] & [s_{-2},s_{-1.3}] \\ [s_{-2.9},s_{-2}] & [s_0,s_0] & [s_1,s_2] & [s_0,s_0] \end{pmatrix},$$

$$\tilde{L}_2 = \begin{pmatrix} [s_0, s_0] & [s_0, s_{0.8}] & [s_3, s_4] & [s_{0.8}, s_{2.4}] \\ [s_{-0.8}, s_0] & [s_0, s_0] & [s_{1.6}, s_{2.4}] & [s_0, s_{1.6}] \\ [s_{-3.2}, s_{-2.4}] & [s_{-2.4}, s_{-1.6}] & [s_0, s_0] & [s_{-1.6}, s_{-0.8}] \\ [s_{-2.4}, s_{-0.8}] & [s_{-1.6}, s_0] & [s_{0.8}, s_{1.6}] & [s_0, s_0] \end{pmatrix},$$

$$\tilde{L}_3 = \begin{pmatrix} [s_0, s_0] & [s_0, s_{4/3}] & [s_{8/3}, s_4] & [s_{4/3}, s_{8/3}] \\ [s_{-4/3}, s_0] & [s_0, s_0] & [s_{8/3}, s_4] & [s_0, s_{4/3}] \\ [s_{-4}, s_{-8/3}] & [s_{-4}, s_{-8/3}] & [s_0, s_0] & [s_{-8/3}, s_0] \\ [s_{-8/3}, s_{-4/3}] & [s_{-1.6}, s_0] & [s_0, s_{8/3}] & [s_0, s_0] \end{pmatrix}.$$

Stage 2: Aggregation

To obtain the collective interval linguistic preference relation, we have to determine the weights of expert in the aggregation process. Using the maximizing consensus model (44.18), we construct the corresponding optimization model.

The optimal value for the above linear programming by Lingo software is $J = 20.36667$. At the same time, we get the weight vector of the expert $\lambda = (0.098,\ 0.453,\ 0.273,\ 0.176)^T$. From Definition 44.6, the group interval linguistic preference relation is computed as:

$$\tilde{L}_3 = \begin{pmatrix} [s_0, s_0] & [s_{0.18}, s_{1.20}] & [s_{2.66}, s_{3.62}] & [s_{1.10}, s_{2.45}] \\ [s_{-1.20}, s_{-0.18}] & [s_0, s_0] & [s_{2.09}, s_{3.06}] & [s_{0.20}, s_{1.34}] \\ [s_{-3.62}, s_{-2.66}] & [s_{-3.06}, s_{-2.09}] & [s_0, s_0] & [s_{-2.00}, s_{-0.66}] \\ [s_{-2.45}, s_{-1.10}] & [s_{-1.34}, s_{-0.20}] & [s_{0.66}, s_{2.00}] & [s_0, s_0] \end{pmatrix}.$$

Stage 3: Exploitation

We use the *ULOWA* operator with a quantifier *at least half*, which implies $(0, 0.4, 0.5, 0.1)^T$ is the weighting vector, to compute the overall assessment value for each alternative. We obtain the interval priority vector:

$$([0.5275, 1.5831],\ [-0.0417, 0.5170],\ [-2.6898, -1.5775],\ [-0.9138, -0.2081])^T$$

corresponding to each alternative. As the interval data are not intersecting, we immediately have $x_1 \succ x_2 \succ x_4 \succ x_3$. The best choice is the first candidate, x_1.

44.7 Concluding Remarks

In management decision making problem, because of the internal subjectivity and imprecision of human judgments, the information available from the multiple experts often appears as different uncertain formats. In this paper, we have developed an information fusion and maximizing consensus integrated approach to deal with such problems. An example of selecting the optimal manager for a company is illustrated to show the effective of the proposed model. The main characteristics of the proposed model are: 1) It allows experts to express their opinions with much flexibility; 2) It incorporates consensus concept into the aggregation process which makes the final solution more acceptable by the experts as well as the decision maker. Although we develop our model initially for alternative selection, it can be applied to other management decision problems. The proposed methods can also be extended into group multiple criteria decision making problems, which allow various evaluation scales to express the attribute values of the alternatives.

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Chapter 45
China Creative Industry Development Efficiency Assessment

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Abstract This paper builds an input-output assessment index system of creative industry development efficiency according to the characteristics of creative industry. Taking use of the C^2R model, the BC^2 model and super-efficiency DEA model, taking the creative industry in China's 26 major cities for example, we implement the DEA model quantitative empirical assessment to China creative industry's reality development efficiency. The assessment result indicates the industrial characteristics of China creative industry development efficiency as descending stepwise development from coastal areas to inland, while the internal development is extremely uneven. According to the overall efficiency value, this paper divides China's 26 major cities into three echelons from high to low, and points out that it is necessary to build regional different optimization ideas and specific optimization path for the future development of China creative industry.

Keywords Creative industry · Development efficiency · DEA assessment

45.1 Introduction

The boom in the global of Creative industry arouses great concern of scholars from various countries, and a variety of literatures on the assessment of the development of creative industry have emerged. Eysenck [2] argues that the creative industry development assessment indicators consist of cognitive indicators, environmental indicators, personality indicators; Landry [3] proposes the city's creative industry assessment should take into account the economic, social, environmental and cul-

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tural factors; Richard Florida [4] introduces high-tech index, innovation index, creative class index, integrated diversification index as the assessment index system for the development of creative industry, also proposes a widely accepted 3Ts assessment index system, and takes technology, talent and tolerant as the assessment index of creative industry development; international institutions or government also promote related study to creative industry development assessment on the basis of the Florid, such as the UNESCO [6] creative industry development assessment index system consist of human capital, technology development, market demand, administrative agencies and, the Hong Kong Creativity Index 5Cs developed by the Government of Hong Kong [7], Shanghai Urban Creativity Index and so on.

From the overall situation of the above studies at home and abroad, the assessment of creative industry development is more focus on evaluating macro level such as the economic development basis of a country or region, the open degree of society, the efficiency of system operation, cultural and educational, to reflect the level of the creative industry development, lacking the assessment to development status decided by development mechanism of creative industry from the meso level. From the perspective of the creative industry development mechanism, the process of industry value creation, is the input process of creative industry input factors such as human capital, cultural capital, institutional capital, marketing capital and other [1], While the achievement of the creative industry value, is thus the economic and social benefits brought by creative industry through the input of production elements. The input process and output results of production elements, together determine the efficiency of creative industry development. Based on the above argument, this paper establishes creative industry input factors assessment index and output assessment index, following with an empirical study of the creative industry development efficiency in China based on DEA model.

45.2 The Content of Creative Industry Development Efficiency Assessment Index

45.2.1 Input Factors index

This paper argues that, input factors index of the creative industry development efficiency assessment, mainly refers to concrete input factors index in the creative industry value creation process, including indicators of human capital, cultural capital, institutional capital, marketing capital.

(1) Human capital index

• The proportion college students account for the local population.

Creative industry takes creative production as the core, creative talent is the inexhaustible source of creative production and the aggregate of producers of high-quality creative, so it is core production inputs of creative industry, and high-quality college students often is a concentrated expression of creative talent and even the level of human capital. Therefore, we believe that the greater proportion of college students means the higher stock and quality of regional human capital, the more prominent creative ability, and the higher human capital input-output efficiency.

• The proportion R&D expenditure accounts for local GDP.

The proportion R&D expenditure accounts for local GDP, reflects the support efforts of local government and creative enterprises to create a good creative talents environment, thereby affecting the human capital accumulation of the local creative industry. Those R&D funds commensurate with the extent of local economic development and needs of the creative industry development, through the interaction between the high capital investment, the introduction of technical staff and high-quality creative research, translates into the local human capital advantage, thus it is an important form of local human capital accumulation and investment, reflecting not only the development potential of creative industry in the region, but also the local creative industry development status.

• The number of research institutions.

Research institutions act as the basic birthplace of creative originality and integration, from which a large number of creative industry theoretical study talent, practical design and technical personnel come, therefore it is also an important input factor of high value-added content creation, marketing aspects. The number of research institutions, reflecting acquisition cost of creative industry talent and market-oriented level of using human capital, is an important element of the human capital investment in the process of creative industry development.

(2) Cultural capital index

• The number of public library books per 100 persons.

The number of books in public libraries is an important form of cultural capital accumulation in a national or regional development of creative industry, with an important impact on the high value-added development of creative industry chain. This paper use the number of public library books per 100 persons to measure this form of culture capital accumulation.

• The proportion foreign population accounts for the local population.

The proportion foreign population accounts for the local population, reflects the extent of local culture tolerance and cultural diversity in a way, also indirectly reflects regional level of capital investment. A greater foreign population percentage in a region means greater cultural diversity stronger culture attraction and creative force. Therefore creative talent with different cultural backgrounds, customs and habits will flow to the region. The integration of migrants and the local population promotes exchange of different culture and technology, and the generation of new ideas and knowledge, and the formation of a powerful cultural capital advantage. Therefore, this paper uses the proportion foreign population accounts for the local population in a period of time as an important measure of creative industry cultural capital investment.

• The proportion household cultural consumption expenditures accounts for total consumption expenditure.

The proportion household cultural consumption expenditures accounts for total consumption expenditure, on one hand, reflects the real purchasing power of the modern residents cultural consumption demand, measures modern residents' cultural capital expenditure level; on the other hand, it is able to some extent to reflect the local residents culture consumption propensity and cultural capital expenditure potential, which together reflect the stock size and investment level of local culture capital.

(3) The institutional capital index

• The number of creative industry cluster.

The creative industry cluster is characterized by the combination of life and work, combination of knowledge and cultural production and consumption, combined of the diverse relaxed environment and unique local characteristics, to achieve the above combination, it needs government to guide the formation and development of creative industry cluster from the perspective of macro institution [5]. Government provides tax relief, investment and financing policies, access system, industry public information service platform and other system-level support, thereby reduces the cost of park creative enterprises that, to ensure the normal operation and development of the creative industry cluster. Based on this, this paper takes number of creative industry cluster as an important measure government institutional capital investment to creative industry, in order to reflect the size and scale of the institutional capital investment.

• The proportion government fiscal expenditure on cultural undertakings accounts for total expenditures.

Creative industry originated in the cultural industry, the development and utilization of cultural capital is important for the development of creative industry, the input-output cycle of cultural capital is long, often along with unexpected high risk. The proportion government fiscal expenditure on cultural undertakings accounts for total expenditures, institutionally reflects the degree of local government's attention to cultural capital, human capital accumulation, also constitute an important form of institutional capital investment to creative industry.

(4) Marketing capital index

• The number of culture and arts intermediary institutions.

The brokers, planners, designers and other creative people in cultural and artistic institutions, although are not direct producers of creative products, but they are the direct links and feedback channels between creative product and market, they are important form of creative industry marketing capitalplaying a key intermediary role as a bridge. Therefore, we believe that a more reasonable number of culture and arts intermediaries, means more full use creative industry marketing capital, and their creative products will be more close to the market demand, the real development of the creative industry may be the better.

• The number of households which use Internet.

Under the conditions of modern information society, the Internet is not only a major information dissemination media of marketing creative aspects, but also produces added value in the form of marketing capital investment. In the Internet age, any creative product information can be rapidly presented to consumers through marketing capital investment, thus it greatly reduces consumer's search costs and time costs for creative products, and enhances the effectiveness that creative products reach the consumer, achieves the "long tail" marketing of the creative product and benign and efficient cycle of creative industry chain value creation. Therefore, the paper argues that the number of households which use Internet is an important part of the creative industry marketing capital, and the number of national or regional households which use Internet, has a direct impact on the possibility of realizing the value of creative products and the overall value-added effect of creative industry.

45.2.2 Output Factors Index

Output factors index of creative industry development efficiency assessment, refers to concrete manifestation of creative industry value realization, including the assessment index of economic benefits and social benefits of creative industry.
(1) Economic benefits index
• The number of patents.

The patents owned by a country or region is an external manifestation of the creative knowledge and thinking, is a kind of high-value creative intellectual property after putting in a lot of human capital, cultural capital, and other production elements. This kind of intellectual property is protected by the patent laws, provides the basis of core competitiveness for local creative enterprises production, making it different from similar enterprises, to some extent represents the output capacity and economic size of regional creative industry. Therefore, this paper argues that more number of patents a country or region has, its competitive advantage for creative production may be the greater, and output results under its human capital, cultural capital, and other creative industry production inputs may be better, the economic benefits of creative enterprise is likely to be greater.
• The creative industry added value.

The creative industry added value reflects the scale of creative industry development, is the most direct expression of the creative industry economic benefits. The whole creative industry chain, including creative content, production and manufacturing, creative marketing, consumption, takes the maximization of creative industry added value as an immediate purpose. Economic benefit is eternal primary pursuit of creative industry. Only when creative industry chain can create enough added value for the normal operation, the pursuit for economic benefits can be achieved, enhancing the ability of creative industry to achieve sustainable value. Therefore, we believe that the greater creative industry added value directly means the higher level of economic benefits of creative industry, the greater ability to create and realize value and the better development of creative industry.
(2) Social benefits index

The creative industry employment. Employment absorbed in the creative industry is direct manifestations of the social benefits of the of creative industry development, It needs to employ persons to participate in creative content, manufacturing, marketing and other creative industry value chain. There are at least two aspects the social benefits embodied in creative industry employment increase: on one hand, the increasing creative industry employment relieves the employment pressure of whole society, and improves residents' income level, in favor of social harmony and stability; on the other hand, with the increase of creative industry employment, social creative atmosphere is enhanced to be able to promote the industry and technical innovation, in favor of economic development mode shift, to improve the overall effectiveness of economic development. Therefore, the creative industry employment is taken as an important indicator to assess the social benefits of creative industry in a country or region, the more creative industry employment means the greater development for local creative industry and even economic and the greater social benefits.

45.3 Selection of the Decision-making Unit and the DEA Model Assessment Index System

According to the above analysis to creative industry development mechanismfactors that influence creative industry development efficiency, and assessment index system based the factors, this paper selects 26 China cities namely Beijing, Tianjin, Qingdao, Jinan, Harbin, Shanghai, Nanjing, Hangzhou, Suzhou, Ningbo, Shijiazhuang, Taiyuan, Zhengzhou, Wuhan, Changsha, Chongqing, Chengdu, Xi'an, Nanning, Kunming, Guangzhou, Shenzhen, Wuxi, Xiamen, Fuzhou, Hefei as the decision-making unit (DMU) of China's creative industry development efficiency assessment. The 10 input factors index include: the proportion college students account for the local population, the proportion R&D expenditure accounts for local GDP, the number of research institutions, the number of public library books per 100 persons, the proportion foreign population accounts for the local population, the proportion household cultural consumption expenditures accounts for total consumption expenditure, the number of creative industry cluster, the proportion government fiscal expenditure on cultural undertakings accounts for total expenditures, the number of culture and arts intermediary institutions, the number of households which use Internet. The 3 output factors index include: the number of patents, the creative industry added value, the creative industry employment. Thus we establish a DEA model assessment index system, its structure in details is shown in Table 45.1.

According to the above DEA model assessment index system for China creative industry development, we mainly collect data for assessment through the industry reports, statistical yearbooks, site search and other ways. Considering accessibility and comparability of the data, we use input-output data of the above 26 major cities' creative industry development in 2008. It should be noted that: the measurement unit of the proportion college students account for the local population, the proportion R&D expenditure accounts for local GDP, the proportion foreign population accounts for the local population, the proportion household cultural consumption expenditures accounts for total consumption expenditure, the proportion government fiscal expenditure on cultural undertakings accounts for total expenditures is (%),the measurement unit of the number of households which use Internet is (10,000 households), all index value keeps two decimal places after rounding off.

Table 45.1 DEA model assessment index system for China creative industry development

Input factors index (X)	The proportion college students account for the local population (X_1)
	The proportion R&D expenditure accounts for local GDP (X_2)
	The number of research institutions (X_3)
	The number of public library books per 100 persons (X_4)
	The proportion foreign population accounts for the local population (X_5)
	The proportion household cultural consumption expenditures accounts for total consumption expenditure (X_6)
	The number of creative industry cluster (X_7)
	The proportion government fiscal expenditure on cultural undertakings accounts for total expenditures (X_8)
	The number of culture and arts intermediary institutions (X_9)
	The number of households which use Internet (X_{10})
Input factors index (Y)	The number of patents (Y_1)
	The creative industry added value (Y_2)
	The creative industry employment (Y_3)

45.4 DEA Model Calculation

In order to make an objective and accurate assessment of China's major cities creative industry development efficiency status, the empirical assessment analysis of 26 DMUs such as Beijing, Shanghai etc. is divided into three steps: the first step is, through the traditional C^2R model, to obtain the overall efficiency value, optimal index weight coefficient value and slack variable value of all DMUs; the second step is, through BC^2 model, to obtain the pure technical efficiency value of DMU, in order to get scale efficiency value of the assessment unit; the third step is, through the super-efficiency DEA model, to obtain a second set of overall efficiency value, in order to provide the necessary data to support further sort analysis.

45.4.1 C^2R Model Calculation

In order to make a comparative assessment of the overall efficiency and scale efficiency of 26 DMUs, according to the C^2R model, we execute optimization calculation with China creative industry development data, we get the overall efficiency value θ, input-output index weight coefficient value λ and slack variable values s^+, s^- of all the 26 DMUs. The results are shown in Tables 45.2 ∼ 45.4.

Table 45.2 C^2R model assessment results of China creative industry development efficiency-1

Value	DMU								
	Beijing	Tianjin	Qingdao	Jinan	Harbin	Shanghai	Nanjing	Hangzhou	Suzhou
s_1^-	0.000	0.000	0.000	6.431	0.000	0.000	3.366	0.000	0.000
s_2^-	0.000	0.347	0.000	0.801	0.428	0.000	0.372	0.000	0.000
s_3^-	0.000	141.684	0.000	121.514	97.095	0.000	122.095	0.000	0.000
s_4^-	0.000	0.000	45.138	0.000	0.000	0.000	0.000	0.000	0.000
s_5^-	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
s_6^-	0.000	0.000	8.117	2.266	0.000	0.000	0.000	0.000	6.687
s_7^-	0.000	0.000	0.592	0.000	0.000	0.000	0.000	0.000	0.000
s_8^-	0.000	0.000	0.000	10.635	3.509	0.000	0.000	0.000	0.000
s_9^-	0.000	0.000	0.000	18.017	23.367	0.000	39.640	0.000	0.000
s_{10}^-	0.000	216.182	0.000	13.540	6.816	0.000	0.000	0.000	0.000
s_1^+	0.000	0.000	0.000	0.000	0.000	0.000	0.289	0.000	0.000
s_2^+	0.000	0.000	0.000	0.017	0.012	0.000	0.000	0.000	0.000
s_3^+	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
$\Sigma_{j=1}^n \lambda_j$	1.000	0.745	1.000	0.281	0.334	1.000	0.650	1.000	1.000
θ	1.000	0.811	1.000	0.786	0.451	1.000	0.863	1.000	1.000

45.4.2 C^2R Model Calculation

C^2R Assessment model can only be used for the assessment to overall efficiency and returns to scale of DMU. However, some DMUs are overall non-DEA efficient, they are scale inefficient, but they are still pure technical efficient. Therefore, in order for all-round, multi-level analysis to creative industry development efficiency in China's 26 major cities, we introduce the BC^2 model into empirical assessment analysis. The pure technical efficiency value θ^p of 26 DMUs is shown in Table 45.5.

Table 45.3 C^2R model assessment results of China creative industry development efficiency-2

Value	DMU								
	Ningbo	Shijiazhuang	Taiyuan	ZhengZhou	Wuhan	Changsha	Chongqing	Chengdu	Xi'an
s_1^-	0.000	0.000	5.846	2.682	0.000	0.000	0.000	0.000	4.582
s_2^-	0.000	0.000	1.161	1.820	0.000	0.000	0.000	0.000	2.746
s_3^-	0.000	0.000	27.248	26.289	0.000	0.000	0.000	0.000	280.111
s_4^-	0.000	0.000	45.138	0.000	0.000	0.000	0.000	0.000	0.000
s_5^-	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
s_6^-	0.000	0.000	8.117	2.266	0.000	0.000	0.000	0.000	6.687
s_7^-	0.000	0.000	0.592	0.000	0.000	0.000	0.000	0.000	0.000
s_8^-	0.000	0.000	13.334	4.972	0.000	0.000	0.000	0.000	6.739
s_9^-	0.000	0.000	8.717	0.000	0.000	0.000	0.000	0.000	0.000
s_{10}^-	0.000	0.000	0.000	18.701	0.000	0.000	0.000	0.000	5.794
s_1^+	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
s_2^+	0.000	0.000	0.000	0.029	0.000	0.000	0.000	0.000	0.039
s_3^+	0.000	0.000	0.002	0.000	0.000	0.000	0.000	0.000	0.000
$\Sigma_{j=1}^n \lambda_j$	1.000	1.000	0.083	0.423	1.000	1.000	1.000	1.000	0.469
θ	1.000	1.000	0.675	0.625	1.000	1.000	1.000	1.000	0.844

Table 45.4 C^2R model assessment results of China creative industry development efficiency-3

Value	DMU							
	Nanning	Kunming	Guangzhou	Shenzhen	Wuxi	Xiamen	Fuzhou	Hefei
s_1^-	1.875	0.000	0.000	0.000	0.527	0.000	0.000	3.333
s_2^-	0.000	0.000	0.000	0.000	0.906	0.000	0.000	0.938
s_3^-	0.000	0.000	0.000	0.000	0.000	0.000	0.000	69.931
s_4^-	7.658	0.000	0.000	0.000	0.000	0.000	0.000	26.505
s_5^-	8.894	0.000	0.000	0.000	8.341	0.000	0.000	0.000
s_6^-	7.699	0.000	0.000	0.000	2.826	0.000	0.000	7.405
s_7^-	1.684	0.000	0.000	0.000	1.488	0.000	0.000	0.005
s_8^-	8.943	0.000	0.000	0.000	5.397	0.000	0.000	6.974
s_9^-	22.541	0.000	0.000	0.000	0.000	0.000	0.000	6.646
s_{10}^-	0.000	0.000	0.000	0.000	9.199	0.000	0.000	0.000
s_1^+	2.514	0.000	0.000	0.000	2.043	0.000	0.000	0.000
s_2^+	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
s_3^+	0.002	0.000	0.000	0.000	0.005	0.000	0.000	0.001
$\Sigma_{j=1}^n \lambda_j$	0.271	1.000	1.000	1.000	0.478	1.000	1.000	0.101
θ	0.895	1.000	1.000	1.000	0.832	1.000	1.000	0.629

45.4.3 Super-efficiency DEA Model Calculation

From Tables 45.2 ∼ 45.5, we can see that the traditional C^2R model and BC^2 model cannot solve the specific sort problem of DMU, we need make partial improvement for traditional C^2R model, to get a more accurate solution to the sort difficult of effective DMU, in order to make a more detailed analysis to creative industry devel-

Table 45.5 BC^2 model assessment results of China creative industry development pure technical efficiency

DMU	Beijing	Tianjin	Qingdao	Jinan	Harbin	Shanghai	Nanjing
θ^p	1.000	0.848	1.000	1.000	0.625	1.000	1.000
DMU	Hangzhou	Suzhou	Ningbo	Shijiazhuang	Taiyuan	Zhengzhou	Wuhan
θ^p	1.000	1.000	1.000	1.000	1.000	1.000	1.000
DMU	Changsha	Chongqing	Chengdu	Xi'an	Nanning	Kunming	Guangzhou
θ^p	1.000	1.000	1.000	1.000	1.000	1.000	1.000
DMU	Shenzhen	Wuxi	Xiamen	Fuzhou	Hefei	average	
θ^p	1.000	1.000	1.000	1.000	1.000	0.980	

opment status in China's major cities. Thus we introduce the super-efficiency DEA model.

We take super-efficiency DEA model calculation with input-output data of the 26 DMUs, to get optimal efficiency value θ^s under the super-efficiency DEA model. The results are shown in Table 45.6.

Table 45.6 Super-efficiency DEA model assessment results of China creative industry development overall efficiency

DMU	Beijing	Tianjin	Qingdao	Jinan	Harbin	Shanghai	Nanjing
θ^s	2.471	0.811	1.862	0.786	0.451	2.098	0.863
DMU	Hangzhou	Suzhou	Ningbo	Shijiazhuang	Taiyuan	Zhengzhou	Wuhan
θ^s	2.236	2.719	1.188	1.047	0.675	0.625	1.116
DMU	Changsha	Chongqing	Chengdu	Xi'an	Nanning	Kunming	Guangzhou
θ^s	2.068	1.699	1.357	0.844	0.895	1.757	1.191
DMU	Shenzhen	Wuxi	Xiamen	Fuzhou	Hefei	average	
θ^s	1.553	0.832	1.151	1.324	0.629	1.317	

45.5 Results Assessment and Analysis

45.5.1 The Assessment of DMU's Overall Efficiency

The description of the overall efficiency value is the overall operating efficiency status of DMU on the basis of constant returns to scale. As shown in Tables 45.2 ∼ 45.4, from the perspective of overall efficiency of China's 26 major cities creative industry development, 16 cities namely Beijing, Qingdao, Shanghai, Hangzhou, Suzhou, Ningbo, Shijiazhuang, Wuhan, Changsha, Chongqing, Chengdu, Kunming, Guangzhou, Shenzhen, Xiamen, Fuzhou are DEA efficient units. 10 cities namely Tianjin, Jinan, Harbin, Nanjing, Taiyuan, Zhengzhou, Xi'an, Nanning, Wuxi, Hefei are non-DEA efficient units. Among 10 non-DEA effective units, Nanning is closest to effective production frontier which consists of efficient DEA units; its overall efficiency value reaches 0.895. Harbin, whose value is 0.451, is farthest away from the efficient production frontier. The overall efficiency value of majority of non-DEA efficient units is between 0.600 and 0.900, while the average efficiency value of 26 cities is 0.900. Therefore, from the overall point of view, the development of creative industry in China remain at a relatively high level of efficiency, which is the reason why China creative industry bucked the trend, leading the national economy maintaining steady and rapid growth.

From the view of the characteristics of the creative industry development overall efficiency, Beijing and Shanghai is the most developed areas in economy and culture in China. Guangzhou, Shenzhen is the most rapid economic development forefront after China's reform and opening up. In China's middle-western economic and cultural center, Wuhan, Changsha, Chongqing, Chengdu, the development of the creative industry is also DEA efficient. In China's middle-western regions with relatively poor economic development, Hefei, Nanning, Zhengzhou, Taiyuan, Xi'an although have rich historical and cultural resources to support the creative industry development, but compared to those DEA efficient cities, their creative industry development are obviously at a disadvantage.

The above results also indirectly reflect that the established assessment index system in this paper can appropriately reflect creative industry development relies on cultural resources and market-oriented characteristics. The results of assessment model can appropriately reflect China's regional economic development status and the reality of the regional creative industry development.

45.5.2 The Assessment of DMU's Technical Efficiency

Different from the overall efficiency value, the technical efficiency value of DMU shows, on the basis of variable returns to scale, the DMU's under given input factors. From the pure technical efficiency values of China's 26 major cities shown in Table 45.5, in addition to the 16 cities which are overall DEA efficient, 8 overall non-

DEA efficient cities namely Jinan, Nanjing, Taiyuan, Zhengzhou, Xi'an, Nanning, Wuxi, Hefei have pure technical efficiency value of 1.000, only Tianjin and Harbin's pure technical efficiency value is less than 1.000, Harbin's pure technical efficiency values is as low as 0.625, indicating that under given input factors, compared with the other 24 cities, Tianjin and Harbin's creative industry technical output capacity is relatively low and need to be further improved. Overall, the 26 cities' average pure efficiency value reaches 0.980, indicating that the development of China major cities' creative industry, is basically in a purely technical efficient production frontier surface, also verifying the SMEs as the main force of China creative industry development, have relatively strong technological innovation capability, integration capability and application capability. High technical efficiency value is also the main driver to support the high overall efficiency value of China major cities.

45.5.3 The Assessment of DMU's Scale Efficiency

DMU's scale efficiency is the largest marginal product brought by a unit of input factors under the same technical and other conditions. According to the principle of DEA model, we can directly calculate the scale efficiency value of each DMU through the formula $\theta^g = \theta/\theta^p$. Therefore, with Tables 45.2 $\sim$ 45.5, we calculate the scale efficiency value of creative industry development of China's 26 major cities; the results are shown in Table 45.7.

Table 45.7 Assessment of China creative industry development scale efficiency

DMU	Beijing	Tianjin	Qingdao	Jinan	Harbin	Shanghai	Nanjing
θ^g	1.000	0.957	1.000	0.786	0.721	1.000	0.863
DMU	Hangzhou	Suzhou	Ningbo	Shijiazhuang	Taiyuan	Zhengzhou	Wuhan
θ^g	1.000	1.000	1.000	1.000	0.675	0.625	1.000
DMU	Changsha	Chongqing	Chengdu	Xi'an	Nanning	Kunming	Guangzhou
$\theta^g s$	1.000	1.000	1.000	0.844	0.895	1.000	1.000
DMU	Shenzhen	Wuxi	Xiamen	Fuzhou	Hefei	average	
$\theta^g s$	1.000	0.832	1.000	1.000	0.629	0.916	

From Table 45.7, we can see that in the 16 cities which are overall DEA efficient, scale efficiency value is 1.000, representing a relatively high level of scale development, indicating that in the 16 cities, the marginal output capacity of creative industry production factors is strong, input quality of input factors is high, overall achieving efficient use. It can be seen at the same time, that the 10 overall non-DEA efficient cities such as Tianjin, Jinan and Harbin etc. remain a certain distance away from the scale efficiency production frontier, among them Zhengzhou has the lowest scale efficiency value 0.625, marginal production capacity of creative industry input factors is relatively insufficient. The average scale efficiency value of 26 cities is 0.916, indicating that the degree of marginal utilization of China's creative industry input factors is overall at a high level, but it remains a big gap compared with the pure technical efficiency value of 0.980, reflecting a certain blindness of the current development of China creative industry, the overemphasis to the amount of inputs factors, the neglect of improvement on its structure and quality, and the insufficiency of efficient utilization to production factors, leading to the marginal productivity of input factors lags far behind the industry technical development. The input structure and quality of production factors need to be improved urgently.

In terms of China creative industry's returns to scale, it can be reflected by the sum of index weight coefficient $\Sigma_{j=1}^{n}\lambda_j$. From Table 45.5, the $\Sigma_{j=1}^{n}\lambda_j$ of 26 overall DEA efficient DMUs is 1.000, representing the constant returns to scale, indicating a high returns to scale and mature development direction of the city's creative industry. Tianjin, Jinan, Harbin and other 7 non-DEA efficient DMUs' $\Sigma_{j=1}^{n}\lambda_j$ are less than 1.000; they are in the stage of increasing returns to scale. The average $\Sigma_{j=1}^{n}\lambda_j$ of the 10 non-DEA effective DMUs is 0.382, returns to scale is at relatively low level. This fully proves the creative industry development characteristics represented by china SMEs, the utilization to input factors remains at a relatively low level, the scale output capacity has a large potential for development, showing increasing trends of returns to scale. With the development of creative industry, the output proportion of creative industry is much greater than input proportion, thus promoting China's economic structural adjustment, achieving the transformation to creative economy, and maintaining a good and fast economic development.

45.5.4 Sort of DMU Overall Efficiency

The traditional C^2R model, BC^2 model cannot further sort overall DEA efficient DMUs, super-efficiency DEA model is a good solution to this problem. We get the second group overall efficiency value through super-efficiency DEA model calculation, as shown in Table 45.4. We can see the overall descending order of China's 26 major cities creative industry development is Suzhou, Beijing, Hangzhou, Shanghai, Changsha, Qingdao, Kunming, Chongqing, Shenzhen, Chengdu, Fuzhou, Guangzhou, Ningbo, Xiamen, Wuhan, Shijiazhuang, Nanning, Nanjing, Xi'an, Wuxi, Tianjin, Jinan, Taiyuan, Hefei, Zhengzhou, Harbin. Under the super-efficiency DEA model, the average overall efficiency value of 26 cities is 1.317, at relatively high efficiency level.

From specific classification and individual analysis of the above sort, we can clearly see in the Fig. 45.1 that, 5 cities namely Suzhou, Beijing, Hangzhou, Shanghai, Changsha are the first echelon of the creative industry development in China, their overall efficiency values are all more than 2.000, while the highest overall efficiency value is 2.719 for Suzhou; 11 cities namely Qingdao, Kunming, Chongqing, Shenzhen, Chengdu, Fuzhou, Guangzhou, Ningbo, Xiamen, Wuhan, Shijiazhuang are the second echelon, while their overall efficiency values are between 1.000-2.000; 10 cities namely Nanning, Nanjing, Xi'an, Wuxi, Tianjin, Jinan, Taiyuan, Hefei, Zhengzhou, Harbin are the third echelon, their overall efficiency values are all lower than 1.000, while the overall efficiency of Harbin value is even only 0.451. From the three echelons classification, we can see that China major cities in the creative industry development shows extreme imbalance, the highest overall efficiency value (Suzhou) is 6.03 times as the lowest overall efficiency value (Harbin), there is a huge gap between the coastal and inland, which is basically consistent with the overall status of regional economic and cultural development, also indicating performance of assessment index system in the DEA model is relatively good.

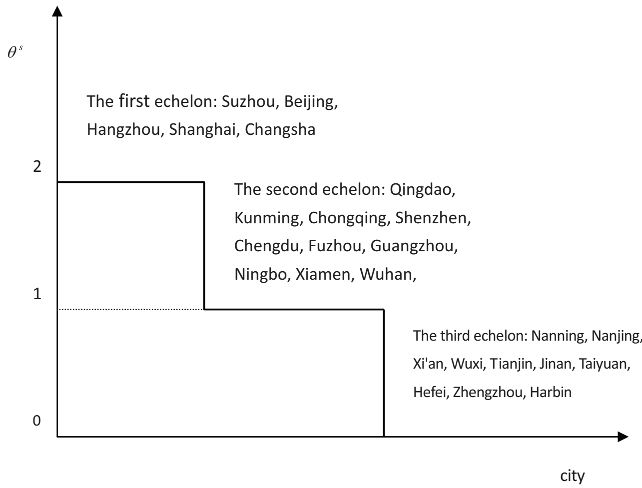

Fig. 45.1 Echelons of China's 26 major cities in the development of creative industry

45.6 Conclusion

The paper identify the assessment unit of China creative industry development efficiency and the DEA model assessment index system, on the basis of data collected for the assessment index, use C^2R model, BC^2 model and super-efficiency DEA model, take an empirical assessment to the China creative industry development efficiency, the assessment results properly reflect the status of creative industry development in China. China creative industry development efficiency basically shows the stepwise development between the coastal and inland, but internal development is extremely unbalanced. According to the efficiency sort of 26 cities in the creative industry development, this paper divided them into three echelons, the first echelon namely Suzhou, Beijing, Hangzhou, Shanghai, Changsha have the highest level of development efficiency in creative industry; the second echelon including 11 cities such as Qingdao, Kunming, Chongqing, Shenzhen, have a relatively high level of development efficiency; the third echelon including 10 cities such as Nanning, Nanjing, Xi'an, Wuxi, have a relatively low level of development efficiency. Based on the above conclusions, China should be on the basis of regional development status of creative industry, focused on improving the structure and quality of the input factors thereby increasing the level of output, build the regional different optimization ideas and specific optimization path for the future development of China creative industry.

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Chapter 46
Optimal Corporate Bankruptcy System Design: From the Perspective of the Contingent Governance

Sheng Ma and Jinjun Gong

Abstract Taking the traditional theory of corporate governance as a logical starting point, this paper builds and interprets the theoretical models of the corporate contingent governance, on the basis of the results of some scholars' researches on the corporate contingent governance theories. Then under this theoretical framework, the optimal bankruptcy system under the conditions of the perfect market economy and the sub-optimal bankruptcy system under the conditions of imperfect market economy are conceptualized, built and designed.

Keywords Corporate governance · The contingent governance · Corporate bankruptcy system · Design

46.1 The Origin of the Problem: The Corporate Governance Theories

Corporate governance, first of all, is a kind of mutual checks and balances, i.e., checks and balances between stakeholders with the interests of shareholders as the core It should be said that corporate governance includes both the corporate governance structure and corporate governance mechanisms. Its core is a set of rights arrangements, the division of responsibility and restraint mechanisms in the framework of the laws, regulations and practices, to ensure that the interests of the stakeholders [1]. In China, how to improve their corporate governance has been an important part of enterprise reform, the society is very concerned about this with heated discussions, and the government has taken measures from all aspects to foster the foundation of modern corporate governance system. However, China's state-owned enterprises have many problems in corporate governance for a long time, and the

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rapidly emerging private enterprises have more difficult problems in corporate governance (one of the important reasons is their lack of internal corporate governance motivation). Therefore, to improve the corporate governance practices of Chinese enterprises will be a complex, long-term and arduous task.

In fact, the traditional corporate governance theories can more accurately be defined as an internal governance theory, with its emphasis on the set of the company's internal institutions and personnel powers configuration problems, and focus on the checks and balances of the various internal powers of the company. However, the issue of corporate governance is a complex system engineering. It not only involves internal governance issues, but also involves external governance issues. Simply put, the company's external governance refers to such a governance mechanism in which the company's external market stakeholders, in a timely manner under certain circumstances, can exert pressure on the company, acquire or take over the company, resulting in the launching of company management replacement or the insolvency proceedings. This can effectively avoid the "moral hazard" and "adverse selection" of the company management, and force the management to operate the company well. Such governance mechanisms include company acquisitions (Take over) and the contingent governance of stakeholders. The former happens when other organization or individuals, based on some considerations, acquire the shares of the target company to a certain percentage, and thus control the company. For the managers of the acquired company, the result is their loss of the control of the company, so it has a huge deterrent on the lazy behavior of company managers; The latter refers to the corporate governance mechanisms in which the company's stakeholders, based on the company's operating condition and in accordance with the law, take over in a timely manner and deprive the company's original managers of management rights Its essence is the contingent supervision and control of the company It ha a far-reaching significance in improving the corporate governance structure. Since in this paper the optimal bankruptcy system design problem is discussed from the perspective of the contingent governance, here we only focus on the second method, i.e., the contingent governance mechanism.

46.2 Theoretical Model of the Corporate Contingent Governance and Basic Interpretation

The Contingent Governance theory[1] was first proposed by Japanese scholar Aoki [2]. He believes that in order to effectively prevent the "moral hazard" and "adverse selection" problem in the production, operation and management process, an effective way is like thiswhen the enterprise is in a normal operating state, the company should be controlled by corporate insiders; when the enterprise is in non-normal operating state (such as bankruptcy proceedings), the control should be transferred from insiders to shareholders, creditors, employees and other stakeholders of interests [2]. Aoki [2] in 1994 and in later articles [3] called such transfer of control over the operating state of business "the contingent governance". Zhang [4] on the basis of state-contingent model, further elaborates the contingent governance theory According to his model, when the enterprise's total revenue is sufficient to pay the workers' wages, the contract revenue of creditor and the minimum expected return of shareholder, the company should be controlled by the management; when total income is greater than the wages and the contract revenue of creditors, but less than the sum of the workers' wages, the contract revenue of creditor and the minimum expected return of shareholder, the company should be controlled by the shareholders; when the total income is greater than the wages, but less than the sum of the workers' wages, the contract revenue of creditor, the creditor should take control;when the total revenue can not pay the workers; wages, the enterprise control rights should be transferred to the workers. However, Yang and Zhou [5] think that the state dependence of corporate control does not mean the automatic transfer of control. For example, when the total revenue is less than the workers' wages and the principal and interest of creditors, will the shareholders take the initiative to transfer the control to the creditors? The answer is uncertain. Therefore, they believe that a system or contract should be set in advance (such as the corresponding provisions in the Bankruptcy Act or debt covenants) to ensure the smooth transfer of control. Based on the researches of these scholars and other scholars [6–9], this article designs the corporate contingent governance model as follows (Fig. 46.1).

Assume the enterprise's operating status (such as normal operation and non-normal operation) is represented by the income I[2], and assume that I is distributed continuously between 0 to I_{max}, where I_{max} is the maximum possible revenue. Sup-

[1] According to Jin Bei and Huang Qunhui, both incorporated state-owned enterprises and unincorporated state-owned enterprises can be called a "new type of state-owned enterprises", that is, both incorporated enterprises and unincorporated enterprises are called "enterprise", According to this logic, since the "corporate enterprises" after the restructuring is a type of enterprise and they face the problem of "governance ", then the enterprises before restructuring (such as the former state-owned enterprises) or unincorporated enterprises are also a type of enterprise and they too face the problem of "governance". Based on this consideration, we use the broader concept of "enterprise contingent governance" rather than "the corporate contingent governance" for this research [11].

[2] Of course, other financial indicators such as asset-liability ratio, overall labor productivity or return on equity can also reflect the state of business. To simplify our analysis of the problem, we only use the corporate revenue as an indicator to show the business situation of enterprises.

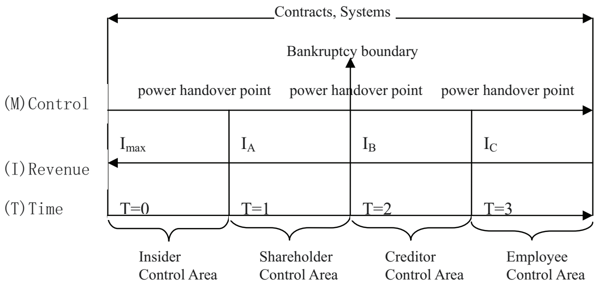

Fig. 46.1 The Theoretical Model of Enterprise Contingent Governance

pose the enterprise employees' contract wages is X, contract revenue of creditors is Y, and the minimum expected revenue of shareholders is Z, then:

When the enterprise is in a normal operating state $(I_{\max} - I_A,\ I_A - I_B)^3$, there are two scenarios: The first scenario is $I_{\max} - I_A$ Stage, when $I > X + Y + Z$, in which the corporate total revenue can pay workers' wages, the contract income of creditors and the minimum expected income of shareholders, can also pay managers incentive compensation in addition to their fixed income (such as bonuses, social prestige, working consumption). The control of the company lies in the hands of managers, this stage is defined as the insider control area; the second scenario is $I_A - I_B$ Stage, when $X + Y < I < X + Y + Z$, in which the corporate total revenue can pay workers' wages and the contract income of creditors but cannot pay the minimum expected income of shareholders. So, shareholders have most incentive to control enterprises and practice contingent governance and the corporate control will be transferred from the managers to the shareholders. The transfer time is the power handover point when $T = 1$, and this stage is defined as shareholders' control area.

When the enterprise is in a non-normal operating state $(I_B - I_C, I_C - 0)$, there are also two scenarios: The first scenario is the $I_B - I_C$ Stage, when $X < I < X + Y$. In this case, the enterprises' revenue are reduced to be able to pay the workers' wages, but unable to pay the contract revenue of creditors, nor the minimum expected return of shareholders. The shareholders have lost the motivation to control the enterprise[4], but creditors may, at this time, take actions (for example, to apply for corporate bankruptcy or take over the business for a reorganization) to minimize their lossIf no actions are taken, they will have losses that are otherwise reparable. Therefore, the creditors have the greatest willingness to control enterprises and practice contingent

[3] In fact, when the corporate revenue is reduced to the $I_A - I_B$ Stage, the minimum expected return of shareholders cannot be met and the enterprise actually has entered the non-normal operating state, but here in order to emphasize the enterprises enter the non-normal operating state only after its entry into bankruptcy proceedings $(T = 2)$, the $I_A - I_B$ Stage is defined as the normal operating state.

[4] When the shareholders now participate in the contingent governance, their marginal cost is greater than marginal revenue. No matter how much effort the shareholders put, they cannot make ends meet.

governance, and the corporate control should be transferred from the stockholders to the creditor. The transfer time is the power handover point when $T = 2$, and this stage is defined as creditors control area. the second scenario is the $I_C - 0$ Stage when $I < X$, in which the corporate income has been unable to pay the workers' wages. Creditors, even if through bankruptcy liquidation procedure, can not guarantee their contract revenue. If creditors pay other prices (such as the consumption of time, restructuring capital reinvestment, etc.) to practice the contingent governance on the indebted enterprises, the result would be that the marginal cost is greater than marginal revenue, so the creditors lose the motivation to control the corporate. At this point, since I can pay part of the workers' wages, and if workers take the initiative to control and govern the enterprises (such as self-help production), their actual income may be far greater than when they are not involved in enterprises contingent governance, so in this case workers have the greatest incentive to participate in the contingent governance of indebted enterprises. the corporate control should be transferred from creditors to workers. The transfer time is the power handover point when $T = 3$ and this stage is defined as worker control areas.

In particular, the time $T = 2$ is the critical point when the enterprise shifts from the normal operating state to a non-normal operating state. The corporate revenue I is in a critical state when it just can not pay creditors contract revenue, control at this time should be transferred from the shareholders to creditors. Since he creditors exercise control mainly through the bankruptcy reorganization and bankruptcy liquidation, so the corporate revenue when $T = 2$ is defined as the bankruptcy boundary.

During the whole processes when the corporate revenue I is reduced from $I_{\max}$ to 0, the time T from $T = 0$ to $T = 3$ (even after $T = 3$), the control is transferred from the insiders to the shareholders, creditors, employees and other contingent governance subjects, there is a set of comprehensive contracts (such as debt contracts) or system arrangement (such as bankruptcy law) to regulate each steps, in order to ensure smooth handover of control.

For the special case of China's state-owned enterprises bankruptcy in the transition period, when the enterprises reach bankruptcy boundary, the control is actually first transferred to the government, so the $T = 2$ stage and subsequent stages are defined as the government control area (applicable only to policy bankruptcy of state-owned enterprises in the transition period,).

The above analysis is somewhat abstract, so we make a summary of the theoretical model of the enterprises contingent governance and its implications.

The corporate contingent governance refers to the orderly transfer of corporate control to different subjects in accordance with the changes in business performance, financial condition or operating state correspondingly[5]. It is a dynamic corporate

[5] The essence of the changes in "enterprise performance, financial condition or operating state" is the changes in business conditions or performance or the adverse selection and moral hazard behavior of a party that have made damage to the interests of other parties, for instance the poor management of managers leads to the decline in corporate profits or dividends and damages the interests of the owners (shareholders); deterioration of the financial situation of enterprises hurt the corporate solvency and increase the financial risk of the creditorsimproper decisions of business managers harm the interests of the employees. Of course, the improvement of the operating con-

governance, the core of which is, during the whole processes from the normal operating state to the non-normal operating state and withdrawal from the market after bankruptcy, the various subjects can take control in a timely and contingent manner and participate in corporate governance. It is to effectively solve such a problem: when changes in corporate performance, financial condition or operating state affect the interests of the stakeholders (managers, owners, creditors and employees) directly or indirectly, some kinds of mechanisms (such as the "Bankruptcy Law" or debt covenants, provisions or arrangements) will be triggered automatically to make re-arrangements between the various stakeholders in order to achieve the re-adjustment of the corporate governance structure.

We find that an important tool to realize the contingent governance is the effective transfer of control (corporatization and reorganization of demutualization, mergers and acquisitions, proxy rights competition discrete merger, liquidation, etc.). The basic premise of this effective transfer of control is to the corporatization of enterprises, because there is no obvious contingent governance to take control in unincorporated enterprise. The best function of corporatization, in view of corporate governance, is to define the corporate property rights, and the clear property rights serve as the basis for a timely and orderly contingent governance among the various stakeholders. Obviously, it is difficult for unincorporated enterprises to implement contingent governance mechanisms. In general, the corporate contingent models in different economic systems are not exactly the same, but in a mature market economy system there are striking similarities in implementing the corporate continent governance, this is, as the business conditions deteriorate, the corporate control is always moving along the direction of managers (insider control) to shareholder, creditor and workers.

After an abstract analysis and a popular generalization of the theoretical model of the corporate contingent governance and its implications, a more simplified description of the corporate contingent governance is as follows (Fig. 46.2).

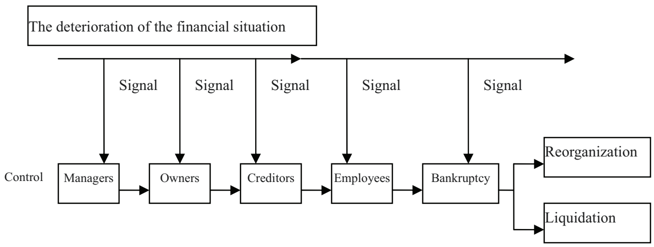

Fig. 46.2 The Simplified Model of Enterprise Contingent Governance

ditions can benefit certain parties, which also can cause changes in the governance structure. For example, the increase in company's profitability will make owners tend to give greater control to managers, which can undermine the control rights of the creditors. More discussions are in [12].

We note that the contingent governance emphasizes the word “contingent”, i.e., corporate stakeholders, as the contingent governance subjects, can have a timely, dynamic and contingent governance in accordance with the operating conditions of enterprises, which coincides the Contingency Management Theory in management. The core idea of the Contingency Management Theory is that there is no hard and fixed management model and that managers should constantly adjust themselves to seize the opportunity to adapt to external changes [10]. From this perspective, the contingent governance theory itself enjoys a corresponding theoretical support, which also highlights the necessity and strong vitality of the contingent governance theory. As the focus of the paper is the optimal corporate bankruptcy system design from the perspective of the contingent governance, we do not intend to analyze the contingent governance theory itself too much. Now we will discuss the corporate bankruptcy system design problems from the perspective of the contingent governance.

46.3 Optimal Bankruptcy System Design from the Perspective of Contingent Governance

46.3.1 Optimal Bankruptcy System Design under the Perfect Market Economy Conditions

In the previous section, we have analyzed the corporate contingent governance theories. Now we take them as supports to design the optimal bankruptcy system[6]. It’s worth emphasizing that irrespective of our discussion of bankruptcy system design under the perfect market economy conditions here or bankruptcy system design under the imperfect market economy conditions in next section, we have a basic premise: the analyses are made from the perspective of the corporate contingent governance. First of all, let’s take a look at the scenario under the perfect market economy conditions.

To do this, we first assume that there is such a simple economic society and that this society is composed by the following categories of people: first, business managers (in order to simplify the analyses of the problem, the managers and business owners are regarded as the same category of people); second, the outside investors[7]; third, the government, whose job is to design the bankruptcy system and whose main consideration is how to maximize the overall welfare of the society when designing the bankruptcy systemfourth, the court, which is responsible for the implementation of the Bankruptcy Lawfifth, in order to further simplify the problem, we assume that

[6] The perfect market economy condition is an ideal state. In this scenario, there is no any uncertainty or information asymmetry.

[7] Since the focus of the paper is to examine the bankruptcy problems when the enterprise go into a financial crisis, outside investors will be here particularly defined as creditors.

creditors are the only contingent governance subjects. Meanwhile, we also assume that the enterprises operate under the perfect market economy conditions.

Based on these assumptions and the aforementioned Contingent Governance Model, we can describe the optimal bankruptcy system with this objective function:

$$Y = \int_i (M+U)dF(X) + \int_i \left[\int_{r_1(x,s)} (Q+U)dH(S) + \int_{r_2(x,s)} (X+aS+U)dH(S) \right] dF(X).$$

In this objective function, Y represents the expected welfare of the society, M represents the debt financing scale of the enterprise, U represents the private benefits the enterprise managers enjoy when they control the enterprise, Q represents the liquidation value that creditors get when the control is transferred to creditors. "i", "j", "$r_1(x,s)$", "$r_2(x,s)$" represent different sets, in which $i = \{x|$creditors agree to renegotiate debt covenants after taking control$\}$, $j = \{x|$creditors do not agree to renegotiate debt covenants after taking control$\}$, $r_1(x,s) = \{(x,s)|$creditor requires enterprises to be liquidated$\}$, $r_2(x,s) = \{(x,s)|$ creditors accept the debt contract re-negotiations and allows businesses to continue to operate after negotiations$\}$.

When $T = 0$, external investors (creditors) sign debt covenants with the enterprise. Assumes that both creditors and managers are risk-neutral. After signing the covenants, the managers choose their effort level s, Because of the "moral hazard", managers may become "lazy", so we assume that the level of their work efforts is in a continuous distribution in a certain range, i.e., $s \in [s_{\min}, s_{\max}]$, The managers try to improve the output of enterprises in a First-order stochastic dominance sense. The more efforts the managers put, the more returns they get, yet higher cost they pay. In other words, when manager work hard to earn high returns, there is a negative utility $H'(s), H'(s) > 0, H''(S) > 0$.

When $T = 1$, the decline in corporate revenue has made the control transferred to the shareholders, between $T = 1$ and $T = 2$, creditors and business managers can observe x, a signal representing financial situation of enterprises, $x \in [s_{\min}, s_{\max}]$, $s_{\min}$ represents the most incomplete information, $s_{\max}$ represents the most complete information, $F(x)$ is its probability distribution function.

When $T = 2$, the control has been transferred to the creditors when creditors observe an accurate but unverifiable signal that the enterprise is in a financial predicament. This is signal is represented by $f(s) = as + b$, in which $f(s)$ represents company's cash flow, s is the manager's effort level, a is a parameters, b is a random variable, $b \in [b_{\min}, b_{\max}]$, the distribution function is $K(s)$, and the density function is $k(s)$. Under perfect market economy conditions, $b = 0$. At this point, the creditors will, according to the financial situation of enterprises, make the decisions whether to liquidate the enterprises, to let managers continue to operate the business or to renegotiate existing debt covenants.

Thus, based on our analysis of the Contingent Governance Model and the objective function of the optimal bankruptcy system, we can list the basic characteristics of an optimal bankruptcy system as follow.

First, in an optimal bankruptcy system, the government can directly define the appropriate sets [“i”,“j”,“$r_1(x,s)$”,“$r_2(x,s)$”] to make the overall social welfare optimal when the enterprise goes bankrupt.

Second, an optimal bankruptcy system should ensure a smooth transferring of control to such contingent governance subjects as creditors when the enterprise is in financial difficulties.

Third, from the perspective of the overall social welfare, when the liquidation value of the enterprise is less than the value of its continuing operations, the optimal bankruptcy system should prevent creditors from excessive liquidation of the enterprise to ensure the continued operation of the enterprise; when the corporate liquidation value is greater than its continuing operations, the optimal bankruptcy system should ensure such contingent governance subjects as creditors have enough power to implement corporate bankruptcy liquidation.

Fourth, when such contingent governance subjects as creditors, due to the “transaction costs” or “information rent” and other reasons, fail to get accurate information as to whether they should continue to operate or liquidate bankruptcy, the manager should have enough incentive to liquidate the worthless insolvent enterprise even if the continued operation is more beneficial to their own utility; the manager also should have sufficient constraints not to liquidate the enterprise that is worthy of continued operation even if the bankruptcy liquidation is more beneficial to their own utility.

46.3.2 Optimal Bankruptcy System Design under the Imperfect Market Economy Conditions

The above analysis of the optimal bankruptcy system is based on the strict assumptions of perfect market economy. However, in the economic and social reality, this optimal bankruptcy system is difficult to achieve (due to the limit of constraints). Unlike the conditions of perfect market economy, in the economic and social reality the decisions of corporate bankruptcy liquidation and the investor’s investment decisions are made by corporate managers and investors (such as creditors) respectively, and the government can not directly choose the ranges of the sets “i”,“j”,“$r_1(x,s)$”, “$r_2(x,s)$”, but only has an indirect impact. Meanwhile, due to the presence of agency problems, such contingent governance subjects as creditors, government, and even shareholders have a worse access to the relevant information about the enterprise than the managers. There is a serious problem of information asymmetry between them. In other words, the market is not “perfect”. So, we need to revise the optimal bankruptcy system under the conditions of perfect market economy[8].

To this end, we introduce the following constraints into the objective function of the optimal bankruptcy system:

[8] Under the imperfect market economic conditions, there is widespread uncertainty and information asymmetry.

$$I \geq U + \int_{s_{\min}}^{s_{\max}} \int_{\omega}^{b_{\max}} (x + as + b - \omega) dk(b) dh(s), \tag{46.1}$$

where $\omega = F - x - as$, F is the book value of debt financing.

$$\int_{r_1} J_2 dH(S) + \int_{r_2} J_4 dH(S) \geq \beta, \tag{46.2}$$

where β is the actual benefits that creditors may get when liquidating the debt enterprises.

$$J_1 + J_2 \leq L, \tag{46.3}$$

$$J_3 + J_4 \leq dX + aS + b + U. \tag{46.4}$$

In the above constraints, I represents the possible gains of corporate managers when they file for bankruptcy; J_1 represents the gains of corporate managers when the enterprise is liquidated; J_2 represents the gains that such contingent governance subjects as creditors can get when the enterprise is liquidated; J_3 represents the gains of enterprise managers when the enterprise continue to operate, J_4 represents the gains that such contingent governance subjects as creditors can get when the enterprise continue to operate. In these constraint formulas, Equation (46.1) represents the incentive compatible constraints of managers, which means that when managers file for bankruptcy their gains should not be less than what they can get if the companies continue to operate. Equation (46.2) represents of the participation constraint of creditors, which means that such contingent governance subjects as creditors allow the debt enterprises be liquidated only when they expect that their gains from corporate bankruptcy will be higher than their gains from its continued operation. Equation (46.3) and Equation (46.4) represent the social feasibility constraints, which mean that for such contingent governance subjects as managers and creditors the sum of their possible benefits should be economically achievable when the enterprise is liquidated or continues to operate.

Thus, under the conditions of information asymmetry, we can get a revised, constraints-dependent and suboptimal objective function of bankruptcy system:

$$Y = \int_i (M + U) dF(X) + \int_i \left[\int_{r_1(x,s)} (Q + U) dH(S) + \int_{r_2(x,s)} (X + aS + U) dH(S) \right] dF(X), \tag{46.5}$$

$$I \geq U + \int_{s_{\min}}^{s_{\max}} \int_{\omega}^{b_{\max}} (x + as + b - \omega) dk(b) dh(s), \tag{46.6}$$

$$\int_{r_1} J_2 dH(S) + \int_{r_2} J_4 dH(S) \geq \beta, \tag{46.7}$$

$$J_1 + J_2 \leq L, \tag{46.8}$$

$$J_3 + J_4 \leq dX + aS + b + U. \tag{46.9}$$

In the above formulas, Equation (46.5) represents the objective function when the government formulate in the bankruptcy system, and Equations (46.6) to (46.9) are the constraints. In this way, we can list the basic characteristics of a sub-optimal bankruptcy system under the imperfect market economy conditions as follow:

First, under the imperfect market economy conditions, due to the presence of widespread information asymmetry, the government can not directly define the sets "i", "j", "$r_1(x,s)$" and "$r_2(x,s)$" to optimize the bankruptcy system.

Second, under the imperfect market economy conditions, a set of suboptimal bankruptcy institutional arrangements should ensure the orderly transfer of control to such contingent governance subjects as creditors when the enterprise is in financial crisis.

Third, due to the information asymmetry, when the enterprise is in financial crisis the managers have better access to the information as to the economical and financial viability of the enterprise than such contingent governance subjects as creditors. So, the suboptimal bankruptcy system must ensure these contingent governance subjects have certain powers (normally this power refers to the corporate control, but can also refer to other powers). With these powers, such contingent governance subjects as creditors can reject managers' bankruptcy filing thereby preventing a valuable enterprise from bankruptcy; they can also file for bankruptcy so that the worthless debt enterprises can be liquidated.

Fourth, when such contingent governance subjects as creditors, due to the "transaction costs" or "information rent" and other reasons, fail to get accurate information as to whether the enterprises should continue to operate or be liquidate a set of suboptimal bankruptcy institutional arrangements should ensure that managers sufficient incentive to voluntarily liquidate the worthless debt enterprise, even if the continued operation has utility greater to themselves; the arrangements should ensure that managers have sufficient constraints not to liquidate a debt enterprise that is worth continuing to operate, even if the bankruptcy and liquidation bring utility greater to themselves.

46.4 Conclusion

Taking the traditional theories of corporate governance as the logical starting point, and on the basis of the results of some scholars' researches on contingent governance theory, we build a theoretical model of the enterprise contingent governance and give its basic interpretations. Then, within this theoretical framework, we conceptualize, build and design the optimal bankruptcy system under the perfect market economy conditions and the sub-optimal bankruptcy system under the imperfect market economy conditions. It's worth noting that, by the completion of this paper in late 2012, almost all the literature and documents that can be retrieved were published before 2006. In other words, the literature on the corporate bankruptcy system from the perspective of contingent governance in the past five years (2006-2012) is basically in a blank state. As a matter of fact, a lot of problems on the enterprise bankruptcy are also worthy of our in-depth study, such as the games after the enterprise go into bankruptcy proceedings (even before the bankruptcy proceedings), contingent governance models of different contingent governance subjects, the review of China's Enterprise Bankruptcy System and reassessment if its efficiency, and the specific reform approaches to China's Enterprise Bankruptcy System. In this sense, we hope this study will make more experts and scholars pay more attention to the problems of corporate bankruptcy, and, of course, the validity of the conclusions of this study is subject to future tests and the criticism from peer experts.

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Chapter 47
A New Hybrid Model of Feature Selection for Imbalanced Data

Bing Zhu, Qingqing Deng and Xiaozhou He

Abstract The study of customer identification has the extremely vital significance to promote the core competitiveness of the enterprise. This paper focus on the problem of feature selection in customer identification. We try to solve the issue of feature selection under class imbalance and a hybrid method is proposed. We improve the data cleaning technology Tomek Links and get a new model called I-Tomlinks. Based on the using of I-Tomlinks for data preprocessing, we combine the group method of data handling (GMDH) and transfer learning together to construct a new feature selection model to solve the problem of class imbalance. The experiments show that the new method gives better predictive performance that other methods used as benchmarks. The new model provides a new tool for customer identification.

Keywords Customer identification · Feature selection · Transfer learning · I-Tomlinks · GMDH

47.1 Introduction

In the increasingly fierce market competition, the enterprises' traditional resources, such as product quality, price and production ability, are unable to bring competitive power for the enterprises. Customer relationship management (CRM) becomes the new resource for enterprise to obtain sustainable profit. The main reason is that it can help the enterprises to maintain customers, improves customer loyalty, so as

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to realize the win-win situation between enterprises and customers [1]. Customer identification is the first step of CRM. It can help enterprises to analyse customers' characteristics effectively, and then enterprises can conduct customer segmentation and make corresponding effective marketing strategies based on it. In order to analyse the characteristics of target customers, enterprises always try its best to collect as more variables as possible. Along with the development of information technology, the customer data collected through the information system contain many variables. For example, the telecom customer data from Teradata CRM research center of Duke University contains 171 variables. Variable redundancy not only affects the model precision which brings the so-called dimension disaster, but also influences the model interpretability. So the research on feature selection is very importance on CRM.

Although some scholars have conducted a series of researches on feature selection methods for the CRM, they did not consider the issue of the data imbalance. Data imbalance is very common in customer identification [2], which is caused by the different distributions of different types of customers. Some attempts have been done to solve this issue. The typical example is using the sampling method to balance the proportion of different classes. The sampling method includes undersampling and overampling, the two sampling methods both have their own advantages and disadvantages. However, most current research with respect to class imbalance only considered the data from the same system. Nevertheless, using information inside the system couldn't solve the problem, so we must turn to ask help from outside the system. In the widespread practice of CRM exists such a phenomenon, that is, there is a lot of customers in the related field "outside the system" which is similar with the target customers "inside the system". Compared with the customers "inside the system", these customers "outside the system" have not only similarities, but also differences. So how to integrate these information "outside the system" and "inside the system" to improve the effect of customer identification with class unbalanced is very important.

Based on the above reasons, this paper puts forward a hybrid model TFGI (transferred feature selection [3] based on GMDH [4] and I-Tomlink) to solve this problem solve this problem. We organize the remainder of this paper as follows: The next section contains a description of the proposed model. Then the data for experiments and performance measurements are provided. Finally, we empirically verify the proposed method and offer some conclusions.

47.2 The Model for Feature Selection

47.2.1 I-Tomlinks

Tomek links is an effective data cleaning techniques. Generally speaking, Tomek links [5] can be defined as a pair of minimally distanced nearest neighbors of opposite classes.

Definition 47.1. The instance pair (x_i, x_j) is called a Tomek link if there is no instance x_k, such that $d(x_i, x_k) < d(x_i, x_j)$ or $d(x_i, x_k) < d(x_i, x_j)$, where x_i and x_j are the instances belong to the majority and minority, respectively. (x_i, x_j) is the distance between x_i and x_j.

If two instances form a Tomek link then either one of these instances is noise or both are near a border. Therefore, one can use Tomek links to clean the unwanted overlapping between classes after synthetic sampling where all Tomek links are removed until all minimally distanced nearest neighbor pairs are in the same class. By removing overlapping examples, one can establish well-defined class clusters in the training set, which can, in turn, lead to well defined classification rules.

In this paper, we consider the data from both inside the system and outside the system, which we calle the source domain and target domain data. Since the introducing of source domain data will only increase the unbalance of target domain data, so we only consider the minority class of source domain. Based on this assumption and an improved Tomek Links (I-Tomlinks) method is proposed. The flowchart is given in Fig. 47.1.

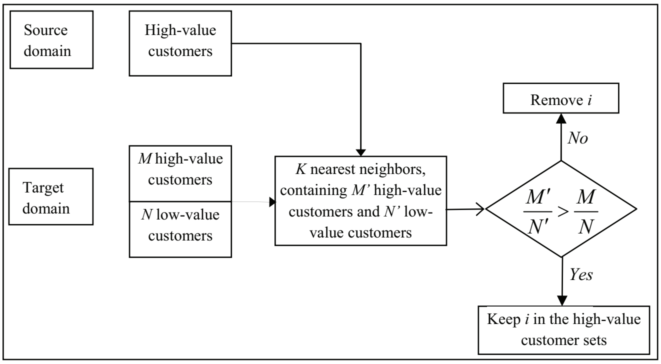


Fig. 47.1 Flowchart of I-Tomlinks

47.2.2 Transferred Feature Selection

Suppose a dataset contains n customers. We denote $\{(x,L)\}$ for every customer sample. x is a d-dimensional vector and it describes the customers' various characteristics. Let L denote the customer class. In this paper, we assume there are only two kinds of customers $L \in \{0,1\}$ where 1 is defined as target customers (or high-value customer) and 0 is defined as non-target customers (or low-value customer). The goal of feature selection is selecting a variable feature subset V from x and make it can effectively describe customer characteristics, especially the characteristics of the target customer which we need.

We denote $D^T \in \{(x_i^T, L_i^T)\},\ i=1,\cdots,n$ for target customer dataset. Here we assume that the majority of target domain is the negative class N^T, while the minority is positive class M^T, $|M^T| \leqslant |N^T|$. In the source domain, there are similar customers, $M^S \in \{(x_i^S, L_i^S)\},\ i=1,\cdots,m$. It has the same feature space $x^S \in (x_1, x_2, \cdots, x_d)$ in the target domain. The goal of transfer feature selection to identify a variable subset V to describe the characteristics of the customers in the target domain effectively with the help of auxiliary customer information in source domain, especially the characteristics of high-value customer. The steps of the algorithm are descripted as follow:

Step 1. Apply I-Tomlink to screen the high-value customer dataset in the source domain to get $M^{S'}$;

Step 2. Employ bootstrap sampling on $M^{S'}$ with replacement to get sample set $\hat{M}_i^{S'}$, $|\hat{M}_i^{S'}| = |M^{S'}|$;

Step 3. Combine $\hat{M}_i^{S'}$ and D^T to obtain training subset $Z^i = D^T \cup \hat{M}_i^{S'}$, and use GMDH to build model on Z^i to get feature subset;

Step 4. According the result of GMDH model, a score $S_i^r,\ r=1,\cdots,d$ for every feature is calculated as follows:

$$S_i^r = \begin{cases} 1/e^i, & \text{if } x_i \in v_i, \\ 0, & \text{if } x_i \notin v_i, \end{cases} \tag{47.1}$$

where e^i is defined as the model error of z^i;

Step 5. Repeat Step 2 $\sim$ 4 to get K feature subsets $\{V^1, V^2, \cdots, V^K\}$;

Step 6. Use weighted voting method to get the final weighted order $E = \{f_1^E, f_2^E, \cdots, f_d^E\}$, where each feature's weighted score is calculated is as follows:

$$CS^r = \sum_{i=1}^{K} S_i^r. \tag{47.2}$$

47.3 Empirical Experiments

47.3.1 Data Description

We use a dataset provided by a cigarette factory of Sichuan province of China. This factory want to introduce a new product in the middle-price cigarette market and it want to know the features of high-value and low-valued customer in the cigarette market for marketing decision. According to the amount of the smoking in the questionnaire, we divided the customer into heavy ones and mild ones. The heavy ones are high-value customers and mild ones are low-valued customers. In the questionnaire, every respondent was asked to provide their socio-demographic factors, purchasing behavior, brand perception and other information. After deleting the variables with too many values, we finally got 65 variables. Using these 65 variables to describe the characteristics of the customer is not realistic. Since the budget is limited, the cigarette factory only obtained 200 samples in area A, containing 24 heavy smokers. Obviously, it is hard for us to get a convincing result by using a small number of heavy smokers. Fortunately, this company conducted a similar survey on two other areas (B, C) and gets some samples of heavy smokers: B area: a total of 230 customers with54 heavy smokers; C area: 180 customers with 46 heavy smokers. We hope that these heavy smokers from area B and C can help us to get better feature research migration to feature selection.

47.3.2 Experimental Settings

In the study, we divided the 200 samples from area A into two parts: 70% sample as learning set (140 samples) and 30% sample test sets (60 samples). In the division process, we keep the proportion of heavy smokers is roughly the same is both parts.

We assess the predictive performance of the models on the holdout test sample as described above. As the overall accuracy is not enough to reflect the result of the experiment for imbalanced data, we have to use another four kinds of measurement to evaluate the experimental results: AUC (area under curve of the receiver operating characteristic graph), heavy smoker classification accuracy (HCA), mild smoker classification accuracy (MCA), number of features.

In order to verify the effectiveness of the new model which we put forward, we compared it with several benchmark methods. In addition, we also considered to conduct the experiment in two dimensions. One is data dimension, and the other is method dimension.

In the methods dimension, we considered five kinds of common feature selection methods. It includes Relief, information gain (IG), sequential backward selection (SBS) [6] and genetic selection (GS) [7] and decision tree (DT). We applied the multi-layer neural network method to build model on the selected feature subsets, which is the most widely used modeling method of the customer classification. In addition, we still considered modeling without considering feature selection in the experiment which use neural network directly and denoted as None.

In data dimension (here we use A denote the target domain, and B,C denote the source domain.), we considered the four cases: (1) using benchmark methods with data in A to choose characteristics; (2) adding all the data from both B, C to A directly; (3) adding the minority class of B, C to A ; (4) adding the data of B, C after I-Tomlink to A.

47.3.3 Results Analysis on Different Datasets

According to the different means of data usage, Tables 47.1 $\sim$ 47.4 show the results of experiments and the bolded value represents the optimal value under every measurement.

Table 47.1 Only consider A

Model	AUC	HCA (%)	MCA (%)	OCA (%)	NOF
None	0.488	14.3	88.7	80.0	$\sim$
Relief	0.562	14.3	98.1	**88.3**	14
IG	**0**.891	0	**100.0**	**88.3**	4
SBS	0.543	14.3	94.3	85.0	18
GS	0.624	28.6	96.2	**88.3**	31
DT	0.468	14.3	79.2	71.7	6
TFGI	0.774	**67.1**	71.7	70.0	28

Table 47.2 Adding all the data of B and C to A

Model	AUC	HCA (%)	MCA (%)	OCA (%)	NOF
None	0.543	14.3	94.3	85.0	$\sim$
Relief	0.58	28.6	88.7	81.7	11
IG	0.651	0	**100.0**	**88.3**	6
SBS	0.543	14.3	94.3	85.0	18
GS	0.639	0	**100.0**	**88.3**	15
DT	0.462	0	90.6	80.0	30
TFGI	**0.774**	**67.1**	71.7	70.0	28

We first analyse the experimental results from the view of data dimension:

- From Table 47.1, we can see OCA is very high, but HCA rate is low, especially the IG. The HCA unexpectedly is 0 while its MCA is 100%. Server other feature selection methods have equal or improved HCA compared with none, but the results is not good enough;
- From Table 47.2, we can see that no methods' HCA is improved except Relief with the increase from 14.3% to 28.6%. Other methods' MCA fall into 0. The

HCA of None is the same as only using data from area A. This is because the data in area B and C is also unbalanced. Adding data from areas B and C increase the problem of imbalance.

- From Table 47.3, we can see that all benchmark feature selection methods' HCA improve to a great extent, from 0 to more than 28.6%. On the contrary, all the MCA have different degree of lower, especially the IG and GS which drop from around 100% to 80%. The results demonstrate that the increase of MCA may decrease the MCA by using the information inside the system.
- From Table 47.4, it can be seen that several benchmark feature selection methods have a certain amount of increase. All the methods except GS have greatly increased in AUC, especially DT. MCA also has risen in relative to the former case, In addition, LCA and OCA also has improved severely, especially Relief method, increased from 85% to 92.5% and improved from 78.3% to 84.9%.

Table 47.3 Add the minority data of B and C to A

Model	AUC	HCA (%)	MCA (%)	OCA (%)	NOF
None	0.515	14.3	**88.7**	80.0	~
Relief	0.59	28.6	84.9	78.3	16
IG	0.629	42.9	83.0	78.3	17
SBS	0.66	28.6	84.9	78.3	24
GS	**0.826**	42.9	86.8	**81.7**	14
DT	0.655	42.9	77.4	73.33	15
TFGI	0.774	**67.1**	71.7	70.0	28

Table 47.4 Adding the screening minority data of B and C to A

Model	AUC	HCA (%)	MCA (%)	OCA (%)	NOF
None	0.544	28.6	81.1	75.0	~
Relief	0.722	28.6	**92.5**	**85.0**	14
IG	0.633	28.6	81.1	75.0	14
SBS	0.674	28.6	83.0	76.67	25
GS	0.667	42.9	90.6	85.0	32
DT	**0.817**	**67.1**	84.9	81.67	8
TFGI	0.774	**67.1**	71.7	70.0	28

Experimental analysis from the prospective of data dimensions can come to the conclusions: the customer with class unbalance has a great influence on feature selection. Adding data from area B, C directly cannot obviously improve the performance, and even may have side-effects. Instead, introducing data after I-Tomlinks screening obviously improve the performance of various methods in the five measurements. It shows that the I-Tomlinks' preprocessing method can improve the precision of the model to a certain extent.

47.3.4 Results Analysis on Different Methods

Figs. 47.2 ∼ 47.7 demonstrate results of different methods on the four different kinds of datasets (represented by 1, 2, 3, 4).

Fig. 47.2 None

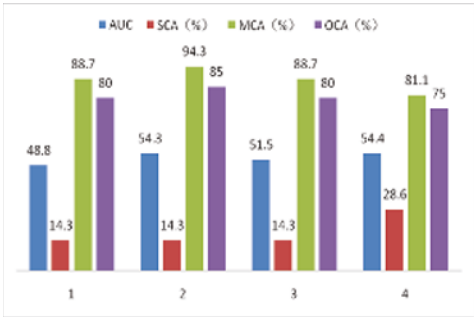


Fig. 47.3 Relief

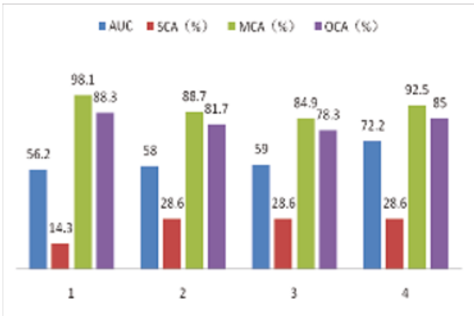


Fig. 47.4 IG

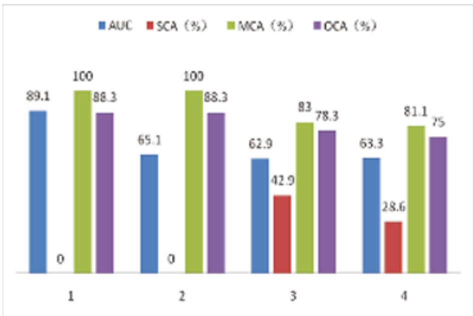
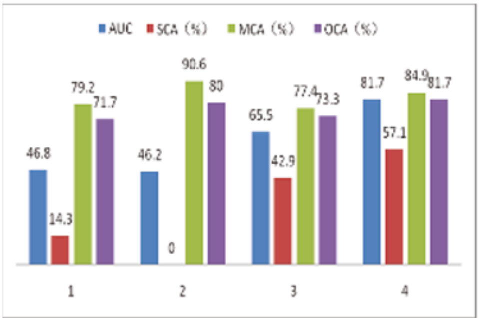


Fig. 47.5 SBS

Fig. 47.6 GS

Fig. 47.7 DT



From these figures, we can see that the influence of data imbalance on the four benchmark methods (IG, SBS, GS and DT) is quite obvious. The HCA of TFGI is 67.1% which is the tallest of all methods. Its AUC value ranks the second. TFGI can effectively identify smokers characteristics.

47.4 Conclusion

In this paper, we focus on managerial problem of how to conduct customer identification with the imbalanced dataset. We put forward a new hybrid model for feature selection under this condition. This model uses a new data processing technology I-Tomlinks methods to deal with data in the related field, and then it combines GMDH and transfer learning to effective analyze the characteristics of the high-value customer in the target field through the introduction of data in the related field. Through an empirical experiment on the cigarette market, it shows that the new hybrid model for feature selection can better analyze the characteristics of high-value customers than existing methods.

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Chapter 48
Research on Inventory Level Distribution for a Closed-loop Support System

Dan Zhao, Mingwu Liu and Xu Zhang

Abstract Performance-based logistics (PBL) is becoming a dominant support strategy for military equipment systems. This paper sets up a closed-loop support system which consisted of a spare parts warehouse and a repair workshop. Firstly, we set up the transition balance equations for the inventory level state. Then, the steady-state probability distribution of spare part inventory level is derived. Then, we conduct several experiments to investigate sensitivities of system's parameters. Our research will help to improving the support level for our army.

Keywords Repairable parts · Inventory level · Distribution · Closed-loop

48.1 Introduction

With equipment systems develop to large-scale and complexity, the repairable parts management of the weapon system is becoming more and more important, but the repair cost is also becoming higher than before. For example, the repair cost of the modern ship equipment is higher than the development cost and purchase price, it has become a major part of life cycle cost for ship equipment. Every year the most of military budget of Chinese Navy is the ship equipment repair cost. Every year United States Department of Defense spends 80% logistics budget on repairing weapon and combat support system [1]. Nowadays in the condition of the spare parts' rising price, traditional repair parts management make the contradictions between the limited budget and the shortage of spare parts more obviously, it may

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affect supplying repair parts timely. So the research of repair parts inventory is especially important.

In order to reduce military cost, through performance based logistics, America and other western developed countries want to solve the problem that weapon system keeps the sustainable fighting capability [2]. Based on life cycle management theory PBL is a US army's strategy which uses to keep the sustainable fighting capability of weapon system. The essence is the weapon system performance purchase, is not same with traditionally purchasing weapon products or repair parts, or purchasing repair service only. PBL make the strategies of Ministry of Defence turn traditionally single and scattered transaction patterns into performance based guarantees patterns, including weapon system availability, reliability, repair, logistics guarantee scale, logistics reaction speed, unit operation cost and so on.

Devries et al [3] studied the most common barriers and enablers at the system, subsystem and component level, as services go forward with PBL implementation. Nowicki et al [4] pointed out that suppliers compute cost not based on the number of repair and components inventory, but based on the effective time the costumers got. So performance based logistics management will become a popular pattern. But the studies above all focus on PBL contract price or the factors which impact on PBL contract, and they don't point out how to enhance the system reliability through improving system parameters. For this reason, coming up with a minimized cost program which based on a higher reliability has the great significant in both theory and practice. In fact, under the influence of random output level, failures, repair service, equipment maintenance and introduced new technology, some people raise some storage management strategy. For example, Braglia et al [7] studied that the supplier built central supply center and regional distribution center, and reduced total cost by the way that it moved repair parts from central supply center to regional distribution center. Ilgin and Tunali [8] pointed out that repair service efficiency exercise a great influence on the inventory level and joint optimization of preventive maintenance repairable parts supply. METRIC theory is used to study the problem of repairable parts inventory. Based on METRIC theory, Yang et al [9] explored the relationship between repair parts inventory level and equipment reliability, when the total cost was fixed; Sleptchenko et al [10] pointed out system reliability affected by repair service efficiency and the repairable parts inventory level; Basten et al [12] took the repair and inventory problem into consideration and built a inventory optimization model for repairable parts. Based on the queuing model; Xiao et al [13] analyzed the relationship between weapon system harm extent of failure and sending maintainers or rescue workers. But those researches above are all based on traditional spare part supply chain, they purpose on getting minimum part inventory or analyzing the factors that make great influence on system reliability. Obviously, they can't meet the system part management requirements that have become more and more complicated and expensive.

This paper considers a closed-loop support system for repairable components, in which both a component failure and the repair lead time of each service in the repair facility follow an independent Poisson distribution. Under the support performance, we build balance equations of repairable part inventory level based on the closes-loop queuing system. We derived the steady-state probability distribution of spare parts inventory level and reveal the properties of the steady-state probability distribution, which will help to improving the support level for our army.

48.2 Model and Analysis

In this paper, we consider a closed-loop support system for maintaining repair parts of equipment systems. The closed-loop system is consisted of a spare parts warehouse and a repair workshop. The basic description for the model is as follows:

- There are N sets of equipment systems needed to be supported. These systems are independent on each other and with the same type of core components. Once a core component fails, the system will immediately stop working. If there are available spare parts in the warehouse, the failure component will be recovered and the system will regain to work. Let the failure distribution of a core component follows a Poisson distribution with consistent rate λ.
- The core components failures of equipment systems are independent on each other. If the warehouse holds spare parts to replace defective part, the equipment system failure will be immediately excluded and the system resumes normal operation. Otherwise, the failure equipment systems will wait maintenance services.
- The failure core component is immediately sent to the repair workshop for repairing. A recovered part is as good as the new one. We assume that the repair workshop is modeled as the single-server queuing system. The customers' arrival process is Poisson process with intensity λ and the repair time is an independent exponent random variable with mean μ^{-1}.
- The recovered part will be kept in the warehouse and the initial core parts inventory reserves is assumed to be s.
- In order to facilitate the analysis, we assume that the replacement time of failure parts is negligible and parts in the warehouse during the reserve period will not malfunction. The transit time for components in the closed-loop support system is also negligible.

Let x represent the component number in the warehouse. As there are$N$ independent, same type, system repairable components, x is from $-N$ to s. When x is negative, it means the shortage number of the warehouse. Suppose y is the number of components which is in the repair workshop. Let z be the number of running components in the independent system components. There are x repairable parts in the warehouse, y failure components in the repair station and z running components, and they satisfy the following relationships:

$$z = \begin{cases} N, & x > 0, \\ N + x, & -N \leq x \leq 0, \end{cases} \quad y = s - x, \quad -N \leq x \leq s. \tag{48.1}$$

In the equilibrium, the inventory level state space $E = \{-N, \cdots, 0, 1, \cdots, s\}$ and the inventory level state process is a Markovian process, the rule of the inventory level state transition is expressed as follows:

- When $x \leq 0$, there is no ready-to-use spare parts in the warehouse, and the operational system is $N+x$ with the failure rate $(N+x)\lambda$. That is to say, at state x, the inventory will be transferred to $x-1$ with intensity $(N+x)\lambda$;
- When $1 \leq x \leq s$, there is on shortage in the warehouse and the number of operational system is N with the failure rate $N\lambda$. At state x, the inventory will be transferred to $x-1$ with intensity $N\lambda$;
- A repaired component arrives at the warehouse from the repair facility. At state x, the repair intensity is μ. That is to say, at state x, the inventory will be transferred to $x+1$ with intensity with μ.

48.3 The Steady-state Probability Distribution

Let $P(x)(x = -N, -N+1, \cdots, s)$ is the steady-state probability distribution of the ready-to-use parts in the warehouse, and $\sum_{x=-N}^{s} P(x) = 1$. Theorem 48.1 gives the steady-state probability distribution.

Theorem 48.1. *In the long-run equilibrium, the steady-state probability distribution of spare parts inventory level state can be expressed as follows:*

$$P_{-N} = \left[\sum_{x=-N}^{0} \frac{\rho^{N+x}}{(N+x)!} + \sum_{x=1}^{s} \frac{\rho^N}{N!} \left(\frac{\rho}{N} \right)^x \right]^{-1}, \tag{48.2}$$

$$P_x = \frac{\rho^{N+x}}{(N+x)!} P_{-N}, -N \leq x \leq 0, \tag{48.3}$$

$$P_x = \frac{\rho^N}{N!} \left(\frac{\rho}{N} \right)^x P_{-N}, 1 \leq x \leq s, \tag{48.4}$$

where, $\rho = \mu/\lambda$.

Proof. According to Markovian process of the spare parts inventory state level, we can set up the following balance equations.

$$\mu P_{-N} = \lambda P_{-N+1}, \tag{48.5}$$

$$[(x+N)\lambda + u] P_x = (x+N+1)\lambda P_{x+1} + u P_{x-1}, \ -N+1 \leq x \leq -1, \tag{48.6}$$

$$(N\lambda + u) P_x = N\lambda P_{x+1} + u P_{x-1}, 0 \leq x \leq s-1, \tag{48.7}$$

$$N\lambda P_s = u P_{s-1}. \tag{48.8}$$

In the long run equilibrium, the steady-state probability distributions of the inventory level $P(x)$ satisfy the above Equations (48.5) $\sim$ (48.8). The balance equations can be obtained by the fact that transition out of a state is equal to transition into a state for a Markov process. For example, we consider a type inventory level state x that lines in the range $-N+1 \leq x \leq -1$. The equation is presented in Equation (48.6). When x is in this range, there is no ready-to-use spare parts, the transition out this state can be only duce to either a failed part arrival or a repaired part arrival. This fact is presented on the left-hand side of Equation (48.6). Either a failed part state $x+1$ will reduce the inventory level by one unit, thus bring it to state x. State x can also be reached from state $x-1$ when a repaired part arrives.

From Equation (48.5), we get:

$$P_{-N+1} = \rho P_{-N}. \tag{48.9}$$

By the iterative method, we can get Equation (48.10) from (48.6).

$$P_x = \frac{\rho^{N+x}}{(N+x)!} P_{-N}, -N+1 \leq x \leq 0. \tag{48.10}$$

With the same manipulation, we get Equation (48.4). Then, we insert Equation (48.3) and Equation (48.4) into $\sum_{x=-N}^{s} P_x = 1$, and get Equation (48.2).

The steady-state probability distribution of the parts inventory level state is the basis of computing various support performance measures. □

48.4 Numerical Experiments

In this section, we present will reveal properties of the steady-state probability distribution of the parts inventory level state. We conducted several experiments because each of them investigated a case and the main parameters which should be considered. In the following, we investigate the sensitivities of system parameters. The numerical results are summed up as follows.

Case 48.1. The effects of failure rate λ on the steady-state probability distribution of the parts inventory. We set other parameters as $\mu = 5,\ N = 5,\ s = 3$.

We sum all the probability distributions at the right column which is denoted $\mathrm{Sum}(P)$. Our experiments show $\mathrm{Sum}(P) = 1$, which is should to be 1 in theory. From Table 48.1, we can get that the failure rate has dramatic effect on the steady-state probability distribution of the parts inventory.

Case 48.2. The effects of repair rate μ on the steady-state probability distribution of the parts inventory. The other parameters are set to be $\lambda = 0.5,\ N = 5,\ s = 3$.

Table 48.2 shows that the repair rate has effect on the steady-state probability distribution of the parts inventory dramatically. For example, P3 increases from 0.0023 to 0.7220 with repair rate increasing from 1 to 9. While P-5 decreases from 0.1345 to 0 with repair rate increasing from 1 to 9. We also can find some other features of the probability distribution for the Fig. 48.1.

Table 48.1 The sensitivities of failure rate

λ	P_{-5}	P_{-4}	P_{-3}	P_{-2}	P_{-1}	P_0	P_1	P_2	P_3	Sum(P)
0.1	0.0000	0.0000	0.0000	0.0000	0.0001	0.0009	0.0090	0.0900	0.9000	1
0.2	0.0000	0.0000	0.0000	0.0002	0.0013	0.0064	0.0320	0.1600	0.8001	1
0.3	0.0000	0.0000	0.0002	0.0014	0.0057	0.0189	0.0631	0.2102	0.7006	1
0.4	0.0000	0.0002	0.0012	0.0049	0.0154	0.0386	0.0964	0.2409	0.6024	1
0.5	0.0001	0.0008	0.0038	0.0127	0.0317	0.0634	0.1268	0.2536	0.5072	1
0.6	0.0003	0.0022	0.0093	0.0260	0.0541	0.0901	0.1502	0.2504	0.4173	1
0.7	0.0007	0.0053	0.0189	0.0451	0.0805	0.1150	0.1643	0.2347	0.3353	1
0.8	0.0017	0.0106	0.0331	0.0691	0.1079	0.1349	0.1686	0.2107	0.2634	1
0.9	0.0034	0.0186	0.0517	0.0958	0.1331	0.1478	0.1643	0.1825	0.2028	1

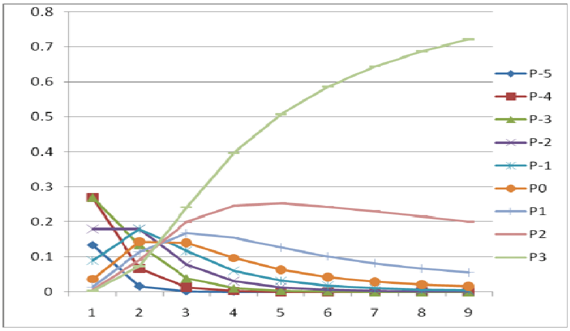

Fig. 48.1 The sensitivities of the probability distribution

Table 48.2 The sensitivities of repair rate

μ	P_{-5}	P_{-4}	P_{-3}	P_{-2}	P_{-1}	P_0	P_1	P_2	P_3	Sum(P)
1	0.1345	0.2691	0.2691	0.1794	0.0897	0.0359	0.0144	0.0057	0.0023	1
2	0.0168	0.0672	0.1344	0.1792	0.1792	0.1434	0.1147	0.0918	0.0734	1
3	0.0022	0.0130	0.0389	0.0778	0.1167	0.1400	0.1680	0.2016	0.2419	1
4	0.0004	0.0028	0.0113	0.0302	0.0604	0.0967	0.1547	0.2475	0.3960	1
5	0.0001	0.0008	0.0038	0.0127	0.0317	0.0634	0.1268	0.2536	0.5072	1
6	0.0000	0.0002	0.0015	0.0059	0.0177	0.0424	0.1018	0.2443	0.5862	1
7	0.0000	0.0001	0.0006	0.0030	0.0105	0.0293	0.0822	0.2301	0.6442	1
8	0.0000	0.0000	0.0003	0.0016	0.0066	0.0210	0.0672	0.2151	0.6882	1
9	0.0000	0.0000	0.0002	0.0010	0.0043	0.0155	0.0558	0.2007	0.7220	1

Case 48.3. The effects of initial inventory level s on the steady-state probability distribution of the parts inventory. The other parameters are set to be $\lambda = 0.5,\ \mu = 5,\ N = 5$.

Table 48.3 shows that the probability distribution $P_x\ (x = -N, -N+1, \cdots 0, \cdots, s)$ is decreasing with initial inventory level s increasing from 0 to 7.

Table 48.3 The sensitivities of initial inventory level

s	0	1	2	3	4	5	6	7
P_{-5}	0.0007	0.0003	0.0002	0.0001	0.0000	0.0000	0.0000	0.0000
P_{-4}	0.0068	0.0032	0.0015	0.0008	0.0004	0.0002	0.0001	0.0000
P_{-3}	0.0338	0.0159	0.0077	0.0038	0.0019	0.0009	0.0005	0.0002
P_{-2}	0.1128	0.053	0.0257	0.0127	0.0063	0.0031	0.0016	0.0008
P_{-1}	0.2820	0.1325	0.0643	0.0317	0.0157	0.0078	0.0039	0.002
P_0	0.5640	0.265	0.1286	0.0634	0.0315	0.0157	0.0078	0.0039
P_1		0.5301	0.2573	0.1268	0.0629	0.0314	0.0157	0.0078
P_2			0.5146	0.2536	0.1259	0.0627	0.0313	0.0156
P_3				0.5072	0.2518	0.1254	0.0626	0.0313
P_4					0.5036	0.2509	0.1252	0.0626
P_5						0.5018	0.2504	0.1251
P_6							0.5009	0.2502
P_7								0.5004
Sum(P)	1	1	1	1	1	1	1	1

Case 48.4. The effects of system sets number N on the steady-state probability distribution of the parts inventory. The other parameters are set to be $\lambda = 0.5$, $\mu = 5$, $s = 3$.

Table 48.4 shows that the probability distribution P_x $(x = -N, -N+1, \cdots, 0, \cdots, s - 1)$ is increasing with the N increasing from 1 to 5. But P_s $(s = 3)$ is decreasing with the N increasing from 1 to 5. For fixed N, the probability P_x is increasing with x increasing from $-N$ to s.

Table 48.4 The sensitivities of number N

N	P_{-5}	P_{-4}	P_{-3}	P_{-2}	P_{-1}	P_0	P_1	P_2	P_3	Sum(P)
1					0.0001	0.0009	0.0090	0.0900	0.9000	1
2				0.0001	0.0013	0.0064	0.0320	0.1600	0.8002	1
3			0.0001	0.0011	0.0057	0.0189	0.0631	0.2102	0.7008	1
4		0.0001	0.0009	0.0046	0.0154	0.0386	0.0964	0.2411	0.6028	1
5	0.0001	0.0008	0.0038	0.0127	0.0317	0.0634	0.1268	0.2536	0.5072	1

48.5 Conclusions

In traditional repairable system, the most of studies focus on how to decide the most suitable repairable part inventory and to reduce the total cost of the support system. But, they do not consider the support performance in conjunction with support cost.

This paper, we set up a closed-loop support system for repairable parts of N sets of independent and identical equipment systems under performance-based contracting. The support system is consisted of a spare parts warehouse and a repairable workshop. We established the inventory levels state as Markov process and derived the steady-state probability of inventory levels, which can be use to calculating various support performance measures. We also investigate the sensitivities of the main parameters. The steady-state probability distribution of the inventory level is affected by the main parameters obviously. Our results can be applied to optimize the closed-loop support system.

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Chapter 49
Multiple Objective Optimization for Multistage Transportation System under Uncertainty

Cuiying Feng, Chi Ouyang and Xiaoling Song

Abstract This paper discusses a multistage dynamic transportation allocation problem (DTAP) in a earth-rock transportation system under fuzzy environment, which is a multi-objective optimization process for minimizing total cost, duration and waste. Uncertain parameters are characterized as triangular fuzzy variables and fuzzy expected value concept is introduced to deal with the uncertainty. Dynamic programming particle swarm optimization algorithm (DP-based PSO) is developed to solve the above problem. Finally, the earth and rockfill dam construction in Pubugou Hydropower is used as a practical application example to demonstrate the practical application value of the optimization method, and the result is presented to highlight the newly developed innovation of the model and optimization algorithm.

Keywords Dynamic transportation allocation problem · Multiple objective optimization · Fuzzy environment · Particle swarm optimization

49.1 Introduction

In a large scale hydropower construction project, transportation system is a very crucial problem because of massive cost and construction duration, it is pressing to deal with comprehensive optimization transportation problem in many real-world applications, especially under a uncertainty environment. Therefore this paper focuses on a multi-objective optimization for multistage earth and rockfill dam construction transportation system under fuzzy environment for minimizing the total operation cost, transportation duration and total waste.

DTAP is often encountered in many practical systems, such as urban planning network traffic, field service support systems, container transportation and flow-

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shop-type production systems [3, 4, 7, 9]. Linear programming [8] and bi-level programming [6] are usually used for solving such transportation problems, while these studies make a significant contribution to DTAP, however they haven't consider both multi-objective and multistage from a view of dynamic. In this paper, the decision-makers should determine a suitable allocation such that the objectives are minimized under constraint conditions, which means that the DTAP is a MODP process in a large scale Hydropower Project.

Similar problems in previous researches are discussed under certain environment or random environment, in which the parameters are known exactly or obey certain distribution. However, transportation systems are often complex, so decision-makers inevitably encounter uncertain parameters when making a decision. First proposed by Zadeh [11], consequently developed by researchers such as Dubois and Prade [2], and has been applied to forecasting, decision-making, and control of actions in environments characterized by vagueness, imprecision, and subjectivity, fuzzy theory is adopted in this paper.

Over the past three decades, many efficient meta-search heuristic techniques have been developed such as genetic algorithms(GA), ant algorithm (AA), simulated annealing and tabu search. Until recently, a new population-based stochastic search method, particle swarm optimization (PSO), inspired by the social behaviors of animals like fish schooling and bird flocking, is proposed for optimization [5]. Existing publications indicate that PSO method has comparable or even superior performance in solving many NP-hard problems with fast and stable convergence. Due to its easy-to-implement, efficiency, and effectiveness, PSO is adopted in this study to develop a DP-based PSO algorithm for solving our transformed optimization model.

The rest of this paper is organized as follows: Sect. 49.2 describes the problem statement of DTAP. A MODP model with fuzzy coefficients is then formulated for minimizing the total operation cost and total waste in Sect. 49.3. In Sect. 49.4, an DP-based PSO algorithm is developed for solving the model. In Sect. 49.5, a real-world construction, Pubugou Hydropower Project, is used as a practical application to demonstrate the practicality of our modeling method and the efficacy of the developed algorithm. Finally, concluding remarks are given in Sect. 49.6.

49.2 Key Problem Statement

In a large scale hydropower construction project, earth and rockfill dam construction is a crucial work. The complete earth and rockfill dam construction process in this paper can be divided into three stages on the basis of total construction duration, flood retention and discharge standard, and construction diversion, which in order are foundation filling, central dam filling and upper dam filling with each stage needing different quantities of earth-rock depending on construction strength. In the first stage, the main work is foundation filling until reaching high alert to solid foundation, and the main work of the second stage is central dam filling and cofferdam filling, the last task is the filling of the dam crest and completion of the project's corresponding height, thickness and slope protection construction.

The earth and rockfill dam construction project transportation system can be divided into two stages according to the construction site's environmental features and transportation routes, the first is from the borrow areas to the stockpile areas using dump trucks, and the second is from the stockpile areas to their corresponding fill areas using belt conveyors. Therefore, the selection of transportation routes and the earth-rock allocation need to be appropriately planned to ensure the provision of adequate earth-rock to meet the various filling intensities at the fill areas and optimize the objectives. The DTAP proposed in this paper aims to achieve the objectives (i.e. cost minimization and waste minimization), which is required to assure optimization and ensure maximum benefit, efficiency and resource utilization.

In the whole construction project, unit cost of earth-rock materials in each stage may be different because of its uncertainty on basis of excavation difficulty, the cost of mechanical production and construction management, indirect shop labor expense, etc. unit cost of stored earth-rock materials in different stockpile areas is different because of its geographic location and stockpile cost, etc. Similarly, there are also other uncertain parameters as shown in the following parts. In practical large scale construction projects, the transportation plan is usually drawn up before any transportation activity commences, then the parameter data may be unknown or partially known because of the lack of statistical data, so there is a strong motivation for considering the fuzzy environment for the DTAP.

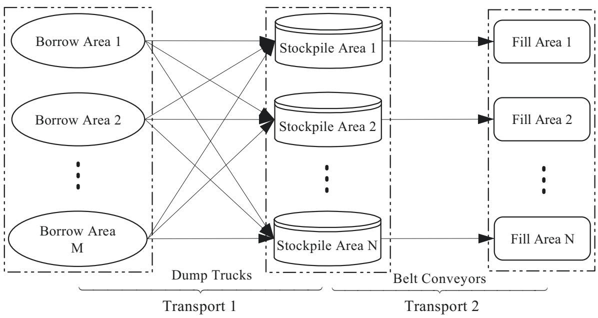

Fig. 49.1 Construction stages and transportation system

49.3 Model Formulation

To model multiple objective optimization for multistage earth and rockfill dam construction transportation system under a fuzzy environment in this paper, the notations are presented as follows:

Sets

B : set of all borrow areas, $i \in B$;
S : set of all stockpile areas or filling areas, $j \in S$, $h \in S$;
K : set of all stages, $k \in K$;
$A_j(k)$: set of borrow areas transporting earth-rock to stockpile area j at stage k.

Parameters

$\tilde{c}_i(k)$: unit cost of earth-rock of borrow area i in stage k;
$\tilde{c}_{ij}(k)$: unit transportation cost of earth-rock from i to j in stage k;
$\tilde{c}_{jh}(k)$: unit transportation cost of earth-rock from j to h in stage k;
$\tilde{t}_{ij}(k)$: transportation time of the first dump truck from i to j in stage k;
$\tilde{t}_{jh}(k)$: unit transportation time of earth-rock from j to h in stage k;
$\tilde{w}_{ij}(k)$: unit waste of earth-rock from i to j in stage k;
$\tilde{w}_{jh}(k)$: unit waste of earth-rock from j to h in stage k;
$\tilde{d}_j(k)$: demand of filling area j at stage k, $\tilde{d}_j(k) = (d_j^L(k), d_j^M(k), d_j^R(k))$;
$B_i(k)$: quantity of available earth-rock in borrow area i;
$S_j(k)$: quantity of available earth-rock in stockpile area j;
α_i : total amounts of earth-rock materials in borrow area i;
β_j : maximum capacity of stockpile area j.

Decision Variables

$$\delta_{ij}(k) = \begin{cases} 1, & \mathrm{i} \in \mathrm{A_j(k)} \\ 0, & \text{otherwise} \end{cases}$$

$x_{ij}(k)$: amount of earth-rock transported from i to j in stage k;
$y_{jh}(k)$: amount of earth-rock transported from j to h in stage k.

49.3.1 Dealing with Fuzzy Parameters and Equivalent Crisp Model

The fuzzy coefficients in the model are defuzzified by using an expected value operator with an optimistic-pessimistic index. For calculating the expected value of the triangle fuzzy numbers, a new measure with an optimistic-pessimistic adjusting index is introduced to characterize the real life problems. The definition of this measure can be found in Xu and Zhou [10]. Let $\tilde{\xi} = (\xi^L, \xi^M, \xi^R)$ be any triangle fuzzy number in the model, then the expected value of $\tilde{\xi}$ should be as follows, where η is the optimistic-pessimistic index to determine the combined attitude of a decision maker.

$$E^{Me}[\tilde{\xi}] = \frac{(1-\eta)}{2}\xi^L + \frac{1}{2}\xi^M + \frac{\eta}{2}\xi^R. \tag{49.1}$$

With the listed notation and the approach that transforms the fuzzy coefficients into expected values, the equivalent crisp model can be represented as follows:

$$\min\ f_c = \sum_{k=1}^{3}\sum_{i=1}^{M}\sum_{j=1}^{N} x_{ij}(k)\delta_{ij}(k)\cdot E^{Me}[\tilde{c}_i(k)] + \sum_{k=1}^{3}\sum_{j=1}^{N}\sum_{i=1}^{M} E^{Me}[\tilde{c}_{ij}(k)]\cdot x_{ij}(k)\delta_{ij}(k)$$

$$+\sum_{k=1}^{3}\sum_{j=1}^{N}\sum_{h=1}^{N}E^{Me}[\tilde{c}_{jh}(k)]\cdot y_{jh}(k),$$

$$\min\ f_w = \sum_{k=1}^{3}\sum_{j=1}^{N}\sum_{i=1}^{M}x_{ij}(k)\delta_{ij}(k) - \sum_{k=1}^{3}\sum_{h=1}^{N}E^{Me}[\tilde{d}_h(k)] - \sum_{j=1}^{N}S_j(3),$$

subject to

$$B_i(k) = B_i(k-1) - \sum_{j=1}^{N}x_{ij}(k)\delta_{ij}(k), \quad \forall i,k, \tag{49.2}$$

$$S_j(k) = S_j(k-1) + \sum_{i=1}^{M}x_{ij}(k)\delta_{ij}(k)\cdot(1-E^{Me}[\tilde{w}_{ij}(k)]) - y_{jh}(k),$$
$$\forall k, j=h, \tag{49.3}$$

$$B_i(0) = \alpha_i, \quad \forall i, \tag{49.4}$$

$$S_j(0) = 0, \quad \forall j, \tag{49.5}$$

$$S_j(k) \le \beta_j, \quad \forall j,k, \tag{49.6}$$

$$x_{ij}(k) \ge C, \quad \forall j,k, \tag{49.7}$$

$$0 \le \sum_{j=1}^{N}x_{ij}(k)\delta_{ij}(k) \le B_i(k-1), \quad \forall i,k, \tag{49.8}$$

$$\sum_{i=1}^{M}\alpha_i - \sum_{k=1}^{3}\sum_{j=1}^{N}(\sum_{i=1}^{M}E^{Me}[\tilde{w}_{ij}(k)]\cdot x_{ij}(k)\delta_{ij}(k) + \sum_{h=1}^{N}E^{Me}[\tilde{w}_{jh}(k)]\cdot y_{jh}(k))$$
$$\ge \sum_{k=1}^{3}\sum_{h=1}^{N}d_h^R(k), \tag{49.9}$$

$$d_h^L(k) + y_{jh}(k)\cdot E^{Me}[\tilde{w}_{jh}(k)] \le y_{jh}(k), \quad \forall j,k, \tag{49.10}$$

$$y_{jh}(k) \le S_j(k-1) + \sum_{i=1}^{M}x_{ij}(k)\delta_{ij}(k)\cdot(1-E^{Me}[\tilde{w}_{ij}(k)]), \quad \forall j,k, \tag{49.11}$$

$$\sum_{k=1}^{3}\max_h(\min_i\{E^{Me}[\tilde{t}_{ij}(k)]|\delta_{ij}(k)=1\} + E^{Me}[\tilde{t}_{jh}(k)]\cdot y_{jh}(k)) \le D, \tag{49.12}$$

where f_c expresses the total cost comprised of purchase cost and transportation cost, f_w expresses the total waste in the whole construction project. Equations (49.2) and (49.3) are state equations, Equations (49.4) and (49.5) are initial conditions, Equation (49.6) ensures that the quantity of available earth-rock in stockpile j at the end of stage k be not more than β_j. Equation (49.7) assumes that the quantity of earth-rock transported from i to j in each stage is at least the heaped capacity C of a dump truck when $\delta_{ij}(k) = 1$. Equation (49.8) implies that the quantity of earth-rock in i that are allocated to j in stage k (i.e., $x_{ij}(k)$) should be nonnegative and not more than the total quantity of available earth-rock of i at the end of stage $k-1$ (i.e., $B_i(k-1)$). Equation (49.9) ensures total amount of earth-rock should satisfy the total maximum demand of all fill areas after considering the waste. Similarly, the quantity of earth-rock in j transported to its corresponding fill area should be no less than the total demand of fill area h ($j = h$) in stage k and not more than the sum of earth-rock transported from borrow areas and left in stockpile area j in the last stage, shown in Equation (49.10), Equation (49.11) and Equation (49.12) shows that there exists a most endurable construction duration for a transportation system (i.e., D) which is accepted by the decision makers.

49.4 Dynamic Programming-based Particle Swarm Optimization

Particle swarm optimization (PSO), proposed by Kennedy and Eberhart [5], is an optimization technique based on swarm intelligence. It is a population based random search method that imitates the physical movements of the individuals in the swarm as a searching mechanism. Unlike the standard PSO, DP-based PSO can reduce the dimensions of a solution representation by using the state equations in the equivalent crisp model. In the standard PSO, the algorithm is initialized with a population (called swarm) of L random individuals (called particles). Each particle is represented by its position in a H-dimensional space, where H is the problem dimension. For the DTAP, the problem dimensions should include decision variables (i.e., $\delta_{ij}(k)$, $x_{ij}(k)$ and $y_{jh}(k)$) and state variables (i.e., $B_i(k)$ and $S_j(k)$).

The basic PSO formula is show as below:

$$V_l(\tau+1) = w(\tau)V_l(\tau) + c_p r_p(\Psi_l - P_l(\tau)) + c_g r_g(\Psi_g - P_l(\tau)), \tag{49.13}$$
$$P_l(\tau+1) = V_l(\tau+1) + P_l(\tau), \tag{49.14}$$

where l is particle index and $l = 1,2,\cdots L$, L is the population size; τ is iteration index and $\tau = 1,2,\cdots T$, T is the iteration limit; $V_l(\tau)$ and $P_l(\tau)$ denote the H-dimension velocity and position for particle l in the τ^{th} iteration respectively; Ψ_l and Ψ_g) denote the personal best position of particle l and the global best encountered after τ iterations, respectively; c_p and c_g are the personal best and global best position acceleration constants respectively, and they determine the relative weight of the global best to the personal best; r_p and r_g are uniform random numbers within $[0,1]$; $w(\tau)$, the inertia weight used to control the impact of the previous velocities on the current velocity that influences the trade-off between the global and the local exploration abilities during the search, and the adaptive inertia weights are set to be varying with iterations as shown in Equation (49.15)

$$w(\tau) = w(T) + \frac{\tau - T}{1 - T}[w(1) - w(T)]. \tag{49.15}$$

49.4.1 Fitness Value Function

There are two objectives in this paper, one is minimizing the total cost, and another one is minimizing the total waste during the transportation and construction system. The fitness value of each particle must reflect the objective values, namely the fitness value used to evaluate the particle is the value of objective function.

49.4.2 Framework of DP-based PSO

The framework of DP-based PSO with representation to solve the dynamic multi-objective construction problems is presented in this section, including the initialization and procedure of DP-based PSO.
Step 1. ***(Initialization)***: Initialize L particles as a swarm: Set iteration $\tau = 1$, generate the position P_l within $[p^{min}, p^{max}]$ and velocity $V_l(1)$ randomly. Then evaluate the fitness value of P_l, represented by $Z(P_l)$, the initial Ψ_l is corresponding to current position $P_l(1)$ and find the global best position.
Step 2. ***(Updating and schematic procedure)***: WHILE maximum number of cycles has not been reached, DO

- Calculate the fitness value of the particle.
- Update pbest: For $l = 1, \cdots, L$, update $\Psi_l = P_l$, if $Z(P_l) < Z(\Psi_l)$.
- Update gbest: For $l = 1, \cdots, L$, update $\Psi_g = \Psi_l$, if $Z(\Psi_l) < Z(\Psi_g)$.
- Update the velocity and the position of each l^{th} particle based on Equation (49.16) and Equation (49.17).
- If $p_{lh}(\tau+1) > p^{\max}$, then

$$p_{lh}(\tau+1) = p^{\max}, v_{lh}(\tau+1) = 0. \tag{49.16}$$

If $p_{lh}(\tau+1) < p^{\min}$, then

$$p_{lh}(\tau+1) = p^{\min}, v_{lh}(\tau+1) = 0. \tag{49.17}$$

Step 3. ***(Stopping criteria)***: If the stopping criterion is met, i.e. $\tau = T$, go to step 4. Otherwise, $\tau = \tau + 1$ and return to step 2.
Step 4. ***(Decoding)***: Decode global best position Ψ_g as the solution set.

49.5 Practical Application to a Construction Project

(1) Project description and data collection

In this section, an earth-rock transportation system in the Pubugou hydropower earth-rock dam construction project is taken as an example to demonstrate the optimization method. The Pubugou Hydropower dam is an earth-rock dam with a gravel soil core, and is 186 meters high with a dam crest elevation of 856 meters, it consists of a core wall anti-seepage material area, an upstream and downstream inverse filter material area, a filtration material area, two earth-rock filling areas, and a slope protection block stone area. The top and bottom elevations of the core wall are 856 meters and 854 meters respectively, with the top and bottom width being 4 meters and 96 meters, and the slope of the upstream and downstream both being 1 : 0.25. The total amount of dam filling is 2364.25×10^4 cubic meters.

All detailed data for the Pubugou Hydropower Project were obtained from Dadu River Basin Hydropower Project Construction Company and investigations were made to collect them. In the Pubugou Hydropower Project, there are 4 borrow areas, 2 stockpile areas and 2 fill areas, where total amount of earth-rock in each borrow area are: $\alpha_1 = 732.4 \times 10^4 m^3$, $\alpha_2 = 581.7 \times 10^4 m^3$, $\alpha_2 = 528.3 \times 10^4 m^3$, $\alpha_2 = 790.2 \times 10^4 m^3$, maximum capacity of each stockpile area are: $\beta_1 = \beta_2 = 20 \times 10^4 m^3$. Table 49.1 shows part of uncertain data (i.e., $\tilde{c}^1_{ij}(k)$ and $\tilde{c}^2_{jh}(k)$).

Table 49.1 The data information of transportation cost of each path in each stage

Model parameters	Stage index		
	$k = 1$	$k = 2$	$k = 3$
$\tilde{c}^1_{11}(k)$	$(4.82, 5.20, 5.56)$	$(5.26, 6.00, 6.44)$	$(5.28, 5.82, 6.18)$
$\tilde{c}^1_{21}(k)$	$(3.02, 3.25, 3.57)$	$(3.23, 3.66, 4.09)$	$(3.18, 3.72, 4.25)$
$\tilde{c}^1_{31}(k)$	$(3.89, 4.23, 4.67)$	$(3.97, 4.34, 4.55)$	$(4.16, 4.59, 4.83)$
$\tilde{c}^1_{41}(k)$	$(5.78, 6.12, 6.47)$	$(6.04, 6.44, 6.58)$	$(6.06, 6.40, 6.75)$

(2) Results and analysis

In the model discussed above, let $D = 2.8 \times 10^3$ (hour), $c = 12.5$ (CNY), $\eta = 0.5$. parameter values selected for the DP-based PSO in our computational experiments: $L = 50$, $T = 100$, $c_p = c_g = 1.5$, $w(T) = 0.1$, $w(1) = 0.9$. After running the proposed DP-based PSO using MATLAB 7.0, the computational results were obtained. The results and performance of the algorithm, as compared to the actual data from the project, are listed in Table 49.2, and Fig. 49.2 shows the results of DP-based PSO Algorithm for transportation allocation decision in Pubugou Hydropower Project.

Table 49.2 Results of DP-based PSO Algorithm for DTAP in Pubugou Hydropower Project

Objective	Total cost or waste		Convergence	Computing
	Fitness value	Actual data	Iteration number	Time (s)
$f_c(10^6)$	582.50	583.67	58	17.34
$f_w(10^4)$	154.16	160.06	43	13.29

It should be noted that the results are obtained based on the following optimistic-pessimistic index, i.e., $\eta = 0.5$. In order to gain insight into the selection principle

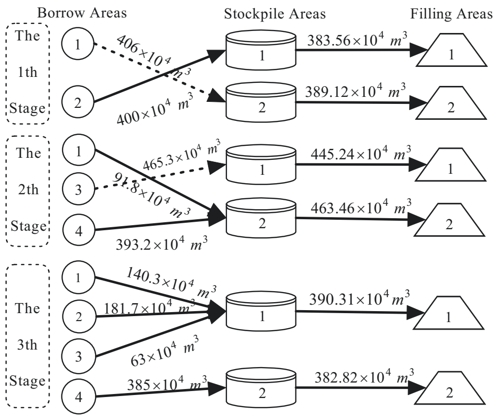

Fig. 49.2 Decision Diagram of transportation allocation in Pubugou Hydropower Project

of the optimistic-pessimistic index (i.e., η), a sensitivity analysis was conducted against this parameter. The decision makers can fine tune this parameter to obtain different solutions under different levels. The solutions reflect different optimistic-pessimistic attitudes for uncertainty (see Table 49.3).

Table 49.3 Sensitivity analysis on the optimistic-pessimistic index

Objective	Optimistic-pessimistic index					
	$\eta = 0$	$\eta = 0.2$	$\eta = 0.4$	$\eta = 0.6$	$\eta = 0.8$	$\eta = 1.0$
$f_c(10^6)$	581.93	582.17	582.41	582.61	582.86	583.12
$f_w(10^4)$	150.49	151.96	153.43	154.87	156.41	158.01

49.6 Conclusions and Future Research

This paper, based on the background of earth-rock transportation systems in Pubugou Hydropower Project, established a multistage multi-objective optimal control model for solving the transportation allocation decision problem under fuzzy environment. Some parameters are characterized as triangular fuzzy numbers and the fuzzy expected value concept was introduced to deal with the uncertainty. Dynamic programming-based particle swarm optimization algorithm was developed based on the particular nature of the model which can automatically controls the particle-updating in feasible solutions space for the equivalent crisp model. An earth-rock dam construction at the Pubugou Hydropower project was used as a practical application example to verify the proposed approach. The results and analysis are presented to highlight the performance of our optimization method, which was proven to have the characteristics of generality, less calculation, high velocity, high efficiency and high precision compared to the standard PSO algorithm.

An important area for future research is considering more restrictions rather than assumptions. For example, by balancing the allocation of earth-rock work from borrow areas, decision-makers usually add a series of restrictions, which would be beneficial in maintaining the stability of the supply chain. Therefore, more research needs to be done and evidence gathered to find solutions to the above problem.

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Part IV
Manufacturing

Chapter 50
The Improvement of *Z*-score Model Based on Listed Company of "Non-Metallic Mineral Products" Industry in China

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Abstract At present, there are many research about *Z*-score model that mainly aimed at the financial warning of listed companies at home and abroad, but the research rarely involve the different categories of listed companies. This paper, using the actual data of listed companies in "non-metallic mineral products" industry and five financial indexes of *Z*-score, establish *Z*-score model with the needed indicators and determine the warning threshold. The coefficient of *Z*-score model is corrected through multiple linear regression model. The model is applicable to "non-metallic mineral products" industry in China. Evidence shows that the model has higher accuracy than the original model for listed company of "non-metallic mineral products" industry in China, and it provides a safe and reliable financial warning standard for "non-metallic mineral products" industry.

Keywords *Z*-score model · Financial early-warning · Listed companies · Non-metallic mineral products industry · Multiple linear regression model

50.1 Introduction

In today's situation, the inside and outside environment that the enterprises are facing to changes at every moment, and the financial crisis of risk and probability is bigger and bigger. In the high risk environment, it will be fatal that if the enterprise only pay close attention to its profitability and ignore its debt paying ability. Although the enterprise's financial crisis is usually a long-term accumulated and ever-developing process, its formation generally can be divided into financial crisis stage of latency, development, worsen and end, however, once it develops rapidly, the enterprise may be into complete financial crisis stage immediately, resulting in

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serious consequences, and even make the enterprise bankrupt. Therefore, the enterprise should build a complete set of financial early-warning institution to make them will be able to detect the presence of risk timely under the circumstance that financial risk appears clue, thus, the enterprise will guard against financial risk through perfecting the management and supervisor mode of the enterprise, and it plays an important role for the enterprise's survival and sustained and stable development.

The prediction of enterprise financial distress began in the 1930s, after more than half a century of development, the enterprise financial early-warning research is mature day after day, and it also has become the focus of domestic and overseas scholars' attention. The enterprise financial early-warning research methods include the trend analysis, discriminant analysis, AIT (artificial intelligence technology), the traditional methods improvement.

(1) Trend analysis method

Trend analysis method began in the 1930s, Fitzpatrick researched financial early-warning using trend analysis method in 1931 [1]. In his research, he used the group of ST and *ST company data to analyze, the result has shown that the financial ratios between ST and *ST company is different significantly, and among them, the retained profits/stockholder's equity and stockholder's equity/liabilities have the highest predictive ability in the enterprise's financial position classification process. But due to some restrictions, trend analysis method is not further researched in the financial forecast areas.

(2) Discriminant analysis method

In the early 1960s to the end of the twentieth century, domestic and overseas scholars use statistics to improve and research the financial early-warning models, the linear discriminant technology is divided into the univariate analysis and the multivariate discriminate analysis.

• Univariate analysis

The most influence of early unibariate analysis was Beaver's research in 1966 [2], the result has shown that the ratio of flows and total liabilities can make the best decision of the company's financial situation, next is asset-liability ratio, and the more close to business failure date, the lower misjudgment rate, the stronger foresight.

• Multivariate discriminate analysis

In 1968, an American scholar, professor Altman combined with the American enterprises actual, he first put forward the enterprise multivariate financial early-warning model, Z-score model, and put multivariate discriminant analysis into the financial risk forecast areas, finally it has obtained the good warning effect [3]. Then, Altman improved Z-score model in 1977 and had developed ZETA model, it made multivariate discriminant analysis in the financial forecast areas to be widely applied, but there were still some limitations [4]. In order to overcome the limitations of Z-score model, Martin [5] lead logistic regression into financial risk research areas. He applied logistic regression model in the bank bankruptcy prediction, the result was that JROA, cost/business income, commercial loan/total loans, bad debt/net operating profit, and total assets/risk, had strong prediction ability. But due to financial ratios has strong correlation, so logistic regression model can't avoid multicollinearity problem.

(3) AIT (artificial intelligence technology) method

At the end of the twentieth century to the beginning of the 21st century, with the sociometric rapid developing and computing technological constantly improving, financial early-warning model not only be restricted to statistics, this period of study into the AIT method, these methods including artificial neural network, case-based reasoning, survival analysis model, etc. Odom and Sharda [6] first put neural network model into financial early-warning research areas, using five financial indexes that Altman proposed, the result has shown, the accuracy rate that neural network model forecast test sample reach 79.5%, so it has more significant accuracy. Bryant [7] researched how to use case-based reasoning technology to forecast the enterprise financial early-warning, but after this, the research about case-based reasoning technology is seldom studied. Lane [8] first put survival analysis model into bank bankruptcy prediction research field, research showed that, the current ratio, financial leverage ratio, operating cash flow and other index of correlation have significant effect to enterprise's survival time, but there are very few domestic scholars to research this model at present.

(4) Traditional methods improvement

Since the 21st century, more and more researches and scholars devote themselves to improve the accuracy of financial early-warning forecast. Due to the *Z*-score model does not apply to the realities of enterprise in China, so if using this model directly, warning misjudgment rate is higher. Therefore, Chinese scholars improved this model in succession, Zhou [9] put forward F scoring model, and they increase the investigation of cash flow changes on the basis of *Z*-score model, then they think that cash flow indicator is the essential factor to judge the enterprise's finance through changing index and expanding the number of samples to correct *Z*-score model, so they put forward the new financial early-warning model that is more in line with the company's actual operation. Chen [10] researched univariate analysis and type linear decision analysis. Zhang [11] built a judge model through the sample selected financial ratios. Wu et al [12] applied Fisher linear decision analysis, multiple linear regression analysis and Logistic regression analysis to build financial risk forecast model respectively. Yang B introduced neural network analysis method to forecast and judge the enterprise financial risk. Xiang [13] applied *Z*-score model to analysis two listed companies in Shanghai and Shenzhen, in China, and point out that *Z*-score model has strong guiding to the financial early-warning of some industries and enterprises. Min et al [14] combined with genetic algorithm and SVM (support vector machine) for bankruptcy prediction to improve SVM performance in the feature subset selection and parameter optimization. Alfaro et al [15] applied integrated learning algorithm-Adaboost to the company failure prediction, and they also taken into account the effect of the quantitative index and qualitative index. Cho et al [16] combined multivariate discriminant analysis, logistic regression, decision-making tree and neural network to optimize the binary classification problem of the financial early-warning to analyze the enterprise financial early-warning. De Andrés et al [17] combined the fuzzy c-means clustering and multivariate adaptive regression to research financial early-warning, and they found this model is better than discriminant analysis and feed forward neural network.

The above model each has its strong point, from the different emphasis to judge the enterprise financial situation. But even the domestic scholars also have some problem to research our country's listed company financial early-warning model: *Z*-score model is based on the American listed companies as samples, selecting the index and ratio, so it may not be appropriate for listed company financial situation in China; in the same country, different time, different industry and different district, the applicability of the model has very big limitation, the domestic scholars consider less of the homogeneity of sample when selecting, and the sample selection often only for domestic listed companies, not considering industry-classified problem.

So in recent years, researchers pay more and more attention to domestic various industry listed companies' financial early-warning model, *Z*-score model. This paper is aimed at building *Z*-score financial early-warning model that is adequate for various industry listed companies in "non-metallic mineral products" in China, using the actual data of listed companies in "non-metallic mineral products" industry and five financial indexes of *Z*-score, establish *Z*-score model with the needed indicators and determine the warning threshold.

50.2 Research Design

50.2.1 Basic Concept

The financial crisis is also called financial distress, it means that the enterprise face loss or manage badly.

In our country related system, the method that identify whether is the enterprise financial crisis has two kinds: one kind of method is from the legal point of view, according to law that definite the enterprise bankruptcy to judge whether the enterprise in the financial crisis; another method is to be identified as ST or *ST company by Stock Exchange.

In the April 22, 1998, Shanghai and Shenzhen Stock Exchange announced that, according to the rules of floatation of shares which implemented in 1988, they would specially treat listed companies' buying and selling of stocks that their financial situation or other situation appear unusual. Due to "Special treatment" is ST, so these stocks abbreviate ST shares. The ST shares mean domestic listed companies are consecutive two years of losses, and *ST shares mean domestic listed companies are consecutive three years of losses.

Because our country related laws are improved uninterruptedly, bankruptcy system is still imperfect, and the exit mechanism of listed company is also not perfect. Therefore we can't make bankruptcy as a standard to judge whether a company in the financial crisis when we research, so this paper selects ST or *ST company that identified by Shanghai and Shenzhen Stock Exchange to analyze.

The early-warning means to warn existent danger or adversity, in order to take corresponding measures to prevent the potential crisis. The financial early-warning means to identify the enterprise financial crisis, and understand the enterprise's financial activity potential risks, so that managers can formulate strategies. Specifically: based on enterprise all kinds of financial statement data and management information to determine investigation index and investigation variable, through analyzing and judging the enterprise state of operation and the ability of financial indicators to find that enterprise whether there is the possibility of financial crisis in the business process.

50.2.2 Z-score Model Refinement

Z-score model is suggested by American scholar, professor Altman in 1968, he first applied multiple linear regression method into the field of enterprise financial early-warning to build enterprise multivariate financial early-warning model, and this model is a model prototype that researched by most scholars.

Professor Altman selected thirty three bankruptcy manufacturing enterprise and thirty three non-bankruptcy manufacturing enterprise in American companies in 1946-1965. In consideration of effect brought from different enterprise scale, Altman got rid of small companies (total assets below 1 million) and the large scale of the company when he screened the research sample. The following reasons: small company financial statement is not complete, and a lot of data is not open to the public, so it's difficult to conduct a comprehensive data analysis; while the large scale of the companies' bankruptcy probability is small, it means that it's not easy to appear financial crisis, so its reference value is low when it's as a sample.

Professor Altman selected twenty-two financial ratios as candidate variables that can explain financial problem from mobility, profitability, financial leverage, debt paying ability, and development ability five aspects, he selected the following five minimum ratio of found error rate as variable through financial knowledge of professional analysis and judgment:

(1) X_1: operating funds/total assets

Operating funds = Current assets – Current liabilities, in judging enterprise financial early-warning, this ratio balances an enterprise's liquidity of assets. The more operating funds means the more operating cash in the enterprise daily operation, and the more strong repayment of debt ability. If the enterprise in the continuous state of loss, the operating funds will continue to reduce, so this ratio is often regarded as one of assessment latitude to judge that enterprise is in the financial crisis.

(2) X_2: retained earnings/total assets

Retained earnings is extracted from enterprise profit over the years or the accumulated in the enterprise internal, including surplus public accumulation and undistributed profit. This ratio reflects the enterprise's accumulative total profitability. Due to the new enterprise time to create and accumulate profit is short, and this ra-

tio must be small, so the possibility of financial crisis occurring is bigger.
(3) X_3: earnings before interest and tax/total assets

Earnings before interest = Total profit + Interest expense, this ratio reflects enterprise's actual profitability without regard to the influence of revenue and financial leverage. Because the enterprise's profitability is the most important influence factor to measure financial position, so this ratio has important significance.
(4) X_4: market price of stock value/aggregate liability

Stock market value means the stock price agreed by trade both parties in the process of stock, and the stock price usually refers to the market value. Market price of stock value means the summation of enterprise all common stock and preferred stock, it reflects the enterprise market value. This ratio balances the ratio relationship between enterprise market value and debt, the more enterprise market value is, the stronger debt paying ability is, and the smaller possibility of financial crisis is.
(5) X_5: sales revenue/total assets

This ratio directly reflects the transfer efficiency of the enterprise total assets, the higher ratio is, and the stronger enterprise business capacity is, otherwise, the profitability is lower. In a word, it comprehensively measures of an enterprise operating management and operation ability. Through the above analysis, professor Altman finalize the following early-warning model:

$$Z = 0.012 * X_1 + 0.014 * X_2 + 0.033 * X_3 + 0.006 * X_4 + 0.999 * X_5. \tag{50.1}$$

After the comparison of analysis, the score of Z is higher, and the enterprise financial situation is better, otherwise is worse. The critical zone of Z-score model is shown in Table 50.1.

Table 50.1 The critical zone of Z-score model

The interval of Z	Enterprise financial early-warning condition.
$Z \geq 2.99$	It shows that the enterprise has good financial situation.
$1.81 < Z < 2.99$	It shows "Grey zone", and the enterprise financial situation is unstable.
$Z \leq 1.81$	The enterprise has a severe financial crisis.

But in this paper, We use the actual data of listed companies in "non-metallic mineral products" industry in China and five financial indexes of Z-score abovementioned to establish Z-score model with the needed indicators and determine the warning threshold.

50.3 Empirical Analysis

For listed company of "non-metallic mineral products" industry, in consideration of the problem of data collection, especially in Chinese market, the number of listed company in an industry is limited, and the number of ST of *ST company is fewer. At the same time, in consideration of the requirement of large sample analysis (when $n \geq 30$, it calls large sample), in the following analysis, we will select Shanghai and Shenzhen (A shares and B shares) forty listed companies financial data as learning set, as a result, we get a new independent variable ratio of the model; we select eight company financial data as test set; finally we bring the forty samples of learning set in the new model to check and prove its applicability.

In the learning set, we select thirty-six non-ST companies as the financial situation normal companies and four *ST (or ST) companies as the financial crisis companies. we select six non-ST companies and two *ST (or ST) companies as the test set samples in test set.

First we find the non-ST (or *ST) companies and normal companies of "non-metallic mineral products" industry in 2010, the ST company means domestic listed companies are consecutive two years of losses, and *ST company means domestic listed companies are consecutive three years of losses. But the previous year before appearing financial loss (it also means a last profit year before the company specially treat), this company still keeps profit, but later years the company is loss in successive years, so this year is the transition year of enterprise financial situation. So when selecting the samples, we should consider the following problem:

- The analysis shows that the transition year of Y years non-ST company is $(Y-3)$ years. This paper analyzes the financial unusual companies that are non-ST companies in 2010, so we should analysis the data of 2007. And for *ST company, applying the $(Y-4)$ year financial data to forecast whether the company is *ST in Y year, but when *ST company is loss in $(Y-3)$ year, it's less significant to forecast whether the company is *ST in Y year by lose.
- At the same time, it must be considered that "Z-score model's accuracy rate reaches 95% before one year that the enterprise bankruptcy, while the accuracy rate down to 75% before two years, and the accuracy rate is less than half before three years, only 48%". Combined with the paper's actual research, in the "non-metallic mineral products" listed company learning set, there are three *ST companies and three ST companies, so it's suitable to use the data of $(Y-2)$ year to forecast the enterprise financial situation in Y year, it's close to the right forecast period of Z-score model. This paper uses the 2008 enterprise financial statement to research, and the basic data is from references. Finally after calculation, we gets variable value summary as shown in Table 50.2.

Due to calculate the relation of independent variable and dependent variable, it must to input independent variable and dependent variable into software, then obtain the coefficient of association. But because Z is not a certain numerical value now, so it only uses that whether there is the financial crisis to distinguish. This paper adopts the current academic circles general method in the setting of the Z value, we will set the Z value of ST or *ST companies that exist the financial crisis to 1 and the Z value of non-ST companies to 0, it also means the discrimination function of all sample enterprise divides into two types of 0 and 1.

Table 50.2 The non-metallic mineral products variable value summary in 2008

Number	Stock Name	I	II	III	IV	V
1	SGA	−0.247590	0.120893	0.050404	0.001205	0.411850
2	Jidong Cement	0.081829	0.099570	0.047296	0.001868	0.358702
3	Yuefuhua	−0.042640	0.094990	0.063905	0.002278	0.977042
4	Beijing New Building Materials	−0.144260	0.174247	0.064494	0.000946	0.498600
5	Jiangxi Cement	−0.254250	0.003835	0.030518	0.000815	0.492351
6	Highsun Group	−0.153660	0.226146	0.138138	0.004620	0.668181
7	Tianshan Stock	−0.234020	0.054772	0.056594	0.000702	0.581724
8	Tongli Cement	−0.447430	−0.502600	0.107552	0.001640	0.714041
9	Zhonggang Jitan	0.023763	−0.085590	0.019744	0.000689	0.830619
10	Ruitai Materials Technology	0.111485	0.139926	0.061372	0.001762	0.557267
11	Luyang Stock	0.303664	0.310702	0.146491	0.005914	0.700562
12	Guanfu Jiayong	−0.146410	0.118740	0.009268	0.000939	0.526960
13	Cimic	0.054280	0.075592	0.022922	0.002687	0.516354
14	Jiuding Xincai	0.086260	0.135177	0.027749	0.001827	0.667172
15	Guotong Stock	0.094758	0.182601	0.089239	0.002811	0.584628
16	Punai Stock	0.360684	0.119614	0.104633	0.004098	0.856626
17	Tapai Group	−0.146550	0.106813	0.071649	0.001524	0.585481
18	Oriental Yuhong	0.473366	0.200805	0.081006	0.007672	1.078476
19	Yellow River Cyclone	0.144704	0.193103	0.030645	0.001164	0.323125
20	New Huaguang	0.303300	0.055714	0.014150	0.001355	0.656459
21	Jiangquan Industry	−0.133650	0.028148	0.017579	0.002067	0.500629
22	Xishui Stock	−0.020730	0.061606	0.014608	0.002300	0.256936
23	Guodong Construction	−0.066850	0.088521	0.017319	0.001725	0.339448
24	Pine Building Materials	0.097082	0.117072	0.069451	0.003207	0.420374
25	Horse Race Industry	0.156404	0.200309	0.124077	0.004023	0.540519
26	FangDa Carbon	0.275208	0.144666	0.152652	0.001908	0.585282
27	Shandong Pharmaceutical Glass	0.265511	0.305396	0.083704	0.004589	0.582913
28	Shitou Stock	0.338841	0.124632	0.002627	0.003756	0.411319
29	Fangxing Science and Technology	−0.259140	−0.136400	0.006342	0.001038	0.790606
30	Taixing Cement	−0.095380	0.101549	0.032749	0.001754	0.704142
31	Conch Cement	0.055462	0.209576	0.076891	0.002002	0.569646
32	Jinjing Science and Techonlogy	−0.198480	0.099466	0.031475	0.001038	0.322408
33	Prism Light Industry	−0.012320	−0.776650	0.207647	0.010698	0.620438
34	Fuyao Glass	−0.068380	0.112034	0.034916	0.001285	0.612548
35	Jianfeng Group	−0.131780	0.081839	0.021305	0.001377	0.652238
36	Duolun Stock	0.434292	0.112481	0.003108	0.003278	0.077048
37	Qilianshan Cement	−0.211120	0.119998	0.079272	0.001280	0.547341
38	Luxin Gaoxin	−0.003940	0.053065	0.019140	0.004767	0.521776
39	Huaxin Cement	−0.156620	0.110771	0.054679	0.000830	0.592502
40	Fujian Cement	−0.157410	0.039925	0.001916	0.001050	0.501373
41	Yaohua Pilkington Glass	0.101669	0.160476	0.003240	0.000669	0.405820
42	Bowin Technology	0.103770	0.112836	0.000365	0.008618	0.095416
43	*ST Yuyuan	0.045220	−0.171060	−0.118180	0.002364	1.286385
44	*ST Dashui	−0.220220	−0.683940	−0.241750	0.003542	0.182246
45	ST Tangtao	−0.390430	−0.361480	−0.069060	0.000916	0.370618
46	*ST Qinling	−0.674970	−0.372260	−0.182890	0.000842	0.403152
47	*ST Gaotao	0.101214	0.075031	−0.032620	0.001082	0.420668
48	*ST Dongtan	−0.379270	−1.264140	−0.168640	0.003021	0.247840

Note: I: Operating funds/total assets (X_1); II: Retained earnings/total assets (X_2); III: Earnings before interest and tax/total assets (X_3); IV: Market price of stock value/aggregate liability (X_4); V: Sales revenue/total assets (X_5)

50.3.1 Construct Model

Assume a new model for: $Z = a_1 * X_1 + a_2 * X_2 + a_3 * X_3 + a_4 * X_4 + a_5 * X_5$. Among: a_1, a_2, a_3, a_4, a_5 are the coefficients of unknown model, Z is the discriminant function value.

I establish correlation sequences in the SPSS software and input the Table 50.2 of forty companies' five independent variable and the data of Z variable. we establish the multiple linear regression model by using SPSS software to confirm model coefficients.

We can get the coefficient of X_1, X_2, X_3, X_4, X_5 are: −0.03, −0.277, −0.697, 0.066, 0.143, from this we get the new Z-score model:

$$Z = 0.03 * X_1 - 0.277 * X_2 - 0.697 * X_3 + 0.066 * X_4 + 0.143 * X_5. \tag{50.2}$$

The above equation of the multiple correlation coefficient $R = 0.832$, it indicates that the test of goodness of fit is better, so we preliminary think that this equation is acceptant.

50.3.2 Determine the Threshold

Through the above method established model, we confirm the new Z-score model from theory, but it still need to confirm the value range of Z value further. Then we put the "non-metallic mineral products" listed company of eight test set of sample into model, and we confirm the threshold of Z value, finally we get a new Z value, as shown in Table 50.3.

Table 50.3 The non-metallic mineral products variable value summary in 2008

Number	Name	New Z value
1	SGA	−0.002217
2	Jidong Cement	−0.011583
3	*ST Yuyuan	0.312508
4	Yuefu Hua	0.070293
5	*ST Dashui	0.390853
6	Beijing New Building Materials	−0.017529
7	Jiangxi Cement	0.055754
8	Highsun Group	−0.058460

When we delimit the range of Z value, we apply indexes that are usually used in statistics to experiment, according to the actual, we select arithmetic average and median to compare, and then confirm the best critical point of Z, as shown in Table 50.4.

Table 50.4 The Z critical value of new Z-score model

Average index	Numerical value	The range of Z value	The number of miscarriage of justice	Judgment accuracy
Arithmetic average	0.092452	$Z \geq 0.092$ is financial crisis company, conversely is financial normal company	0	100%
Median	0.026769	$Z \geq 0.027$ is financial crisis company, conversely is financial normal company	2	75%

According to the analysis of Table 50.4, the accuracy of selecting arithmetic average as the range critical value of Z value is higher, so we confirm the critical value of "non-metallic mineral products" listed companies' new Z-score model: $Z \geq 0.092$ is financial crisis company, conversely is financial normal company.

50.3.3 Old and New Model Comparative Analysis

In order to further prove the validity of new Z-score model and the critical value of Z value, and then we bring the forty samples of learning set in the new model to compare the judgmental accuracy of new Z-score model with the old one, as shown in Table 50.5.

We work out from the judgment situation of Table 50.5 that the accuracy of original Z-score model is just 10% to judge whether the enterprise is in the financial crisis, while the accuracy of new Z-score model reaches up to 87.50%, it shows that the financial early-warning guiding is very strong for new model to "non-metallic mineral products" listed companies.

50.4 Conclusion

This paper emphasize analysis the professor Altman's Z-score model, we in-depth discuss the sample source, variable select, characteristic and shortage. Due to the Z-score model is based on the research of U.S. stock market, so its financial early-warning guiding is not strong for our country listed companies, as a result, we select the "non-metallic mineral products" listed companies to research. We conclude the new Z-score model and confirm the critical value of Z value, and we explain the financial accuracy of the new model through the test. In the future, we can apply the financial specialized knowledge and confirm the financial early-warning index and variable that is more suitable for our country listed companies. After building the judgment model, it can further research the scientific studies about early-warning model of financial crisis happened one or three years before in the future work.

Table 50.5 The judgmental compare new model with old model

Number	Name	The *Z* value of old model	Judgment situation	The *Z* value of new model	Judgment situation
1	Tianshan Stock	0.411830		0.035636	
2	Tongli Cement	0.362291		0.179895	Error
3	Zhonggang Jitan	0.979006		0.128058	Error
4	Ruitai Materials Technology	0.500944		−0.005075	
5	Luyang Stock	0.489873		−0.096708	
6	Guanfu Jiayong	0.673421		0.040459	
7	Cimic	0.580973		0.035472	
8	Jiuding Xincai	0.704480		0.036153	
9	Guotong Stock	0.829531		−0.031835	
10	Punai Stock	0.562042		0.005885	
11	Tapai Group	0.712725		0.008694	
12	Oriental Yuhong	0.526650		0.028443	
13	Yellow River Cyclone	0.518320		−0.032907	
14	New Huaguang	0.670359		0.059569	
15	Jiangquan Industry	0.590699		0.055686	
16	*ST Qinling	0.499611	Correct	0.308546	
17	Xishui Stock	0.865250		0.010269	
18	Guodong Construction	0.587006		0.014069	
19	Pine Building Materials	1.088608		−0.023424	
20	Horse Race Industry	0.328260		−0.069100	
21	FangDa Carbon	0.660697		−0.070906	
22	Shandong Pharmaceutical Glass	0.499511		−0.067242	
23	Shitou Stock	0.257789		0.012547	
24	Fangxing Science and Technology	0.340128		0.154262	Error
25	Taixing Cement	0.425069		0.052714	
26	*ST Gaotao	0.408992	Correct	0.059143	Error
27	Conch Cement	0.548778		−0.031718	
28	Jinjing Science and Techonlogy	0.595074		0.002637	
29	Prism Light Industry	0.592582		0.160200	Error
30	Fuyao Glass	0.416828		0.034361	
31	Jianfeng Group	0.785012		0.059795	
32	*ST Dongtan	0.098209	Correct	0.514727	
33	Duolun Stock	0.704806		−0.035118	
34	Qilianshan Cement	0.575225		−0.003804	
35	Luxin Gaoxin	0.322141		0.047007	
36	Huaxin Cement	0.615713		0.020686	
37	Fujian Cement	0.613843		0.064093	
38	Yaohua Pilkington Glass	0.651861		0.008316	
39	Bowin Technology	0.083879		−0.020410	
40	ST Tangtao	0.593390	Correct	0.213037	

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Chapter 51
Brand Scandals Spillover Model Based on the GMDH

Yufeng Yang and Weiping Yu

Abstract This paper collected the number of web pages to build the GMDH autoregressive model in order to study the 'Shuanghui clenbuterol' scandal spillover to competing brands 'Yurun'. The model can reflect the speed of scandal spillover through the network and how it changed accurately by monitoring the different time periods brands scandal overflow speed, and it can predict scandals network spillovers, compared with actual spillovers. The experimental results showed that GMDH has good value of prediction. The model has a higher value in prediction, can help enterprises to effectively monitor brand scandal overflow, and respond it with targeted.

Keywords Brand scandal · Spillover · Proliferation of network public opinion · GMDH autoregressive

51.1 Introduction

As human society entered the era of new media, the internet technology and the development of digital products is changing with the each passing day. Meanwhile, the online media has been increasingly developed, and the public opinion propagation has stepped into the "public microphone" era. In recent years, once a brand scandal broke, the internet public opinion would become the most important push of the event's development. From 2008 to 2011, the number of hot brand scandal events counted by the public opinion section of the People's Network and the brand scandal section of the World Brand Lab, was up to 80.

After the brand scandal broke, negative information spread quickly on the internet, influenced by the online media. For example, the day the Net Ease reprinted

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the “Shuanghui Clenbuterol” incident; up to 92,576 netizens have made comments to the news. The day the Sina reprinted “Kumho Tires Recycled Rubber” incident, 6657 netizens have made comments, 28 tire brands were mentioned, reached 53% of the example. The report of the brand scandals would influence the whole industry. For example, the first two weeks after the plasticizer incident broke, Taiwan beverage distributors did not sell a box of their goods in the mainland, and sales volume of bottled beverage declined by about 30% compared with it was in the same period last year. Sept 15th, 2008, Sanlu melamine incident broke, China’s dairy industry got a comprehensive loss, and the production growth rate was of -26.56%.

In the existing theoretical research, brand scandal aspect is mainly about brand scandal classification and its impact research, brand scandal external spillover effects and internal spillover effects; monitoring internet public opinion aspect mainly about the model of internet public opinion monitoring and early warning analysis, the theoretical construct of internet monitoring indicator system, hotspot information and its early warning method research, the spreading and evolution of public emergency on internet, the internet public opinion monitoring model, the internet public opinion spreading model of major public crisis. None of the existing research contents and results deeply discussed the spillover effects of Brand scandal, nor did they solve the fast dynamic motoring problem of scandal spillover effects on internet. In this article we intend to use the GMDH algorithm to explore the characteristic of spillover effects on the internet, and to build the brand scandals spillover model by analyzing cases.

This article takes Shuanghui clenbuterol incident as a case for studying. March 15th, 2011, CCTV “3 o 15 special action” program reported that clenbuterol pig got into Shuanghui. the information of the incident quickly spreaded on the internet by the online media, the number of the netizens’ comments to the incident rapidly increased on the major forums. The observation shows the comments are not only to the Shuanghui incident, there are a lot of netizens questioned about the cleanliness of “Yurun and Jinluo”, and called on the relevant departments to give those brands a test. Thus it can be seen, the spillover effects of the brand scandal do exist in the internet public opinion, and information of scandals obviously spreads in the internet public opinion.

After the brand scandal broke in March, Shuanghui Company experienced stock suspension, supermarket products off shelves. The loss was of billions, the Shuanghui Group deeply reflected and made a lot of public relations. Till August, the things were starting to get better. Product sales have been recovered as it was before the scandal broke. Therefore, the impact was big within six months. This article would mainly analyzes the scandal spillover effects to the competing brand “Yurun”, from March to September, 2011.

51.1.1 Research on Brand Scandal Spillover Effect

The scandal of a brand makes other brands which had a certain relationship with it but with a scandal affected, is called brand scandal spillover effects [1]. The spillover effects of the brand scandal to the similar brands and competing brands requires enterprises make timely observation and collection, analysis to the response information of other enterprises in the same industry, and make quick reaction to the important information [1]. The existing research to the influencing factors of brand scandal spillover effects includes: consumer's brand loyalty [1], the strength and direction of the association between the brand [3, 4], the scandal properties [5–8], and brand similarities [7–9] and so on. Researches have two main perspectives: focus on the spillover effects of the other brands in the brand portfolio, that's what we call internal spillovers; focus on the impact on enterprises' external subject, that's what we call external spillovers. Research of brand scandal internal spillover effects: Brand scandal would increase the consumers' uncertainty on the quality of similar products in the market [10], and break the market structure stability [11]. Research in this field is mainly concerned about the influencing factors of spillover effect. It is mainly about three aspects — the relationship between the brands, consumer-brand relationship, brand and category relationship. Ahluwalia [1] pointed out that, if consumers are loyal to a brand, the spillover effects of the scandal would be reduced, but the positive message would easily spill over into other attributes. Lei [3] found that the negative spillover effects in the brand portfolio are influenced by both the brand associate strength and brand associate direction. Zhang et al [4] validated the spillover effects on the parent brand caused by extended brand's negative information. Duan and Yu [12] explored the effects on brand portfolio purchase intention caused by negligence and intentional sub-brand harm crisis. Duan and Yu [13] took the enterprises that implement the main sub-brand portfolio strategies as a study object, study the spillover effects of brand hurt events in the brand portfolio.

Research of brand scandal external spillover effects:

- The Spillover effects to other brands in the brand alliance. Votolato and Unnava found that, comparing with the loss of morality negative events, the negative information about Alliance's ability are more likely to cause the consumers' positive attitude [5]; He, Wang found that in a negligence endorsement situation, brand scandal would produce a negative impact on brand image and endorsement star, and the negative spillover effects of the ability scandals are stronger than the morality scandals [6]. Research in this area is focused on the analysis of spillover strength of the brand scandal in the brand alliance, whether the conclusions are applicable to brand scandal spillover effects to the competing brands has yet to be proven.
- The spillover effects to the category/industry and competing brand. Scandal increased the accessibility and relevance of scandal brand [14], if scandal brand is typical in the category/industry or the event property is a common one in the category/industry, thanks to the association internet transmission effect, the brand negative scandal would spillover, thus the consumer category/industry be-

lief would be affected [7], the consumers' category attitudes would reduce while the perceiving category risk would increase [9].

Dahlen and Lange [9] consider that the brands which are similar to the scandal brand in the category/industry would be adversely affected; the dissimilar brands would be positively affected. Roehm and Tybou [7] pointed out, to activate consumers' association of the similarity between the scandal brand and competitive brand would lead to brand scandal making spillover effects. Wang et al [15] proved consumers' choice similarity makes negative spillover effects occur. The larger clusters of scandal broke, the stronger the central brand is, the greater brand scandal's negative spillover effects of competing brands would be [8]. Zhuang and Yu [16] defined three type of brand negative exposure event — the type of product performance, the type of external morality and the type of morality causes negative product performance. Studies have shown that cognitive needs and the type of event have interaction effects to the spillover effects, put forward the research of brand negative exposure event, products — moral matrix and spillover effects of category and competitive brand [17].

In the research of this article, the definition of brand scandal spillover effects also complies with the definition of Ahluwalia. The existing research methods about brand scandal spillover effects are laboratory experimental method and content analysis, which could not solve the fast dynamic monitoring problem of scandal spillovers in the network environment. The research of brand scandal spillover effect in the article is mainly based on the public opinion propagation in the network environment, this has not yet been paid attention and analyzed by existing research. The quickly advancing internet technology makes the internet public opinion become the most important push of the brand scandal event's development, in the same way, brand scandal spillover effects have a strong spreading power and influence on the internet, the article explored primarily basing on this aspect.

51.1.2 Research on Internet Information Diffusion and Public Opinion Monitoring

Thanks to the online media, the information could be spread rapidly and wildly. To study on the diffusion of information on internet, Wei et al [18] put forward the crisis information diffusion model based on the BASS model, and simulated the diffusion law and the diffusion status differences of the two types of information in different conditions, by the software.

The model of internet public opinion monitoring and early warning analysis in our country, is still in the exploratory stage, the main results includes the internet monitoring index system theory construction [19, 21] and study on hot spot information and early warning method [21, 23], the latter focus on the gathering of information retrieval work, and the information filtering, classification, clustering, summaries of public opinion, it paid less attention to the analysis of the views and attitudes in the information. Sun, Dong proposed the model of major public crisis internet public opinion diffusion monitoring based on the agent, stressed that the basic idea of the analysis should be: to choose a popular website or forum first, then use a text mining tool to capture and analysis data automatically, namely the attitude of the netizens, at last, get the situation of the netizens' public opinion toward the crisis by the evolution behavior of the interaction between the Agent netizens individual and environment [24].

None of the existing research contents and results solved the fast dynamic motoring problem of scandal spillover effects on internet, the article using GMDH autoregressive algorithms studied on Shuanghui clenbuterol scandal spillover effects to the competing brand "Yurun" based on the theory of brand scandal spillover effects, build the brand scandals spillover model.

51.2 GMDH Autoregressive Algorithms

Group Method of Data Handling, short for GMDH, was proposed in 1967 by the A. G. Ivakhnenko academician from Ukrainian Academy of Sciences, is a method based on the evolution of the genetic and evolutionary. It follows the given guidelines to select better ones from a series of candidate models. The method is characterized by data packeting and the use of the inner and outer criteria throughout the entire modeling process. GMDH is based on the selection theory the oldest, most productive tentative rules in the human history. In the process the genetic is continuously restricted by the outside world, and coordinate with the surrounding environment, the species gradually changed. In order to obtain a new generation, in the breeding process in large quantities, the species with best characteristics and needed to be improved further more should be screened out so that they could be used to breeding. After some stage selection, the ideal species could be bred [25]. GMDH algorithm is based on the theory of evolution — "Genetic variation Select evolution". It is starting from a simple sets of initial model (function), combined with certain rules, and generates new intermediate prospective model (genetic variation), and then be screened (selection), and repeat the genetic mutation. This makes the intermediate prospective model more and more complex, until we get the optimal complexity of the model. GMDH modeling process is shown in Fig. 51.1.

GMDH autoregressive model is combined by the GMDH algorithm thoughts and regular autoregressive thought. That means we use only the predictor data, no other indicators data, and then use the historical data of predicted indicators as input variables, screening with outside criteria until we get the optimal model. It divide the observed sample data into training set and the testing set. When modeling with GMDH method, we start from the sets of reference function initial model (functions), do parameter estimation to the training set by using the internal criteria (least squares method) to get the intermediate prospective model (genetic variation), do the intermediate prospective model's selection to the testing set by using the external criteria. Repeating this genetic variation, selection and evolution process, makes

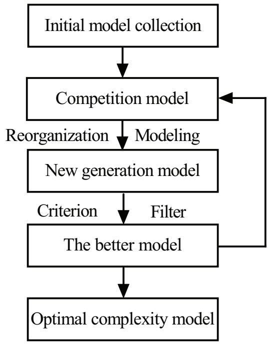

Fig. 51.1 GMDH modeling process

the intermediate prospective model to be more and more complex, until we get the model of optimal complexity.

GMDH algorithm‘s basic steps are consists of the following four stages:

- Divide sample set W into set A (Training set) and set B (Testing SET) $(W = A+B)$.
- Establish the relationship of the general function between the input variable and output variable. Generally use the Kolmogorov-Gabor polynomial reference functions.
- Select an out criterion as an objective function. The GMDH algorithm allows a number of selection criterion to determine the system which has its own complexity, such as minimum error rule.
- Calculate the selection criterion (the outside criterion) values, choose the transfer function which can fit outside criterion to optimal model to keep on building the network, until the model structure cannot be improved at last, we can get the optimal complexity model [26].

51.3 Empirical Analysis

51.3.1 Data Sources

After the brand scandal was reported, the information in the internet would be rapidly spreaded. Public perceived brand scandal information and respond. With the development of internet technology innovation, online media play an increasingly important role in the dissemination of information. The features of Web 2.0 make the network dissemination interactive and its performance can be seen on the internet timely. In this study, network spillover of brands scandal refers to web pages of various forums about the scandal.

Google is widely considered the world’s largest search engine. Using the Google search engine, the number of forum web pages with brand scandal spillover information can be collected. This article based on the internet, especially the major forum, through the Google search engine to collect the number of pages to build the brand scandal network spillover model.

In the top 10 enterprises in the official website (www.chinameat.cn) announced by the China Meat Association, Shuanghui, Yurun rank the top two. This article uses 'Yurun clenbuterol' as key word in the Google search forum category information, when the 'Yurun' keyword 'clenbuterol' exists in the same forum. That means the network scandal spillovers. Artificial selection contains 'Yurun' and 'clenbuterol' affixed to the number of pages for acquisition, and every three days recording the number of pages. Yurun data was collected from March 5th, 2011 to September 30th, 2011. The cumulative number of pages for the last time was up to 421. The number of pages means the influence Shuanghui scandal spill over to Yurun.

51.3.2 Analysis of Prediction

Monitoring brand scandals network spillover dynamically is useful for enterprises to take response measures timely. Through the real-time observation and recording the change of web pages, enterprises can predict the scandal spillover changes and assess the response measures in order to maintain a good image.

We collected data of 70 and used the first 60 as the training set of the model, the last 10 data as predicted results testing set. We used software Knowledge Miner 5.0, and get the GMDH autoregressive model:

$$y(t) = 0.9082y(t-1) + 37.82. \tag{51.1}$$

In the formula, t is the time of observation, the interval is three days, $y(t)$ means the number of pages.

In this model fitting, R^2 is 0.9911, squared error was 0.0101, reached 91% capacity in the description of the data. Fig. 51.2 shows the effect of model fitting is perfect, indicating the validity of the model, predict the 61-70 data trend is consistent with the actual trend exactly. As shown in Table 51.1, the calculation results shows that the maximum relative error of 2.94%, the minimum relative error is 0.43%, the average relative error is 1.54%, predictive testing confirmed the predictive ability of the model, relative errors are less than 3%, the model predictive capacity is satisfactory.

51.3.3 Research on the Scandals Network Spillover Speed

Scandals network spillover speed means the growth in the number of the forum page which contains brand "YURUN" and scandal keyword "Clenbuterol". We used the data to make empirical analysis and determine the spillover model and Equation

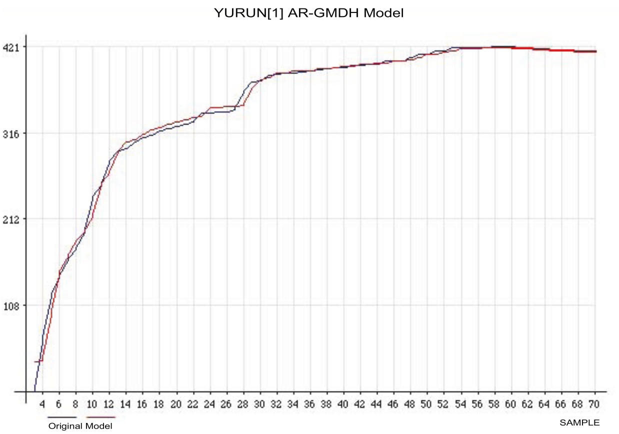

Fig. 51.2 Model fitting

Table 51.1 "Yurun" spillovers data prediction

Prediction time	Prediction value	True value	Relative error (%)
61(2011.9.3)	420.17	422	0.43
62(2011.9.6)	419.41	422	0.61
63(2011.9.9)	418.73	423	1.01
64(2011.9.12)	418.10	423	1.16
65(2011.9.15)	417.54	424	1.52
66(2011.9.18)	417.02	424	1.65
67(2011.9.21)	416.56	424	1.76
68(2011.9.24)	416.13	425	2.09
69(2011.9.27)	415.75	425	2.18
70(2011.9.30)	415.40	428	2.94

(51.1). After iterative derivation of the Equation (51.1), the relationship between the number of pages and the time can be changed into Equation (51.2):

$$y(t) = -451.538159570292 \times 0.9082^{t} + 411.0869565217391. \tag{51.2}$$

Use the derivative $\frac{dy}{dt}$ reprents its speed:

$$\frac{dy}{dt} = -451.538159570292 \times \ln 0.9082. \tag{51.3}$$

Since the formula (51.3) contains a negative sign, so, it should be absolute value $\left|\frac{dy}{dt}\right|$.

Based on the result of the formula (51.3), the spillover speed can be divided into five stages, as Table 51.2 and Fig. 51.3 shows:

Table 51.2 Different overflows and speed range

NO.	RANGE	TIME	SPEED		
			MAX SPEED	MIN SPEED	AVERAGE SPEED
I	1-3	3.5-3.13	39.49	32.57	35.86
II	4-8	3.14-3.28	29.58	20.12	24.39
III	9-15	3.29-4.18	18.28	10.26	13.69
IV	16-39	4.19-6.29	9.31	1.02	3.078
V	40-70	6.30-9-30	0.92	0.05	0.217

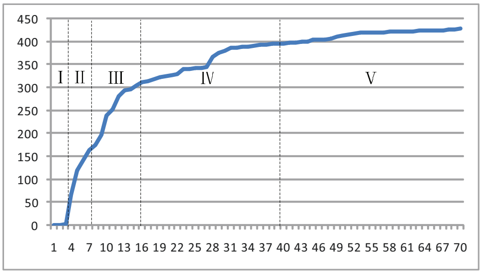

Fig. 51.3 Different overflows speed

After ‘Shuanghui clenbuterol’ event was reported, the characteristics of the growth of the number of pages had different changes in different time periods, what can be seen from Table 51.2. Overall, the process of change was from fast to slow. As Fig. 51.3 shows, in part I period of time, the fastest spillover speed is more than 30, and the average is 35.86. When consumers are most concerned about the developments, the scandal network spillover speed is proved to be fastest. In part II, the spillover speed is still fast, but there is a slowing trend. The speed is between 20 to 30, the average speed is 24.39. In part III period of time, the spillover speed is between 10-20, with an average speed of 13.69, which become slower. In part IV period, he spillover speed is between 1-10, the average speed is 3.078, and the speed is very slow. In part V period of time, the spillover speed turned to be less than 1, the average speed is 0.217. For competitive enterprises, concerning about the development of the scandal event, and changes in the intensity of network spillover, is conducive to enterprises to know the different scandals network spillover stages and take appropriate response measures at different stages.

51.4 Conclusion and Discussion

We collected the number of web pages to build the GMDH autoregressive model in order to study the ‘Shuanghui clenbuterol’ scandal spillover to competing brands ‘Yurun’. We confirmed that the model can reflect the speed of scandal spillover through the network and how it changed accurately by monitoring the different time periods brands scandal overflow speed, and it can predict scandals network spillovers, compared with actual spillovers. The experimental results showed that GMDH has good value of prediction.

This article enriched the research on brand scandal spillover, particularly, in the rapidly developing Internet technology era. We combined the brand scandal spillover effect and the feature of Internet information dissemination to explore brand scandal spillover on network. Through collecting web data and using GMDH algorithm theory, we built brand scandals network spillover model. Our study also confirmed the application of GMDH in data prediction.

The model can help companies monitor information dissemination of brand scandal spillover on the internet effectively, and then response effectively. We build brands scandal network overflow model can help the enterprise monitoring brand scandal spillover effects on the internet through monitoring the scandals network spillover in the different time. Research on the speed of spillover can enable enterprises to take effective measures to prevent the scandal spillovers increasing. It can also warn the competitive brand or industry timely, and protect the image of the enterprise and industry.

Future research could be directed further from the following aspects, only take into account the spillover effects of the scandal of a certain type in a certain industry, no spillovers comparison of different industries and different types of scandals. Secondly, enterprises affected by the spillover effect in the scandal event would take the initiative to response and had a certain influence on the spillover effects. At the same time, comments on the Internet about brand scandal may be full of emotional, which can be reflected in the different of positive emotion and negative emotion. We will research on scandals of different industries, different types and competitive enterprises in the scandal, in response to the impact of the spillover effect, brand scandal in the network overflow consumer's emotional tendencies and so on.

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Chapter 52
GDP Growth Sources of Finance in Pakistan

Asif Kamran, Nadeem A. Syed, Khurram Amin and Syed Nayyer Ali

Abstract All the serious challenges Pakistan's GDP is facing today like very wide budget and trade deficits, galloping inflation, increase in the level of poverty, power outages, water shortages, closure of industries, food insecurity, etc, has diverted our attention from realizing the very serious challenge that we have overcome. Since the 1950s we had a system in this country where the Ministry of Finance and all the economic ministries were headed by World Bank and IMF officials of Pakistan origin. People feel vindicated to see representatives of the people occupying ministries of finance and economic affairs. Monopolies and cartels have played a major role in restricting output and escalating prices in Pakistan. Most of the members of cartels are ministers and other influential. The Government has to devise both a short term as well a long term policy to deal with the situation. In the short run the Government should scrutinize the imports of the country and temporarily halt the import of nonessential consumer goods, luxuries, etc. The research data has been collected which consists of a survey of 42 respondents, among whom the questionnaires have been distributed. The data is presented in tabulated and graphical form. Through this research a vast segment of respondents was analyzed, while dividing them into several age groups. The questionnaire has enabled the researcher to re-

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main objective, detached, value-free and non-influential on the study. The results have been analyzed through several tools to be able to give recommendations and draw conclusions.

Keywords Gross domestic product (GDP) · Uncertain variable · Gross domestic income (GDI) · System of national accounts (SNA)

52.1 Introduction to GDP

The gross domestic product (GDP) or gross domestic income (GDI) is one of the measures of national income and output for a given country's economy. GDP is defined as the total market value of all final goods and services produced within the country in a given period of time (usually a calendar year). It is also considered the sum of a value added at every stage of production (the intermediate stages) of all final goods and services produced within a country in a given period of time, and it is given a money value.

The most common approach to measuring and understanding GDP is the expenditure method:

$$\begin{aligned} \text{GDP} = &\ \text{consumption} + \text{gross investment} + \text{government spending} \\ &+ (\text{exports} - \text{imports}), \end{aligned} \tag{52.1}$$

$$\text{GDP} = C + I + G + (X - M). \tag{52.2}$$

"Gross" means depreciation of capital stock is not subtracted. If net investment (which is gross investment minus depreciation) is substituted for gross investment in the equation above, then the formula for net domestic product is obtained. As per Tandon Consumption and investment in this equation are expenditure on final goods and services [2]. The exports-minus-imports part of the equation (often called net exports) adjusts this by subtracting the part of this expenditure not produced domestically (the imports), and adding back in domestic area (the exports).

Economists (since Keynes) have preferred to split the general consumption term into two parts; private consumption, and public sector (or government) spending. Two advantages of dividing total consumption this way in theoretical macroeconomics are: Private consumption is a central concern of welfare economics. The private investment and trade portions of the economy are ultimately directed (in mainstream economic models) to increases in long-term private consumption.

As per Shahida and Wizarat [3], if separated from endogenous private consumption, government consumption can be treated as exogenous, so that different government spending levels can be considered within a meaningful macroeconomic framework [6].

52.1.1 Measuring GDP

The components of GDP: Each of the variables C, I, G and XM (where GDP= $C+I+G+(X-M)$ as above).

C is private consumption in the economy. This includes most personal expenditures of households such as food, rent, and medical expenses and so on but does not include new housing.

(Note: * GDP is sometimes also referred to as Y in reference to a GDP graph).

C is private consumption in the economy. This includes most personal expenditures of households such as food, rent, and medical expenses and so on but does not include new housing.

As per Wizarat and Shahida they defined as investments by business or households in capital. Examples of investment by a business include construction of a new mine, purchase of software, or purchase of machinery and equipment for a factory [5]. Spending by households (not government) on new houses is also included in Investment. In contrast to its colloquial meaning, 'Investment' in GDP does not mean purchases of financial products. Buying financial products is classed as 'saving', as opposed to investment. The distinction is (in theory) clear: if money is converted into goods or services, it is investment; but, if you buy a bond or a share of stock, this transfer payment is excluded from the GDP sum. That is because the stocks and bonds affect the financial capital which in turn affects the production and sales which in turn affects the investments. So stocks and bonds indirectly affect the GDP. Although such purchases would be called investments in normal speech, from the total-economy point of view, this is simply swapping of deeds, and not part of real production or the GDP formula.

G is the sum of government expenditures on final goods and services. It includes salaries of public servants, purchase of weapons for the military, and any investment expenditure by a government. It does not include any transfer payments, such as social security or unemployment benefits.

X is gross exports. GDP captures the amount a country produces, including goods and services produced for other nations' consumption, therefore exports are added.

M is gross imports. Imports are subtracted since imported goods will be included in the terms G, I, or C, and must be deducted to avoid counting foreign supply as domestic.

Examples of GDP component variables

Examples of C, I, G, and NX: If you spend money to renovate your hotel so that occupancy rates increase, that is private investment, but if you buy shares in a consortium to do the same thing it is saving. The former is included when measuring GDP (in I), the latter is not. However, when the consortium conducted its own expenditure on renovation, that expenditure would be included in GDP.

For example, if a hotel is a private home then renovation spending would be measured as Consumption, but if a government agency is converting the hotel into an office for civil servants the renovation spending would be measured as part of public sector spending (G).

If the renovation involves the purchase of a chandelier from abroad, that spending would also be counted as an increase in imports, so that NX would fall and the total GDP is affected by the purchase. (This highlights the fact that GDP is intended to measure domestic production rather than total consumption or spending. Spending is really a convenient means of estimating production.)

If a domestic producer is paid to make the chandelier for a foreign hotel, the situation would be reversed, and the payment would be counted in NX (positively, as and export). Again, GDP is attempting to measure production through the means of expenditure; if the chandelier produced had been bought domestically it would have been included in the GDP figures (in *C* or *I*) when purchased by a consumer or a business, but because it was exported it is necessary to ‘correct’ the amount consumed domestically to give the amount produced domestically.

52.1.2 Types of GDP and GDP Growth

World map showing GDP real growth rates for 2007. Current GDP is GDP expressed in the current prices of the period being measured

Nominal GDP growth is GDP growth in nominal prices (unadjusted for price changes).

Real GDP growth is GDP growth adjusted for price changes.

Calculating the real GDP growth allows economists to determine if production increased or decreased, regardless of changes in the purchasing power of the currency.

52.1.3 Measurement

(1) International standards

As per Burney, the international standard for measuring GDP is contained in the book System of National Accounts (1993), which was prepared by representatives of the International Monetary Fund, European Union, Organization for Economic Co-operation and Development, United Nations and World Bank [4]. The publication is normally referred to as SNA93 to distinguish it from the previous edition published in 1968 (called SNA68). SNA93 provides a set of rules and procedures for the measurement of national accounts. The standards are designed to be flexible, to allow for differences in local statistical needs and conditions.

(2) National measurement

Within each country GDP is normally measured by a national government statistical agency, as private sector organizations normally do not have access to the information required (especially information on expenditure and production by governments).

(3) Interest rates

As per Richard, net interest expense is a transfer payment in all sectors except the financial sector. Net interest expenses in the financial sector are seen as production and value added and is added to GDP [10].

52.1.4 GDP Is "The Economy"

As per Wizarat and Shahida, When people refer to "the economy" they are generally referring to GDP. If a newsperson says, "The economy grew by 3.5 percent last year", it means that GDP grew by 3.5 percent during the year (compared with the previous year's GDP). Incidentally, a growing economy characterizes an expansion, which is also known as a recovery [5]. A contracting economy characterizes a recession. For now, it's important to know that a society benefits greatly from a stable, growing economy.

A growing economy generates increasing amounts of jobs, incomes, and goods and services for its citizens. All of these are good things, of course. In a contracting economy, jobs and incomes are lost and the amount of goods and services produced shrinks. This puts people out of work, and means that there are fewer goods and services to go around. A stagnant economy-one that is neither growing nor contracting-isn't much better than one that's contracting. As the population grows, people need more jobs and more goods and services, and a stagnant economy doesn't produce them.

If you look at the formula for GDP, you'll see that if any one component increases, then the total GDP increases (assuming that the other components remain unchanged). For example:

- If consumer spending grows-if people buy more clothing and cars and homes-then the economy grows.
- If business investment grows-if companies invest in new buildings and equipment and buy more raw materials-then the economy grows.
- If government spending grows-if money is poured into the space program, defense, roads, and police forces-then the economy grows.

By the same token, if any one component of GDP decreases, then total GDP decreases unless another component of the GDP increases enough to make up for the loss.

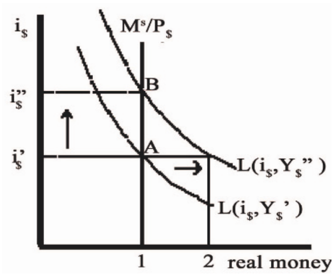
52.1.5 Effect of a Real GDP Increase (i.e., Economic Growth) on Interest Rates

Lastly consider the effects of an increase in real GDP. Such an increase represents economic growth. Thus, the study of the effects of a real GDP increase is the same as asking how economic growth will affect interest rates.

GDP may increase for a variety of reasons and are discussed in subsequent chapters. For now we will imagine that GDP increases for some unspecified reason and consider the consequences of such a change in the money market.

Suppose the money market is originally in equilibrium at point A in the adjoining diagram with real money supply $M^S/P_\$$ and interest rate \$'. Suppose real GDP $(Y_\$)$ increases ceteris paribus. Again, the ceteris paribus assumption means that we assume all other exogenous variables in the model remain fixed at their original levels. In this exercise it means that the money supply (M^S) and the price level $(P_\$)$ remain fixed. An increase in GDP will raise the demand for money because people will need more money to make the transactions necessary to purchase the new GDP. In other words, real money demand rises due to the transactions demand effect. This increase is reflected in the rightward shift of the real money demand function from $L(i_\$, Y_\$')$ to $L(i_\$, Y_\$'')$ (see Fig. 52.1).

Fig. 52.1 Real money



At the original interest rate, \$', real money demand has increased to 2 along the horizontal axis while real money supply remains at 1. This means that real money demand exceeds real money supply and the current interest rate is lower than the equilibrium rate. Adjustment to the higher interest rate will follow the "interest rate too low" equilibrium story.

The final equilibrium will occur at point B on the diagram. As the interest rate rises from \$' to \$", real money demand will have fallen from 2 to 1. Thus, an increase in real GDP (i.e., economic growth) will cause an increase in average interest rates in an economy. In contrast, a decrease in real GDP (a recession) will cause a decrease in average interest rates in an economy.

52.1.6 Pakistan's GDP Growth

Pakistan is a nation with a diverse economy that includes textiles, chemicals, food processing, agriculture and other industries. It is the 25th largest economy in the world. The economy has suffered in the past from decades of internal political disputes, a fast growing population, mixed levels of foreign investment, and a costly, ongoing confrontation with neighboring India. However, IMF-approved government policies, bolstered by foreign investment and renewed access to global markets, have generated solid macroeconomic recovery the last decade. Substantial macroeconomic reforms since 2000, most notably at privatizing the banking sector have helped the economy. Pakistan has seen a growing middle class population since then and poverty levels have decreased by 10% since 2001. GDP growth, spurred by gains in the industrial and service sectors, remained in the 6-8% range in 2004-06. In 2005, the World Bank named Pakistan the top reformer in its region and in the top 10 reformers globally (see Table 52.1).

Table 52.1 GDP — real growth rate: 6.3% (2007 EST)

Year	GDP — real growth rate	Rank	Percent change	Date of information
2003	4.50%	48		FY01/02 est.
2004	5.50%	45	22.22%	2003 est.
2005	6.10%	47	10.91%	2004 est.
2006	6.60%	48	8.20%	2005 est.
2007	6.60%	59	0.00%	2006 est.
2008	6.30%	62	−4.55%	2007 est.

52.1.7 Statement of Problem

GDP is a significant factor in identifying the growth of a country; there are many efforts by the government to increase the growth rate of the economy thus increasing the GDP. Pakistan as a growing nation has shown potential in the latter years with a sufficient growth in GPD but unfortunately it has now decreased below expectations, thus my topic "Sources of financing in the growth of GDP".

The research looks in to the related matters and analyzes the following:

- economy overview,
- efforts by the government,
- international funding,
- indicators and their effect on GDP,
- future prospective.

52.2 Significance of the Study

This effort is basically a research report and it is being conducted to find the potentiality of sources such as production, taxation extra to help increase the GDP of Pakistan. This research will provide an outline to Economists, Finance students and the relative concerns. This project that is basically an effort to,

- The understand sector in brief,
- The identify prospects of growth,
- Provide financial estimates.

52.2.1 Scope of the Study & Delimitation

Due to political instability, the policies of Pakistan keep changing as the government changes and because of it might be affecting on the economy.

Most importantly, another thing that needs to be considered here is conducting such study is my first experience and I have no earlier experience regarding such survey.

In light of these reasons, the report may not be valid for a long period of time. So the time frame of this report is kept up to one year.

52.2.2 Basic Assumption

The research is conducted through utmost effort to find the possible financial sources that will contribute towards the growth of the economy and in turns the GDP. As the mode of investment, government policies and the international economic environments constantly and highly changing, So there are some assumptions that are kept in order to project a better picture of the business.

Some of them are:

- The current market trend continue in the market.
- The government will remain the same.
- The government will not change its basic laws concerning the mega projects and the working of different areas such construction of roads, bridges and parks.
- The investment pattern will remain in the favor this sector.
- Government would not change any of its regulatory laws.

In the light of the above basic assumptions the study will be carried out and the change of any of the above assumptions might influence the study and will reduce the level of accuracy of the study.

52.3 Research Design & Methods

The research is designed to check the financial sources affecting the growth of the economy. It is also to cover all the important aspects related to the matter. Furthermore, further data will be gathered from various sources in order to achieve the objective.

While designing this research study it was considered that it should serve the purpose of practical applicability and should be in line with the objective of the study. The data will be gathered through secondary data as well as primary data. Secondary data will be gathered from the internet or different published articles from concerned magazines. Arranging unstructured interviews with the concerned people and hearing their views about the opportunity will be the method used for gathering of primary data. The type of study is explorative since the study will cover the potentiality of the sources in the current era.

52.3.1 Respondents of the Study

Respondents of the study are:

- Economists,
- Financial advisors,
- Concerned teachers.

52.3.2 Research Instrument

The main instrument used in this research is unstructured interviews through which a wide variety of information can be retrieved from the respondents. Primary data is gathered in the form of interviews & questionnaires. Interviews will be conducted by personally meeting the concerned people and asking them about the related issues and concerns of the objective being studied. Interviews will be preferred but due to the shortage of time and availability of the respondents' questionnaire will be provided. Secondary Data Sources include research reports of previous researchers, newspapers, magazines, and Internet.

52.3.3 Treatment of Data

The data collected through primary research will be calculated on the qualitative basis as well as on numerical basis that is quantitative basis. The relevant statistical data that will be converted into the form of charts and the interpretations of that secondary data will be done.

52.3.4 Presentation Analysis

The data gathered will be analyzed on qualitative as well as on quantitative basis and the presentation of the findings will be in the form of charts, tables and explanations.
(1) Structural issues

As per ABN-AMRO Bank report [1] stated that the ultimate causes of poor exports are grounded in long-term and deep structural issues relating to the lack of diversification of export industries, poor compliance with quality standards, and concentration of exports in a small number of markets, it added.

Tarin conceded that the industrial base in Pakistan is “very low, highly lopsided and mostly dependent on textiles”. The industrial base is low because of basic structural weaknesses developed over the years. It has not developed like other developing countries. The manufacturing sector contributes 25 to 35 per cent to the GDP in developing countries but we have not developed like others. We are now making efforts to follow that route and broad-base our industrial sector, said the minister.
(2) Performance

Excessive protectionism in the past has been the root cause for a lackluster performance of the industrial sector in general. “My biggest concern is that we had strength in textiles, but we are in danger of losing our edge because of over-protection to the textile industry and if we do not prepare for the international marketing competition.” ABN-AMRO Bank [1] report said the share of manufacturing in GDP was 12 per cent when General Musharraf took over and has increased to 19 per cent in 2006-07. He said the industrial sector has played a key role in developing countries but this area has not developed in Pakistan like other developing countries. The manufacturing sector contributes 25 to 35 per cent to the GDP in developing countries but we have not developed like others. “We are now making efforts to follow that route and broad-base our industrial sector.”

To change this structural base is a long-term job and basic challenges we are going to face are lack of skills, modernization of technology and provision of raw material. So, we are now focusing on skill development, including managerial skills and labor skills, particularly in the engineering sector. Tarin said our engineering sector, particularly iron and steel, has been hostage to protectionism. The Pakistan Steel Mills that should have been a source of strength for iron and steel has, in fact, been hampering growth. So we have reduced import duties to make raw material available at lower costs.
(3) Initiatives

Secondly, Pakistan has been lacking marketing initiatives. Hence, the Engineering Development Board is being revitalized while efforts are being made to urbanize the SME sector. The minister did not agree that utility costs were extremely high in Pakistan. “That is a myth.” He said the textile ministry has recently got a study done by an international firm WERNER’s which after comparing a number of countries has come up with the conclusion that utility costs are not high. However, efficient use is the key and this is an area where we could improve things by developing managerial and labor skills and technology up gradation.

52.4 Analysis of the Questionnaire

(1) How can you define GDP?

GDP stand for Growth Domestic Product and is one of the measures of a country's income and output from a country's economy, it's a total value of all the final goods and services produced in a particular economy (Statistical supplement (2008-09)) [7]. Firstly it is equal to the total expenditures for all the final goods and services produced within a country now secondly it is equal to the sum of the value added of every stage of production by all the industries within the country third it is equal to the sum of income generated by production in the country.

(2) GDP is widely used by economists to gauge the health of an Economy; do you think it is a correct measure?

I have included this question in order to understand the preferences of the economist in the measure of the country's total production

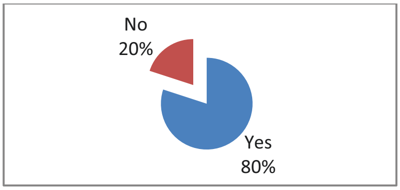


Fig. 52.2 Whether GDP is widely used by economists to gauge the health of an Economy

Through research I found that most of the economist measure GDP as a correct measure for calculating country's income, 20% replied NO and 80% says yes (see Fig. 52.2).

(3) In your opinion Pakistan's *G*

I have included this question in order to understand the current knowledge of the respondents about the economic condition of Pakistan.

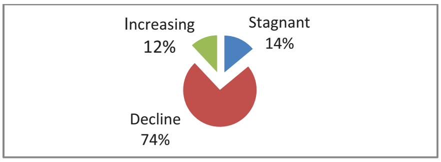


Fig. 52.3 Current knowledge of the respondents about the economic condition of Pakistan

I found out that the people were very current with the economic conditions 12% people says increasing GDP, 14% people says Stagnant and 74% people says GDP Decline (see Fig. 52.3), as the new that Pakistan's economy was in a declining state majorly due to the economic condition of the world.

(4) What steps the government has taken?

Through research I found out that major's reason for this economic decline was due to the world's economic crisis and due to the rich Pakistan's saw major flight of capital and liquidity crunch.

(5) What is your opinion on the steps taken by the government?

I have included this question in order to find out what the respondents thought about the recent activities of the government to establish the economic conditions of Pakistan.

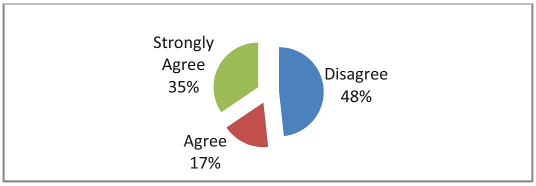


Fig. 52.4 The respondents thought about the recent activities of the government to establish the economic conditions of Pakistan

Through the research I found out the 70% of people Disagreed 25% agreed and 5% strongly agreed.

Through the research I found out the 48% of people Disagreed 17% agreed and 35% strongly agreed (see Fig. 52.4).

(6) In the light of above discussion do you think GDP is a not good predictor of a countries growth?

I included this question to find out that now after acquiring knowledge about GDP and it's current reputation as the measurer of the country's growth so from perspective of the respondent that is it a correct measure or not.

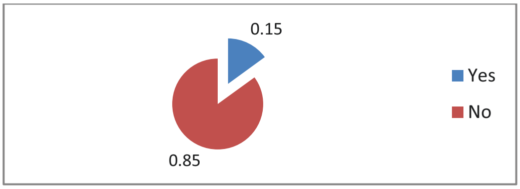


Fig. 52.5 Whether GDP is not a good predictor of a countries growth

In this question we found that 15% people says Yes and 85% people says No (see Fig. 52.5).

(7) In your opinion what factors affect GDP the most?

Through research I found out that the main factor that effected GDP was the current interest rates of the country which directly affected the investments of the country thus affecting the growth.

Secondly I found out that the net export was very low as compare to the net imports which indicated huge flight of capital thus indicating decrease in foreign reserve of the country.

(8) What steps the government has taken to ensure the stability of this particular factor?

Government has taken help from IMF in terms of loan secondly has introduced a strict monetary policy which insures the stability of the interest rate also restrictions on the import of foreign goods.

(9) What is your thought on the government efforts?

I have included this question to find the perception of the respondents about the efforts of the government for the stability of the economy and interns of the growth of the GDP.

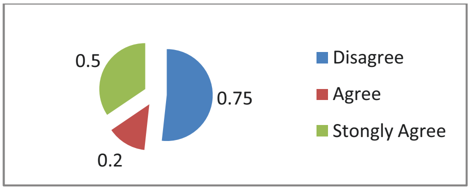


Fig. 52.6 Thought on the government efforts

I have concluded that the steps taken by the government are not satisfactory (see Fig. 52.6).

(10) What else could be done?

I have included this question to know about further steps to be taken and concluded that the government should encourages the exporters by ensuring and restricting illegal trade and government should also ensure the cut down of interest rate as it would directly affect the growth of the industries of the country which will also affect the inflation of the country.

(11) What other factors can you identify?

Through research I found out that other factors include the consumption factors and expenditure factors, consumption in the sense that as the country's income will grow and consumption will also increase thus increasing the GDP. Secondly if we talk about expenditures we will say that if government increases its expenditures and that will end up affecting the GDP.

(12) How the recent recession has affected the country's GDP?

Through research I found out that the recent recession has increased the unemployment rate through which masses have lost their purchasing power. Secondly the interest rate has grown up due to which it has affected the inflation rate.

(13) Due to recession has the factor lost its importance?

I have included this question to know about the perception of the respondents about the factors that have lost the importance which were discussed before.

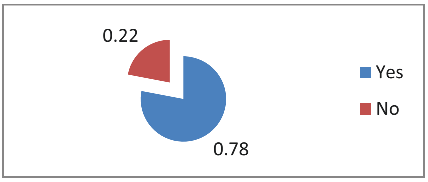


Fig. 52.7 The perception of the respondents about the factors that have lost the importance

Through research I found out that since as these factors were very important in increasing the growth rate of the economy and government was really influenced in the increasing of these factors but due to the world economic crisis and the current crunch in the Pakistani economy, these factors were not able to fully play their role in the economic conditions of the country also because of which governments effort has also not been worthwhile but still government is trying to make the most situation and get back the economy on line (see Fig. 52.7).

52.5 Conclusions

All the serious challenges Pakistan's GDP is facing today like very wide budget and trade deficits, galloping inflation, increase in the level of poverty, power outages, water shortages, closure of industries, food insecurity, etc, has diverted our attention from realizing the very serious challenge that we have overcome. Since the 1950s we had a system in this country where the Ministry of Finance and all the economic ministries were headed by World Bank and IMF officials of Pakistan origin. With increase in the indebtedness of the country the situation got from bad to worse. The worst period was the decade of the 1990s when not only the economic ministries, but even prime ministers came from these institutions. During negotiations between the Government of Pakistan (GOP) and the International Financial Institutions (IFIs) it was difficult to distinguish between the GOP and the IFIs, for both sides comprised of IFI officials. These were very trying times for those of us who value independence and economic sovereignty of the country. As per Wizarat and Shahida, there are several articles questioning the wisdom of a system which even after elections denied the representatives of the people to have anything to do with the ministries that dealt with the wealth and finances of the people [9]. So people feel vindicated to see representatives of the people occupying ministries of finance and economic affairs.

Starting with this positive note let us now try to give some suggestions to the new government on crisis management of the economy and thus the GDP. But before we venture into discussing specific problems and challenges let me present two broad observations. It is quite acceptable for a country to deviate from its normal course during times of emergency and ultimately come back to the designated path. For example, the United States of America states that it is committed to liberalization and globalization. Yet, in the aftermath of a crisis it imposed a 30% tariff on the import of steel. Therefore, crisis management warrants we deviate temporarily from liberalization to fix the distortion, and return to the path when things return to normal. Second, in order to retain our economic sovereignty it will be better not to resort to policy based lending.

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Chapter 53
Game Analysis on the Price-fixing Strategy of Hi-tech Products

Hong Mo and Zhaojun Feng

Abstract Competition in the market characterized by the pricing mechanism has become an important development trend of the market in high-tech products. This paper took two oligarch Hi-Tech enterprises as the study objects, and constructed game model to analyzed the criterion of price-fixing and strategy on the different conditions. On this basis, this paper researched the policy making and improvement for our government to stability the products price in the Hi-Tech products market.

Keywords Hi-tech products · Price · Game theory

53.1 Introduction

Compared to traditional products, high-tech products with a high-tech, high input, high-risk, high-yield and high innovative features, its product market characteristics are perishable, facing uncertainty, frequent replacement and upgrading [1]. As high-tech products faced with the strongly uncertainty market environment, in the fierce market competition, weaker firms are very easy to be out of business or merged by other enterprises. Therefore, for the high-tech enterprises, in order to success in market competition, it is particularly important to determine an appropriate product price according to the characteristics of the market environment. This paper uses the method of game theory to analysis the pricing strategy of two oligarchic enterprises which Provides similar products on the market and explore the important influencing factors of high-tech product pricing. And then this paper discusses how the government adjusts the price of high-tech products through the formulation of

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policies, so as to help the high-tech enterprises to adapt to the development of the market rule.

53.2 Modeling

Since the 1980s, game theory has become an important means of economics and management studies and an indispensable tool in the analysis of economic behavior [2]. This part mainly discusses pricing game analysis of two oligarchic enterprises in two cases. A case is in a free competitive market environment, due to the homogeneity of the products produced by the two high-tech companies, the final product market prices exactly the same, according to the final price of the product, how the two companies to determine their own production in order to achieve their own profit maximization. Another case is the products produced by the two high-tech companies are not completely homogeneous, the final product market prices is differentiate, how the two companies to determine their own price and production in order to achieve their own profit maximization.

53.2.1 Price Competition Model Analysis

This part firstly assumed static game under complete information, there are two enterprises can influence the market price of a high-tech product in the market, respectively, in A and B. The yields were denoted q_1 and q_2 respectively: product price p_1 and p_2, variable cost per unit of product c_1 and c_2, respectively. For ease of calculation, the fixed costs of the two enterprises are 0 [3].

Let the market inverse demand function: $P = a - bq = a - b(q_1 + q_2)$, where a is the output when the price is 0, b is the change in price when the market supply is increased by one unit.

For enterprise A and B: the inverse demand function:

$$\begin{cases} p_1 = a_1 - b_1 q_1 - d q_2, \\ p_2 = a_2 - b_2 q_2 - d q_1, \end{cases}$$

where d is the cross price effects of two enterprises, can be said that the degree of product substitution, at the same product condition, $a_1 = a_2$, $b_1 = b_2 = d$. Then according to the inverse demand function $P = a - bQ = a - b(q_1 + q_2)$ available:

$$\begin{cases} \pi_1 = (a - b(q_1 + q_2))q_1 - c_1, \\ \pi_2 = (a - b(q_1 + q_2))q_2 - c_2, \end{cases}$$

So: $\begin{cases} \frac{\partial \pi_1}{\partial q_1} = a - 2bq_1 - bq_2 - c_1, \\ \frac{\partial \pi_2}{\partial q_2} = a - 2bq_2 - bq_1 - c_2. \end{cases}$ Easy to find: $\begin{cases} q_1 = \frac{a-c_1-bq_2}{2b}, \\ q_2 = \frac{a-c_2-bq_1}{2b}. \end{cases}$

(1) If $c_1 < c_2$ and $a > 2c_2 - c_1$ or $c_1 > c_2$ and $a > 2c_1 - c_2$ or $c_1 = c_2$, there is an uniqueness of the Nash equilibrium point:

$$\begin{cases} q_1^* = \frac{a-2c_1+c_2}{3b}, \\ q_2^* = \frac{a-2c_2+c_1}{3b}. \end{cases}$$

At this point, the two high-tech firms in order to maximize profit, the yield is according to their respective variable cost. Therefore, to want to get a greater advantage in market competition, the firms should gone through technology innovation, refined the connotation, focused to lower their unit costs to achieve the market development initiative.

(2) When $a < 2c_1 - c_2$, $q_1^* = 0$, $q_2^* = \frac{a-c_2}{2b}$

At this point, the yield of the enterprise B to realize profit maximization is $q_2^* = \frac{a-c_2}{2b}$, enterprise A will be squeezed out.

(3) When $a < 2c_2 - c_1$, $q_2^* = 0$, $q_1^* = \frac{a-c_1}{2b}$

At this point, the yield of the enterprise A to realize profit maximization is $q_1^* = \frac{a-c_1}{2b}$, enterprise B will be squeezed out.

Therefore, can be seen from (2) (3), under the complete information static game, in the process of market competition the two high-tech enterprises in order to defeat their opponents in the competition and maximize their profits should dug their own potential to minimize variable costs.

53.2.2 Different Product Price Competition Model Analysis

If the product of two high-tech firms is differentiation of similar products, the replacement rate of two products is recorded as d. Assumed enterprise A takes the lead in pricing: p_1, the yields were denoted q_1 and q_2 respectivelythe prices of the product of enterprise B is p_2, the variable costs per unit of product are c_1 and c_2 respectively, For ease of calculation, assumed the fixed costs of the two enterprises are 0 [4].

As enterprise A takes the lead in pricing, enterprise B in order to pursue the optimal price to maximize profits, the profits can be expressed as follows: $\pi_2 = (a - bp_2 + dp_1)(p_2 - c_2)$.

In order to simplify the calculation, assumed $b = 1$, then $\pi_2 = (a - p_2 + dp_1)(p_2 - c_2)$.

The one-order optimality condition is: $\frac{\partial \pi_2}{\partial p_2} = a + dp_1 - 2p_2 + c_2 = 0$.

The response function is: $p_2 = \frac{a+dp_1+c_2}{2}$.

When enterprise A realized the strategy of enterprise B will do the appropriate response strategy, its profits:

$$\pi_1 = (a - p_1 + dp_2)(p_1 - c_1) = \left(a + \frac{ad}{2} - \frac{dc_2}{2} + \left(\frac{d^2}{2} - 1\right) p_1\right)(p_1 - c_1).$$

The one-order optimality condition is:

$$\frac{\partial \pi_1}{\partial p_1} = a + \frac{ad}{2} + \frac{dc_2}{2} - \left(\frac{d^2}{2} - 1\right) c_1 + \left(d^2 - 2\right) p_1 = 0.$$

The balanced solution is:

$$p_1^* = \frac{a}{2-d} - \frac{1}{2+d} c_1 + \frac{d}{4-d^2} c_2,\; p_2^* = \frac{a}{2-d} + \frac{d}{4+2d} c_1 + \frac{2}{4-d^2} c_2.$$

Therefore, the yields of the two enterprises are:

$$\begin{cases} q_1 = \frac{a}{2-d} + \frac{2+d^2}{4+2d} c_1 + \frac{d}{4-d^2} c_2, \\ q_2 = \frac{a}{2-d} - \frac{3d}{4+2d} c_1 + \frac{d^2-2}{4-d^2} c_2. \end{cases}$$

Because: $p_1 - p_2 = -\frac{1}{2} c_1 - \frac{1}{d+2} c_2 < 0$, that is $p_1 < p_2$:

$$q_1 - q_2 = \frac{d^2 + 3d + 2}{4 + 2d} c_1 + \frac{d^2 - d - 2}{d^2 - 4} c_2.$$

So, when $0 < d < 2$, $q_1 - q_2 > 0$, that is $q_1 > q_2$.

After Game two steps above can be seen, the unit price of the leading pricing enterprise is lower than the price of the following enterprise, and in order to pursue the maximization of profits, the output of the following enterprise will be lower than the leading pricing enterprise, the size of the two corporate profits also depends on the discretion of the respective unit variable cost.

53.3 Analysis on Improvement of High-tech Products Market Price System

With the rapid development of science and technology, competition of high-tech enterprises increasingly fierce, in the state's macroeconomic control policies, the market competition will penetrate through the whole process of high-tech products development and production. In order to further stabilize the product market and continue to enhance China's technological strength and maintain the stability of prices of high-tech products in the fierce market competition, It is necessary to continue to adjust and perfect the national macro policy.

(1) Moderate new system to promote competitive pricing of high-tech product

For some time, the high-tech products market is gradually formed several major corporate monopoly market situation, there are significant technical and trade barriers in the market, is difficult to enter the small and medium enterprises, is not conducive to the healthy development of China's science and technology. Therefore, in the new situation, we must recognize that the general direction of development of science and technology, the government should break the industry monopoly through the constant improvement of the formulation of policies, laws and regulations in certain areas gradually and introduce competition mechanism moderate to improve the scientific and technological content of the high-tech products.

(2) Encourage enterprises to actively carry out technological innovation

For science and technology enterprise, in order to place in the high-tech products on the market, continue to expand their market share by leading the development of the price advantage, consistent excess returns, gain a competitive edge, it should continue to carry out technological innovation, through product innovation, process innovation and management innovation, continue to reduce production costs, improve the technological content of products, timely adjust their development strategy to seize the initiative in the competition in the market competition.

(3) Encourage SMEs to participate in market research and development and cooperation with large enterprises

Under the conditions of market economy, along with the optimization and adjustment of industrial structure in China,, there is a good environment for small and medium-sized enterprises (SMES) to enter the high-tech products market. As long as SMES and private enterprises can increase earnings while they participate in the high-tech market, it would bring driving force to SMES, at the same time help to break the high-tech products industry monopolies in the market, enhance the vitality of the development of the industry. Therefore, the government should encourage SEMS and other high-tech enterprise engaged in high-tech product research and development cooperation through the policy making and adjustment, through the means such as tax incentives, encourage conditional enterprise actively participate in market competition, promoting China's high-tech products market structure adjustment and industrial upgrading, which makes our country's high-tech industry into the stable and orderly development track.

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Chapter 54
Evaluation of Support Systems Based on Demand of Manufacturing Industry Development

Yongjun Tang and Xiaoguo Xiong

Abstract Development of manufacturing industry requires effective and efficient industrial support systems. The paper argues that support systems of manufacturing industry development consist of sub-system of support and sub-systemof control, which each sub-system comprises four basic elements. The paper introduces matching coefficient to represent the matching relation. Matching coefficient refers to the proportion of separate element levels of support system in leading regions with reference value against the industrial added value. The coefficient can be employed to analyze the contribution of the support system to industrial development and forecast the conditions required for the system to meet future demand. In the paper, Guangxi is taken as an example to demonstrate the calculation of matching coefficient.

Keywords Manufacturing industry development · Support system · Matching coefficient · Evaluation

54.1 Introduction

Manufacturing industry development holds overriding position in economic growth, while the support system has direct bearing on its scale, pace, quality and efficiency. This paper firstly defines the concept of the support system of manufacturing industry development and concludes its significance in both theoretical and practical terms. Then we analyze current conditions of China's support system and compare

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with the required standards to find out the shortages. Finally we develop an ideal system to support manufacturing industry development and economic growth.

54.2 Concepts of Support System of Manufacturing Industry

54.2.1 Definition and Features

References focusing on support system and evaluating on how it works to support manufacturing industry development are not yet found. Studies on industrial development support mainly focus on factors affecting industrialization, element input of industrial development and other aspects. For example, Si [1] contended that three factors affect regional industrialization - capital, labor input and technological progress. Ma [2] reasoned that technological innovation and its support to industrial development should be stressed to realize new industrialization. Luo [3] concluded that capital input and technological progress are main factors affecting industrial development in Guizhou Province by establishing econometric models. Gen [4] held that industrial element input in China for the next 10 years will mainly concentrate on labor, energy, environment, capital and technological progress.

By summarizing the study results, manufacturing industry development support system refers to separate element systems and their structural status. Element system refers to sub-system of support and sub-system of control which constitute the support systems. Each sub-system comprises four basic elements which are manifested by series of indicators. Structural status of element system refers to four basic elements, structure of element indicator system and their interactions.

(1) Sub-system of support

Sub-system of support comprises four elements -human resources, technological resources, capital resources and productive materials. The input of these four traditional elements constitutes the pillars of manufacturing industry development and reflects its capacity and level.

- **Human resources.** With the deepening of economic globalization and knowledge-based economy, industrial development increasingly relies on quality and efficiency of economic growth. As the unique characteristic makes it a vital element in improving quality and performance of economic growth, human resources becomes the overriding element of manufacturing industry development.
- **Technological resources.** Technological resources refer to market-oriented scientific research activities. It is a dynamical process during which science researches are materialized into commodities and thus commercial value is realized. In a time of techno-economy, technological resources are increasingly becoming the driving force of manufacturing industry development, with countries and regions vying to seize the height of science and technology so as to lead the trend of manufacturing industry development.

- **Capital resources.** As the most basic element of manufacturing industry development, capital has deciding influence on its scale and pace. Quantity and circulation pace of capital resources are important limiting factors of manufacturing industry development.
- **Production materials.** Productive materials are prerequisite of manufacturing industry development. It includes land and energy. As the basis of industrial production, utility rate of land has direct bearing on its productivity. In contrast, energy is natural material which generates power. Energy is necessary material as well as the power source ofmanufacturing industry production.

(2) Sub-system of control

Sub-system of control comprises elements including management, market, information and environment. It reflects the influence of inner environment and social environment on manufacturing industry development [5].

- **Management.** Effective management keeps plans, arrangements, coordinative and controlling activities of industrial enterprises in order, thus helping minimize cost and maximize economic benefits.
- **Market.** As the vehicle and manifestation of economic operation, market includes commodity market, financial market and technology market. Commodity market is place for exchange and distribution of tangible materials and products, while financial market is place for trade via credit instruments and financing between capital providers and seekers. Technology market is place or institution for technology trade. Maturity, fairness and openness of the three markets have direct bearing on sales of industrial products and efficiency of manufacturing industry development.
- **Information.** Information has increasing importance to manufacturing industry development as technological progress, capital introduction, market targeting and decision-making all relies on availability, accuracy and marketability of information seized by enterprises. In-depth emerging of information and industrial production is beneficial to production and distribution of industrial products as well as transformation and upgrading of manufacturing industry.
- **Environment.** Environment includes traffic, logistics and regional conditions. Traffic and logistic conditions provide guidance to and have overall influence on manufacturing industry development, while regional conditions reflect industrial development potential and external conditions.

54.2.2 Mechanism of Manufacturing Industry Development Support System

Mechanism of manufacturing industry development support system refers to interactions between separate system elements during the process of manufacturing industry development.

Firstly, observe the chart upwards from the middle, we could conclude that industrial production requires human resources, technological resources, capital resources and productive materials, or in other words, the introduction of sub-systems of the support system. And next, expanded industrial reproduction is sustained through constant personnel cultivation, technological innovation, capital funding and resource input. Therefore, the chart reflects that sub-support system is both foundation and core to industrial production and expanded industrial reproduction.

Secondly, observe the chart upwards from both sides, we can conclude that industrial production and expanded industrial reproduction are subject to the four elements of sub- system of control. Above all, management of sub- system of control should be continuously improved during industrial production and expanded industrial reproduction, or it produces adverse influence on both of them. Then, external environment can affect element quality and efficiency of sub- system of control, while improvement of the element quality can in turn optimize production environment. Still, while market demand is met by products, it in turn, stimulates industrial production and expanded industrial reproduction. Lastly, information about trial-produced new products and old products will be fed back continuously from the market. The information feedback ultimately helps the upgrading of new products and improvement of old products in terms of both quantity and quality.

In summary, industrial production and expanded industrial reproduction require the input of four elements of sub- system of support. In the meantime, to the influence of four elements of sub system of control, industrial production and expanded industrial reproduction move in circles and improve continuously.

54.2.3 Indicators of Manufacturing Industry Development Support System

In alignment to the economic concepts of the eight elements and mechanism reasoned above,the paper selects following indicators to represent conditions of the eight elements. Availability of statistics is taken into consideration.

(1) Sub-system of support

Indicators employed to measure human resources are population with junior college diploma or above per 10,000 people and R&D personnel (FTE) per 10,000 people, while indicators used to measure science and technology are proportion of R&D spending to GDP gross value and number of patent for invention. Indicator employed to measure capital resources is total investment value on industrial fixed assets. Indicators employed to measure productive materials include land area for industrial use, total industrial consumption of coal, total consumption of oil products of manufacturing industry and total consumption of power of the industry.

(2) Sub-system of control

Indicators employed to measure managementare sales ratio, turnover rate of floating assets, total capital contribution and ratio of profit to cost, while indicators used to measure market are transaction volume in commodity market, financial market and technology market whose value goes above 100 million Yuan. Information is measured by indicators including internet users per 10,000 people, year-end mobile phone users per 10,000 people, proportion of people working for information transmission, computer services and software sectors to total urban employment. Environment is measured by indicators such as regional public expenditure, imports & export gross value, mileage of railways, expressways, first- and second-class roads as well as freight volume.

54.3 Evaluation on Manufacturing Industry Development Support System

In line with basic principles of value engineering, following equation can be drawn:

Performance of manufacturing industry development support system = manufacturing industry development/industrial development support system

Therefore, to improve the performance of the support system, we can increase the level of system elements so as to increase aggregate of manufacturing industry. But there are occasions in which the performance of the support system can be improved when the level of system elements remains unchanged or grows smaller: aggregate of the industry increases while the level of system elements remain unchanged; the level of system elements reduces while aggregate of the industry remains unchanged; the level of system elements decreases while aggregate of the industry increases; the level of system elements reduces significantly while aggregate of the industry decreases slightly.

Therefore, though manufacturing industry development requires the support system, it does not mean that the higher is the support system element levels the better is the system. Nor does it mean that the performance of the support system is directly proportional to the system itself.

54.3.1 Matching Principle between Support System and Manufacturing Industry Development

In respect of demand of manufacturing industry, the support system emphasizes on matching with demand of the industry instead of separate element levels. Quantity and level of the support system vary depending on different stage and growth pace of manufacturing industry development. To be more specific, mismatch with demand of the industry means either surplus or inadequacy of the support system. The support system reaches best performance only when it exactly matches to demand of manufacturing industry. In this paper, matching coefficient is introduced to evaluate the matching relation between the support system and demand of manufacturing industry in targeted region. In a historical perspective, industrial development in regions around the world is progressing gradually. In every stage of industrialization, different elements are employed to support industrial development. Matching coefficient is the quantitative representation of the conditions of the support system.

As industrial added value is usually employed as indicator of manufacturing industry development, matching coefficient of support system in a targeted region refers to the ratio of element values in leading regions with reference value against industrial added value.

Table 54.1 Matching coefficient of the support system

	Elements	Matching coefficient
Sub-support system	Human resources	Population with junior college diploma or above per 10,000 people/industrial added value R&D personnel (FTE) per 10,000 people/industrial added value
	Technological resources	Ratio of R&D spending against GDP gross value Number of patent for invention/industrial added value
	Capital resources	Total investment fixed industrial assets/industrial added value
	Production materials	Land area for industrial use/industrial added value Total industrial consumption of coal/industrial added value Total industrial consumption of oil products/industrial added value Total industrial consumption of power/industrial added value
Sub-control system	Management	Sales rate Turnover rate of floating assets Total capital contribution Ratio of profit to cost
	Market	Transaction volume in market whose value goes above 100 million Yuan/industrial added value transaction volume in financial market/industrial added value transaction volume in technology market/industrial added value
	Information	Internet users per 10,000 people/industrial added value Year-end mobile phone users/industrial added value Ratio of people working for information transmission, computer services and software sectors to total urban employment.
	Environment	Public expenditure/ industrial added value Total imports & exports value/ industrial added value Mileage of railways/industrial added value Mileage of expressways/industrial added value Mileage of first- and second-class roads/industrial added value Freight volume/industrial added value

Table 54.1 indicates the matching coefficient of support system elements. In general, the ratio of element values in leading regions with reference value against industrial added value is used as the matching coefficient. In rare occasions when the element value is measured in percentage, it does not have to set against industrial added value. For instance, proportion of R&D spending to total GDP gross value,

sales rate, turnover rate of floating assets, total capital contribution and ratio of profit to cost are employed directly as matching coefficients of technological resources and management.

54.4 Calculation Method of Matching Coefficient

54.4.1 Selection of Calculation Method

Logically, methods applied to calculate matching coefficient can be divided into normative study and empirical study. The former summarizes previous research results on matching coefficient of manufacturing industry development support system and combines it with current studies. However, given the vacancy of theoretical studies on matching coefficient of manufacturing industry development support system, normative study method can not be employed. In other words, only empirical study can be applied. Empirical study can be carried out in domestic and foreign sphere. But due tounavailability of foreign data and its inconformity to China's realities, the paper analyzes matching relation between support system in leading region with reference value and demand of industrial development only in domestic sphere.

54.4.2 Selection of Leading Region with Reference Value

To ensure the reference value of matching coefficient calculation in leading regions, two principles should be observed in selection. Principle 1 is the region selected should enter into certain stage of industrialization prior to targeted region.And Principle 2 is that industrial structure of manufacturing industry of the region selected should have reference value to the targeted region.

Only regions meet the two principles above can be selected to provide reference for matching coefficient calculation and construction of manufacturing industry development support system in targeted regions.

54.4.3 Example: Calculation of Matching Coefficient of Manufacturing Industry Development Support System in Guangxi

(1) Selection of leading province with reference value

We evaluate 26 provinces nationwide except Guangxi in accordance with principles in selection of leading regions with reference value:

Firstly, six provinces have not entered into intermediate stage of industrialization prior to 2009 including Sichuan, Gansu, Yunnan, Hainan, Guizhou and Tibet. Therefore, these six provinces cannot be selected.

Secondly, structure of manufacturing industry in Guangxi is vastly different from that of nine provinces including Shanxi, Shaanxi, Qinhai, Inner Mongolia, Ningxia, Xingjiang, Jilin and Heilongjiang.

Thus, ruling out the above 15 provinces, the other 11 provinces are selected as leading province with reference value including Hebei, Jiangsu, Zhejiang, Fujian, Shandong, Hubei, Guangdong, Henan, Hunan, Anhui and Jiangxi. The years these 11 provinces entering into intermediate stage of industrialization are shown in Table 54.2.

Table 54.2 Time of 11 leading provinces entering into industrialization stage

Province	Jiangsu, Guangdong	Zhejiang	Fujian	Shandong	Hebei, Hubei	Henan, Hunan	Anhui, Jiangxi
The year entering intermediate age of industrialization	1995	1996	2000	2001	2003	2007	2008

(2) Calculation of matching coefficient

Take the indicator of personnel with junior college diploma and above in 10,000 people as an example. The proportion of the indicator to industrial added value in five years after entering into intermediate stage of industrialization is shown in Table 54.3.

Table 54.3 Industrial added-value of leading provinces in five years after entering into industrialization stage

Province	Hebei	Jiangsu	Zhe jiang	Fujian	Shan dong	Hubei	Guang dong	Henan	Hunan	Anhui	Jiangxi
1st year	1360.9	0.0	1036.4	2018.3	659.3	2003.6	0.0	440.9	1354.1	978.8	1978.4
2nd year	945.4	630.9	1092.2	1787.5	716.9	2279.7	1038.1	465.0	1120.9		
3rd year	681.2	898.5	884.5	2094.1	905.0	1637.4	958.6				
4th year	599.1	1118.6	1155.3	2045.2	658.3	2179.8	891.8				
5th year	570.5	828.6	1024.4	1700.8	538.7	1826.7	556.2				

In Table 54.3, 0 means data is not found; unit of industrial added value is trillion Yuan. As Henan and Hunan entered into intermediate stage of industrialization in 2007 three years prior to Guangxi, only the data in 2008 and 2009 is selected. As Anhui and Jiangxi entered into intermediate stage of industrialization in 2007 two years prior to Guangxi, only the data in 2009 is selected.

Drawing the average value of matching coefficient in leading provinces in five years after entering intointermediate stage of industrialization, the matching coefficient for personnel with junior college diploma and above in 10,000 people in Guangxi during 2011-2015 period can thus be calculated. The data is shown in following chart:

Table 54.4 Personnel with junior college diploma or above in 10,000 people in Guangxi during 2011-2015

Year	2011	2012	2013	2014	2015
Matching coefficient	1314.5	1119.6	1151.3	1235.4	1006.6

Likewise, matching coefficient for other indicators of the industrial development support system in Guangxi can be calculated. A full set of support system matching coefficient serves for following benefits: providing guidance to element input to fuel Guangxi manufacturing industry development, facilitating transformation and upgrading of the industry and increasing industrial economic aggregate in the region; keep the vibrant momentum of Guangxi manufacturing industry development in driving economic growth.

(3) Correction of matching coefficient

Correction of the matching coefficient calculated in leading provinces is necessary to reduce tolerance and provide reference to actual conditions. Draw the ratio of element values against industrial added value in certain region during the 11th Five-year Plan, and compare it to matching coefficient in leading provinces. The calculation should be corrected when obvious differential arises.

Two principles should be followed when making corrections:

Firstly, the matching coefficient in the certain region should comply with basic economic principles. For instance, the data increases in steady pace and no obvious fluctuations occur.

Secondly, when comparing the matching coefficient in certain region to that in leading provinces, correction is not needed if only minor differential arises. When the differential is obvious, the calculation should be corrected according to actual conditions. For instance, matching coefficient in leading provinces can be reduced or increased to lower tolerance.

54.5 Conclusion

On the basis of input-output theory and theory of industrialization, the paper explores and puts forth element matching theory which has great theoretical importance. The paper not only provides matching method, but also fills in the vacancy of studies on manufacturing industry development support system. In the meantime, the paper points out that manufacturing industry development must rely on the support system and that quantity and level of the support system should match with demand of the industry. The paper also takes Guangxi as an example to deduce the calculation method of matching coefficient, providing great realistic significance.

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Chapter 55
A Quantitative Analysis for House Price Target of Real Estate Control Policy in China

Ziyang Geng, Li Zhang and Xueting Li

Abstract A new set of real estate control policies have been carrying out to inhibit soaring house price and deal volume is going down rapidly. Not only customer and real estate firms are all care about the house price target, but also it is an important index for government to adjust their policies. Taking into account that customer is the weaker side comparing with real estate firms, we can conclude that customer will buy a house on the price equaling to their expected value for the house once the control policies have all done. Then we will give a new interpretation to Myerson and Satterthwaite's model in order to do quantitative analysis on house price. Finally we will know that government should only take some care not to make the lower limit of expected value range below the upper limit of costs range, otherwise house price must follow the analytic result to maximize society remain when deal volume reach appropriate level.

Keywords Principal-agent theory · Control policy · House price · Adjustment target

55.1 Introduction

Nowadays, abnormally high housing price has grown into social problem which severely hinders the indemnification and improvement of people's livelihood. Recent years, the Central Government has been carrying out a set of policies to control housing price and deal volume is going down rapidly across the country especially in first-tier cities such as Beijing, Shanghai and Shenzhen, which shows the govern-

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ment's firm determination and strong effectiveness. However, it is important to know that the control policies aim at promoting the stability and healthy development of real estate market rather than hitting the real estate firms. Therefore, a bottom line needs to be set for the housing price adjustment target.

Consumer will wait and see if they believe that housing price will certainly drop with the government intervening, thus leads to deal volume shrinking. For consumers, when is the timing to purchase a house? This is also a key question for the government, what position is appropriate for the housing price adjustment? We conclude a critical revelation by analyzing the reason for consumers' wait-and-see phenomenon: it is the fact that expected value for the house is below the current housing price leads to the shrink of deal volume.

Before 2004-2005, nationwide housing price and its up-trend were low as well as the deal volume. However, years later commercial residential buildings were considered as a scarce resource, especially in first-tier and second-tier cities, leading to housing price soaring and crazy purchase. The deal volume had an explosive growth although housing price was at a high level. No matter what causes this phenomenon, real estate firms' deliberate guide or market principle, objectively the improvement of consumers' expected value prompt purchase which stimulates the increase of housing price. The soaring housing price makes consumer have a better expectation promoting housing price into a fast increasing passageway. During this process, consumers are kidnapped by housing price passively and have no choice but improve their expectation of house value - consumers always think house value will increase in the future no matter what the housing price is now.

The interaction between consumer's expected value of scarce house and housing price during the development of real estate occurs not only in our country but also in other countries of world. For example, during the 30 years after 1970 in USA, the housing price of metropolises represented by coastal cities increased 247% while the average housing price of country only increased 72%. The main reason was the limited house supplication in metropolises leading to housing price increasing due to mutual stimulation between expected value and housing price [1]. When excessive housing price may cause bubbles, the governments of these countries will also take administrative and economic measures to intervene. Many real estate control measures of our government come from reference of these counties' experience and the effect of our control policies is more notable.

When the control policies are carried out, consumers believe that policy is more powerful than market and housing price will certainly decline. Therefore, the expected value which forms passively and is much higher than self-income level will easily drop below the extremely high price and the situation of wait-and-see and deal volume shrinking will certainly emerged. We believe that consumers' expected value will be lower than the average housing price in market and deal volume will not return back to the level of boom period so long as the keynote of government control is inhibiting housing price. Moreover, we have to admit that consumers are disadvantaged in comparison with real estate firms in our current real estate market. Therefore, we can assume that consumers will rapidly adjust lower expected value to housing price level and reach a deal in accordance with current price in order to prevent housing price soaring by real estate firms, once they think the control policies are end and housing price is at bottom. From these we can conclude that housing price target chosen by government means consumers' expected value level, on the other hand, it's about which level government hope to guide consumers' expected value to decline too.

Supply costs of real estate firms, including development costs and risk costs, vary during the implementation of control policy. The development costs become constant costs when events completes, however, issues such as fund-chain breaking may bring risk costs. If deal volume is continuously low, the risk costs will constantly increase as time goes by and may even lead to bankruptcy. Therefore, the low deal volume will force real estate firms to decrease housing price during control policies working.

The analysis above show the response of supply and demand sides during policy control process: the expected value of demand side declines continuously while supply side decreases housing price constantly due to soaring costs.

Therefore, this paper suggests that the idea of the government setting target housing price should be as described below. The expected value will be almost adjusted to target housing price level in a very short time after the end of policy control, so the expected value at this time can be acted as target housing price. In order to satisfy actual social housing demand including rigid demand, deal volume has to reach appropriate level. In the market aspect, deal volume is actually decided by the gap between average supply costs and expected value. The deal volume will not reach the hoped level of government if this gap is too small. With policy control going on, the gap between costs and expected value will become smaller and smaller. Therefore, under the premise of the following two conditions the lowest housing price should be the expected value when the gap is minimum: (1) deal volume at an appropriate level; (2) in the situation of current costs and expected value, when deal volume reach the level described as (1) social surplus is maximum. If this lowest target housing price can guarantee the reasonable profits of real estate firms, it can be final target housing price, otherwise it should have an appropriate increase to be target housing price. The idea is directly illustrated by Fig. 55.1 which suggests that the target housing price will eventually be linked with costs.

55.2 Basic Assumptions

- Control policies aim at maximizing society remain when housing price returns to a reasonable level and deal volume reach appropriate level.
- Control policies are to curb speculation and turn the buy-for-residing demander into the major demand side of the market. Customer is a weaker side comparing with real estate firms.
- During the control policies are implemented, the costs of real estate firms rise due to the increase in the risk costs, leading to price reduction and consumers' expected value declining.

- Price reduction lags in the downward adjustment of consumers' expected value and is always higher than it. At the end of the policy control, house price are close to consumers' expected value.
- During a relatively long period after the control policies have all done, the house price will remain moderate upward or down trend, consistent with consumers' expected value.
- Consumers will buy a house on the price equaling to their expected value once the control policies have all done.
- During the implement of the control policies, on when the house price reach the target level can deal volume return to an appropriate level.

55.3 Model

Use the principal-agent theory to build model. All the real estate firms will be treated as a whole seller in one region while all consumers will be regarded as a whole buyer. For every unit of both sides, we assume they have the same behavior, specifically in this paper, which is everyone's tendency to conceal their private information, therefore the whole also shows a tendency to conceal private information.

Presume the government in the beginning of the policy control to use this model. Before policy control starts, assume that the costs of each house is c, expected value of each house for buyer is v, meanwhile, c and v are private information of seller and buyer respectively. Set c in the range of $[\underline{c}, \overline{c}]$, moreover c has the same continuous density function $f_1(\cdot)$ and continuous distribution function $F_1(\cdot)$ which are stringent positive in any moment of the interval. Presume v has continuous density function $f_2(\cdot)$ and continuous distribution function $F_2(\cdot)$ which are stringent positive on the interval of $[\underline{v}, \overline{v}]$. The risk of both buyer and seller is neutral.

The government serves as an arbiter between seller and buyer. When the profit of seller is too large, government will take policy control measures to decrease hous-

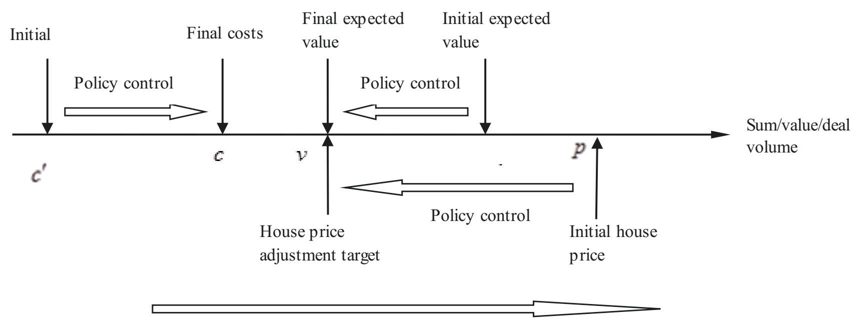

Fig. 55.1 Diagram of supply costs, expected value, house price and deal volume varies with the implement of control polices

ing price for protecting buyer's profit. The government will also try to promote the healthy development of real estate market when housing price is too low. Therefore government can be treated as a selflessness principal and both seller and buyer are agents. During the process of trading, both seller and buyer can transmit false information (assuming transmit information by announcement) to others as the motive for benefiting from housing price change. If seller announced costs are higher than actual costs, they have reasons to keep house price not decrease under a false cost. As the same, buyer announced expected value is lower than actual expected value in order to require seller to drop housing price under the false expected value. Due to worrying about agents concealing their own actual information, which leads housing price not reflecting the true balance of supply and demand, the principals need to prevent adverse selection in the model.

$x(c,v) \in [0,a]$ indicates deal volume level. No deal volume, $x(c,v) = 0$; deal volume recovering back to appropriate level such as boom period of real estate market, $x(c,v) = a$. Assuming that $x(c,v)$ is common knowledge, both sides of agents can foresee deal volume is $x(\hat{c},\hat{v})$ when they announced costs or expected value is $\hat{c}$ and $\hat{v}$ respectively. The value of $x(c,v)$ is observable so $x(c,v)$ is set as decision function. $t(c,v)$ indicates transfer income of seller benefiting from buyer when deal volume is $x(c,v)$. Based on display principle, direct display mechanism of exist enticing the agents true reflection of their personal information, this display mechanism is set as $t(\hat{c},\hat{v}), x(\hat{c},\hat{v})$. That is to say, when both sides of agents announced personal information are $\hat{c}$ and $\hat{v}$, deal volume has to be $x(\hat{c},\hat{v})$ and deal transfer payment is $t(\hat{c},\hat{v})$.

Assume $X_1(\hat{c}) = E_v[x(\hat{c},v)]$, $X_2(\hat{v}) = E_c[x(c,\hat{v})]$ represent deal volume level when seller announced costs information is $\hat{c}$ and buyer announced expected value information is $\hat{v}$ respectively. E_c and E_v represent the expected value of variable c and v respectively. According to basic assumption 4, 5 and 6, the average transfer profit of seller is $t(\hat{c},\hat{v}) = \hat{v}x(\hat{c},\hat{v})$ when deal volume level is $x(c,v)$.

Assume $T_1(\hat{c}) = E_v[t(\hat{c},v)] = E_v[vx(\hat{c},v)]$, $T_2(\hat{v}) = -E_c[t(c,\hat{v})] = -\hat{v}X_2(\hat{v})$ represent expected transfer profit of both seller and buyer respectively.

Assume

$$\varphi_1(c,\hat{c}) = T_1(\hat{c}) - cX_1(\hat{c}) = E_v[vx(\hat{c},v)] - cE_v[x(\hat{c},v)], \tag{55.1}$$

$$\varphi_2(v,\hat{v}) = vX_2(\hat{v}) + T_2(\hat{v}) = vX_2(\hat{v}) - \hat{v}X_2(\hat{v}) \tag{55.2}$$

represent expected utility, when seller's actual costs is c and its announced costs is $\hat{c}$ or buyer's actual expected value is c and its announced expected value is $\hat{c}$, respectively.

When target housing price is reached, any pair numbers $\{c,\tilde{c}\}$ and $\{v,\tilde{v}\}$ in their own range have to meet the following adverse selection incentive compatibility constraints:

$$\varphi_1(c,c) \geq \varphi_1(c,\tilde{c}), \tag{55.3}$$

$$\varphi_1(\tilde{c},\tilde{c}) \geq \varphi_1(\tilde{c},c), \tag{55.4}$$

$$\varphi_2(v,v) \geq \varphi_2(v,\tilde{v}), \tag{55.5}$$

$$\varphi_2(\tilde{v},\tilde{v}) \geq \varphi_2(\tilde{v},v). \tag{55.6}$$

Although the principal is government, it can't force both seller and buyer to involve in the housing market transaction. So as for agents, their participation constraint of transaction is assumed as:

$$\varphi_1(c,c) \geq 0, \tag{55.7}$$
$$\varphi_2(v,v) \geq 0. \tag{55.8}$$

The payment of buyer equals the profit of seller so principal need to guarantee the following balanced budget constraint is satisfied:

$$E_c T_1(c) + E_v T_2(v) = 0. \tag{55.9}$$

In order to maximize social surplus, principal builds up planning model as followed:

$$(P):\ \max_{x(c,v)} E_{c,v}[(v-c)x(c,v)],$$
$$\text{s.t } (55.3)-(55.9).$$

The solution of planning (P) will reveal (c,v) and $x(c,v)=a$ at any time, whether they can maximize social surplus during control process. The principal will choose v from the minimum $v-c$ value, which can make $x(c,v)=a$ to be the optimum solution, as housing price control target.

55.4 Model Analysis

Myerson and Satterthwaite [2] put forward model shaped like planning (P) in the situation of general commodity exchange. In their model, the final knockdown price of both sides is in the range of c to v. Moreover, in the case of $x(c,v) \in [0,1]$ if $\bar{c} > \underline{v}$, they prove that planning (P) in optimal time is unable to obtain $x(c,v)=1$ with only condition of $v \geq c$. with only condition of Based on the assumption of disadvantage consumer, this paper believe the housing price adjustment target is as the same as consumer expected value at the end of policy control. Thus, we make new interpretations of model in general commodity exchange background as above and apply planning (P) model to related analysis of real estate policy control in our country. To make the analysis process complete and clear, the model solving process is given as followed referencing the analysis of Myerson and Satterthwaite [2].

Assume

$$\varphi_1(c,\hat{c}) = T_1(\hat{c}) - cX_1(\hat{c}) = \psi_1(X_1(\hat{c}),T_1(\hat{c}),c),$$
$$\varphi_2(v,\hat{v}) = vX_2(\hat{v}) + T_2(\hat{v}) = \psi_2(X_2(\hat{v}),T_2(\hat{v}),v).$$

Telling the truth maximize the utility of each other, that is to say, the first-order condition of the establishment of the incentive compatibility constraint is:

$$\begin{aligned}\frac{\partial \varphi_1(c,c)}{\partial c} &= \frac{\partial \psi_1}{\partial X_1}\frac{dX_1}{dc} + \frac{\partial \psi_1}{\partial T_1}\frac{dT_1}{dc} = -c{X_1}'(c) + {T_1}'(c) = 0,\\ \frac{\partial \varphi_2(v,v)}{\partial v} &= \frac{\partial \psi_2}{\partial X_2}\frac{dX_2}{dv} + \frac{\partial \psi_2}{\partial T_2}\frac{dT_2}{dv} = v{X_2}'(v) + {T_2}'(v) = 0.\end{aligned}$$

Assume

$$\begin{aligned}U_1(c) &= \max_{\hat{c}} \psi_1(X_1(\hat{c}), T_1(\hat{c}), c) = \psi_1(X_1(c), T_1(c), c)\\ &= T_1(c) - cX_1(c), \qquad (55.10)\\ U_2(v) &= \max_{\hat{v}} \psi_2(X_2(\hat{v}), T_2(\hat{v}), v) = \psi_2(X_2(v), T_2(v), v)\\ &= vX_2(v) + T_2(v). \qquad (55.11)\end{aligned}$$

Apply Envelope theorem to obtain:

$$\frac{dU_1}{dc} = \frac{\partial \psi_1}{\partial c} = -c{X_1}'(c) + {T_1}'(c) - X_1(c) = -X_1(c), \qquad (55.12)$$

$$\frac{dU_2}{dv} = \frac{\partial \psi_2}{\partial v} = v{X_2}'(v) + {T_2}'(v) + X_2(v) = X_2(v). \qquad (55.13)$$

So conditions (55.3), (55.4) (55.5), (55.6) can be replaced by (55.12), (55.13). According to (55.12), (55.13), $U_1(c), U_2(v)$ are monotonically non- increasing function and monotonically non- decreasing function respectively. Conditions (55.7), (55.8) can be replaced by:

$$U_1(\overline{c}) \geq 0, \qquad (55.14)$$

$$U_2(\underline{v}) \geq 0. \qquad (55.15)$$

Integrate Equations (55.12), (55.13):

$$U_1(c) = U_1(\overline{c}) + \int_c^{\overline{c}} X_1(\mu)d\mu, \qquad (55.16)$$

$$U_2(v) = U_2(\underline{v}) + \int_{\underline{v}}^{v} X_2(\gamma)d\gamma. \qquad (55.17)$$

Separation conditions

$$\begin{aligned}\frac{\partial}{\partial c}\left(\frac{\partial \psi_1}{\partial X_1}\Big/\frac{\partial \psi_1}{\partial T_1}\right) &= -1 < 0,\\ \frac{\partial}{\partial v}\left(\frac{\partial \psi_2}{\partial X_2}\Big/\frac{\partial \psi_2}{\partial T_2}\right) &= 1 > 0.\end{aligned}$$

According to Fudenberg and Tirole [3], Equations (55.16), (55.17) are also sufficient condition for incentive compatibility constraint when X_1 is non-increasing and X_2 is non-decreasing. Therefore incentive compatibility constraints (55.3), (55.4), (55.5) (55.6) can be replaced by (55.16), (55.17).

$$T_1(c)+T_2(v)=cX_1(c)-vX_2(v)+U_1(\overline{c})+U_2(\underline{v})+\int_c^{\overline{c}}X_1(\mu)d\mu+\int_{\underline{v}}^{v}X_2(\gamma)d\gamma.$$

Obtain from condition (55.9):

$$\begin{aligned}0= &\int_{\underline{c}}^{\overline{c}}[cX_1(c)+\int_c^{\overline{c}}X_1(\mu)d\mu]f_1(c)dc+U_1(\overline{c})\\&+\int_{\underline{v}}^{\overline{v}}[\int_{\underline{v}}^{v}X_2(\gamma)d\gamma-vX_2(v)]f_2(v)dv+U_2(\underline{v}).\end{aligned} \tag{55.18}$$

Integrate Equation (55.18) by parts:

$$\begin{aligned}U_1(\overline{c})+U_2(\underline{v})= &-\int_{\underline{c}}^{\overline{c}}(c+\frac{F_1(c)}{f_1(c)})X_1(c)f_1(c)dc\\&+\int_{\underline{v}}^{\overline{v}}(v-\frac{1-F_2(v)}{f_2(v)})X_2(v)f_2(v)dv.\end{aligned} \tag{55.19}$$

When $x(c,v)=a, X_1(c)=X_2(v)=a$ and obtain from Equation (55.19):

$$\begin{aligned}&U_1(\overline{c})+U_2(\underline{v})\\&=a\{-\int_{\underline{c}}^{\overline{c}}cf_1(c)dc-\int_{\underline{c}}^{\overline{c}}F_1(c)dc+\int_{\underline{v}}^{\overline{v}}vf_2(v)dv-\int_{\underline{v}}^{\overline{v}}[1-F_2(v)]dv\}\\&=a\{-E(c)-[cF_1(c)|_{\underline{c}}^{\overline{c}}-\int_{\underline{c}}^{\overline{c}}cf_1(c)dc]+E(v)\\&\quad-(\overline{v}-\underline{v})+[vF_2(v)|_{\underline{v}}^{\overline{v}}-\int_{\underline{v}}^{\overline{v}}vf_2(v)dv]\}\\&=a\{-E(c)-\overline{c}+E(c)+E(v)-\overline{v}+\underline{v}+\overline{v}-E(v)\}\\&=a(\underline{v}-\overline{c})\geq 0.\end{aligned} \tag{55.20}$$

As $\overline{c}\leq\underline{v}$, Equation (55.20) is established and $c\leq v$ is for any pair numbers (c,v) belonging to interval $[\underline{v},\overline{v}]$ and $[\underline{c},\overline{c}]$. Thus Equations (55.14), (55.15) necessarily meet when incentive compatibility constraint meets according to Equations (55.1), (55.2). In other words, the optimum solution of planning (P) is always $x(c,v)=a$ for any given pair numbers (c,v) when $\overline{c}\leq\underline{v}$. This situation illustrates the lower limit of range of consumer's expected value is higher than the upper limit of the range of the development firm's costs when the control policies begin. In this case the principal only need to note that the lower range of the expected value is not reduced under $\overline{c}$ with the influence of control policies, or the situation will be transformed to $\overline{c}>\underline{v}$. The specific housing price adjustment target is determined by the principal considering various factors, which is beyond the research scope of this paper and not to get to the bottom.

The Equation (55.20) is not established when $\overline{c} > \underline{v}$. According to Equation (55.2), $U_2(\underline{v}) = 0$ when incentive compatibility constraint is satisfied. So Equations (55.14), (55.15) can be replaced by $U_1(\overline{c}) + U_2(\underline{v}) \geq 0$. According to the definition of $X_1(c), X_2(v)$, Equation (55.19) can be transformed to:

$$\begin{aligned} U_1(\overline{c}) + U_2(\underline{v}) = & \int_{\underline{c}}^{\overline{c}} \int_{\underline{v}}^{\overline{v}} \left[\left(v - \frac{1 - F_2(v)}{f_2(v)} \right) \right. \\ & \left. - \left(c + \frac{F_1(c)}{f_1(c)} \right) \right] x(c,v) f_1(c) f_2(v) dv dc. \end{aligned} \tag{55.21}$$

Assume

$$\xi_1(c) = c + \frac{F_1(c)}{f_1(c)}, \quad \xi_2(v) = v - \frac{1 - F_2(v)}{f_2(v)}.$$

Formula (55.21) is revised as $U_1(\overline{c}) + U_2(\underline{v}) = E_{c,v}\{[\xi_2(v) - \xi_1(c]x(c,v)\}$.

Thus planning (P) is transformed to:

$$(P_1): \max_{x(c,v)} E_{c,v}[(v-c)x(c,v)], \tag{55.22}$$

$$\text{s.t. } E_{c,v}\{[\xi_2(v) - \xi_1(c)]x(c,v)\} \geq 0. \tag{55.23}$$

The integrand functions of target function in planning (P_1) and constraint function are linear function of $x(c,v)$. Set $\lambda \geq 0$ as Lagrange multiplier of Equation (55.23), the Lagrange function of planning (P_1) is:

$$L = E_{c,v}\{[(v + \lambda \xi_2(v) - (c + \lambda \xi_1(c))]x(c,v)\}. \tag{55.24}$$

The integrand function of Lagrange function is the linear function of $x(c,v)$, so the extremum of $x(c,v)$, which obtains by using first-order condition to solve $x(c,v)$ from Equation (55.24) with Lagrange method, is also its maximum. Actually the maximum of $x(c,v)$ can be obtained from Equation (55.24) directly.

$$x(c,v) = \begin{cases} a, & v + \lambda \xi_2(v) \geq c + \lambda \xi_1(c), \\ 0, & v + \lambda \xi_2(v) < c + \lambda \xi_1(c). \end{cases} \tag{55.25}$$

According to definition of $\xi_1(c), \xi_2(v)$, if and only if

$$v - \frac{\lambda}{1+\lambda} \frac{1 - F_2(v)}{f_2(v)} \geq c + \frac{\lambda}{1+\lambda} \frac{F_1(c)}{f_1(c)} \tag{55.26}$$

deal volume reach a when it is optimal.

Lemma 55.1. *If* $\overline{c} > \underline{v}$, $\lambda > 0$ *when it is optimal, in other words, Equation (55.23) is equation.*

Proof. If $\overline{c} > \underline{v}$ and $\lambda = 0$, thus Equation (55.26) is $v \geq c$. $x(c,v) = a$, when Equation (55.26) is satisfied. However Equation (55.20) is strictly less than zero which is contradictory with strictly established inequality (55.23) as $\lambda = 0$, so $\lambda > 0$. □

Assume

$$\mu = \frac{\lambda}{1+\lambda},$$

according to Lemma 55.1, if $x(c,v) = a$ when it is optimal:

$$v - c \geq \mu\left(\frac{1-F_2(v)}{f_2(v)} + \frac{F_1(c)}{f_1(c)}\right) > 0,$$

that is to say, the value of v minus c is at least bigger than

$$\mu\left(\frac{1-F_2(v)}{f_2(v)} + \frac{F_1(c)}{f_1(c)}\right).$$

As for the principal, the lowest target housing price is determined by:

$$v = c + \mu\left(\frac{1-F_2(v)}{f_2(v)} + \frac{F_1(c)}{f_1(c)}\right). \tag{55.27}$$

In order to obtain the value of μ, considering Equation (55.23) is equation, $x(c,v) = a$ and Equation (55.26) when it is optimal, there will be:

$$\int_{\underline{c}}^{v-\mu(\frac{1-F_2(v)}{f_2(v)}+\frac{F_1(c)}{f_1(c)})} \int_{c+\mu(\frac{1-F_2(v)}{f_2(v)}+\frac{F_1(c)}{f_1(c)})}^{\overline{v}} \left[\tilde{v} - \frac{1-F_2(\tilde{v})}{f_2(\tilde{v})} - \left(\tilde{c} + \frac{F_1(\tilde{c})}{f_1(\tilde{c})}\right)\right]$$
$$f_2(\tilde{v})f_1(\tilde{c})d\tilde{v}d\tilde{c} = 0. \tag{55.28}$$

$v(c)$ can be obtained by taking the value of $\mu(c,v)$ from the Equation (55.28) into Equation (55.27). $v(c)$ shows the specific influence of the costs to target house price. For example, if c and v are uniform distribution, c and v are in the range of $[0,\theta]$ and $F_1(c) = c, F_2(v) = v$, thus Equation (55.26) can be transformed as:

$$v - c \geq \frac{\mu}{1+\mu}. \tag{55.29}$$

Assume

$$\beta = \frac{\mu}{1+\mu},$$

then Equation (55.28) is transformed as:

$$\int_0^{\theta-\beta} \int_{c+\beta}^{\theta} (2v - 1 - 2c)dvdc = 0. \tag{55.30}$$

Obtain from Equation (55.30):

$$\frac{1}{3}\beta^3+\theta\left[\frac{1}{3}\theta^2+\beta-\frac{1}{2}\theta-\beta^2\right]=0. \tag{55.31}$$

So the effect of costs to the minimum target house price is $v=c+\beta$, of which β is determined by the Equation (55.31).

Proposition 55.1. *If $\overline{c}\leq\underline{v}$, target house price are determined by comprehensive consideration of the principal only noticing the low limit of the expected values not below $\overline{c}$ with the influence of policy control. On the contrary, if $\overline{c}>\underline{v}$ the lowest target housing price is affected by costs and shows as $v(c)$ which is determined by Equations (55.27), (55.28). If the lowest target housing price can't guarantee real estate firms' proper profits the principal can determine target housing price after appropriate increasing.*

55.5 Conclusions

A preliminary quantitative analysis was given previously toward house price adjustment target for real estate control policy in China. Taking into account that customer is a weaker side comparing with real estate firms, a result was obtained that customer would buy a house on the price equaling to their expected value for the house. Then a new interpretation was given to Myerson and Satterthwaite's model in the context of general commodity exchange in order to do quantitative analysis on house price. Results showed that target house price had a correlation with the costs. When $\overline{c}>v$, the principle must obtain the real-time realistic data of costs and expected value in practice, then data into analytic Equation to find out whether it has reached the target house price. Since c and v are private information which results from joint action of individuals, the principle can only estimate by methods such as statistics instead of collecting the unattainable accurate data, thus the deviation of estimated results is the main factor which affects the accuracy of judgment toward house price adjustment. In addition, a downward switching condition was provided for the situation $\overline{c}\leq v$ which is more likely to occur when the house price are extremely high, that is not to make the lower limit of expected value range below $\overline{c}$, otherwise it will turn into the situation $\overline{c}>v$ and become even more difficult in practice, cause the results come through the integration and tradeoff of multi-field. We hope that this paper will play a little valuable role in this area.

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Chapter 56
Indicator Selection of Joint Purchasing Mode of Small and Medium-Size Enterprises

Liming Zhang

Abstract There are mainly 3 types of joint purchasing modes of SMEs: joint purchasing mode constructed by SMEs spontaneously, joint purchasing mode constructed by industry association, and joint purchasing mode constructed by the third party. How to choose joint purchasing mode is critical for SMEs to implement joint purchasing. Based on theoretical study and practical survey, it is found in the paper that when SMEs choose or establish joint purchasing organization, 15 evaluation indicators of 4 dimensions including operation management capacity, technical capacity, market influence capacity, and service capacity are used for the evaluation.

Keywords SMEs · Joint purchasing · Mode · Indicator

56.1 Introduction

In the present, SMEs commonly use traditional purchasing mode, through which, SMEs trade with suppliers independently [2]. In this purchasing mode, SMEs face these problems such as: weak bargaining capacity, low informatization level, poor pre-control capacity, low professional quality purchasers, incomplete purchasing system, and shortage of supplier management. Therefore, in new historical conditions, SMEs must choose a new type purchasing mode, joint purchasing, to change the shortages of current purchasing mode.

Joint purchasing mode is the further expansion of centralized purchasing, which refers to the purchasing alliance behaviors several enterprises in certain industry or similar industries [3]. Specifically, it combines the independent orders from independent enterprises in certain industry or similar industries to form uniform purchasing group, which purchases from the suppliers [4]. It is shown in the domestic

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and foreign practice results that the alliance of joint purchasing mode in homogeneous enterprises than that in non-homogeneous enterprises.

SMEs use the joint purchasing mode to get rid of the independent status and combine with each other through certain means. In this way, purchasing orders of same or similar products or services are integrated into a big order for the purchasing to suppliers [5]. SMEs deliver a great amount of products or services in joint purchasing, which is paid attention to by the suppliers [6]. Therefore, SMEs will have great bargaining capacity to acquire the price lower than independent purchasing, which saves the purchasing cost [7]. Therefore, certain fund support is provided for the enterprise innovation and market exploration [8].

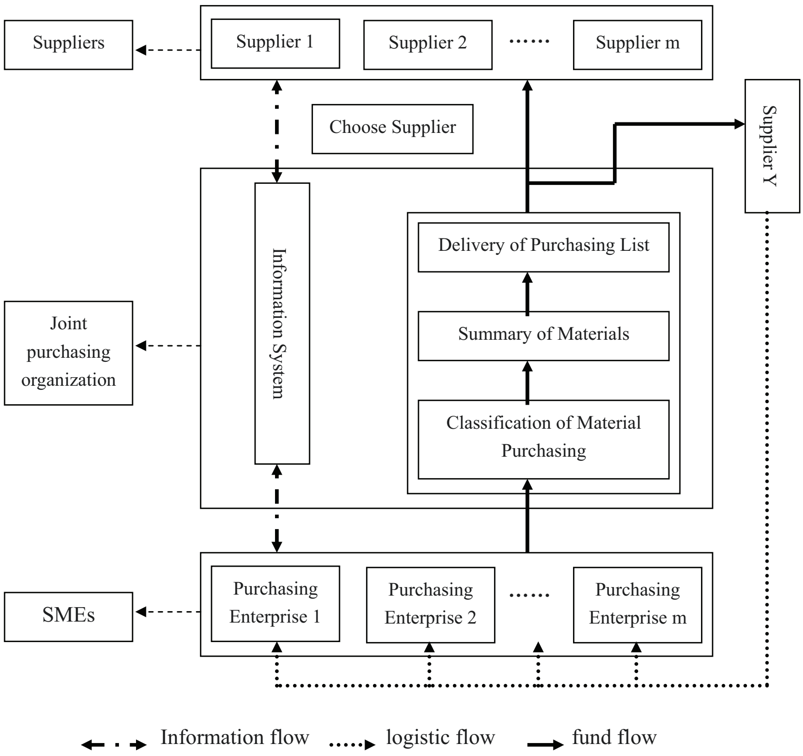

Fig. 56.1 Joint purchasing organization mode of SMEs (Data source: Chen [1])

56.2 Joint Purchasing Mode of SMEs

In the production practice, SMEs have double identities, purchaser and supplier. During the study process of joint purchasing mode for SMEs, it is assumed that SMEs only play the role of purchasers, while suppliers are the merchants or producers providing services or products to SMEs or joint purchasing organization of SMEs. The suppliers' role as purchasers in the next round of joint purchasing organization is not considered [9]. Therefore, the joint purchasing mode of SMEs has subjects include SMEs, joint purchasing organization of SMEs, and suppliers (as shown in Fig 56.1). Joint purchasing organization integrates SMEs of homogeneous materials to realize the objective of joint purchasing by purchasing from the determined excellent suppliers and obtaining price discount based on scale advantage [10].

Seen from the joint purchasing organization mode, it can be found that joint purchasing organization plans an irreplaceable role in the joint purchasing organization mode of SMEs. How to integrate the SMEs of similar homogeneous materials is critical for the success of the purchasing mode. Therefore, based on different launchers of joint purchasing organization of SMEs, there are mainly 3 types of joint purchasing modes for SMEs:

(1) Constructed by SMEs spontaneously

The organization constructed by SMEs spontaneously refers to the joint purchasing organization that SMEs combine with each other for common objective through methods including entrust, agreement, or common investment in purchasing company. To a great extent, member enterprises of joint purchasing organization will participate in the purchasing activities to complete information acquisition, supplier selection and control of purchasing activities [11].

(2) Constructed by industry association

With very strong regional characteristic, industry association is a non-profit professional organization. Based on its good credibility and steady strength, it can keep long-term cooperative relation with material suppliers and own relatively strong bargaining advantage. Therefore, enterprises can acquire purchasing materials or services at low transaction cost [12]. In addition, such a joint purchasing organization can enhance the effective and timely management by adjusting the conflict or dispute among enterprises in actual purchasing process through industry association.

(3) Constructed by the third party

The joint purchasing organization constructed by the third party may be guided by the government, or be guided by the profitable organization specializing in purchasing business. The joint purchasing organization led by the government has strong policy nature. If SMEs cannot express its initiative, the purchasing organization will not give full play of its function, but becomes formalistic. Being the joint purchasing organization, a service provider specializing in the purchasing business (profitable organization) integrates the orders of various SMEs and produces the scale advantage of purchasing to trade directly with product manufacturers or service providers, which saves the purchasing cost and circulation cost greatly.

56.3 Responsibility for the Key Indicator Selection

When SMEs participate in the joint purchasing organization or construct the joint purchasing organization together, they will face the selection among 3 types of joint purchasing modes of SMEs: joint purchasing mode constructed by SMEs spontaneously, joint purchasing mode constructed by industry association, and joint purchasing mode constructed by the third party. Therefore, what is the important evidence for the SMEs to choose their joint purchasing mode? Which key evaluation indicators influence their important decisions? Therefore, healthy and reasonable evaluation indicator system is the important basis and core link for joint purchasing organization of SMEs, and is the important premise for the effective implementation and promotion of joint purchasing organization of SMEs.

56.3.1 Theoretical Evidence

In 1966, Dickson was the first person who carried out systematic study on the supplier evaluation rule. According to his paper, through the study on relevant literatures related to purchasing problem, 50 different factors influencing the supplier performance were summarized, of which 23 standard factors for supplier evaluation were classified. Through the investigation on 273 purchasing managers and agents in Purchasing Managers Association of America (received 170 replies; effective recovery rate was 62.3%), 23 evaluation standards were sorted by Dickson based on the investigation result, as shown in Table 56.1.

In 1991, Weber made a statistics on the research results of 74 research literatures related to supplier selection standard (42 researches were published after 1985) written by various scholars after Dickson, and sorted the importance of various evaluation rules in these research results, as shown in Table 56.1. What shall be pointed out is Dickson and Weber studied the supplier evaluation standards in 1966 and 1991. Since different research methods are applied, sort orders of supplier evaluation standards are different. The difference in order should not be regarded as the change trend of evaluation standards along with the time. Particularly, the evaluation on suppliers in specific industry or enterprises shall be based on the environment and feature to choose reasonable evaluation standard and formulate practical sort order.

Seen from Table 56.1, it can be found that as to the sort order of 23 supplier evaluation indicators, Dickson analyzed more from the angle of actual corporate operation (on behalf of purchasing manager or purchasing agent); Weber mainly analyzed from the angle of theoretical circles (classified the literature results of academic circles after the paper of Dickson in 1967). Therefore, based on previous studies, the above supplier selection indicators are taken as the important evidence for the selection questionnaire of joint purchasing mode of SMEs in the paper. Meanwhile, according to the characteristics of SMEs, through the integration and modification of industrial expert opinions, the evaluation indicators are summarized into 16 factors such as: purchasing price, timely goods delivery, quality, management

Table 56.1 Sort order of importance of supplier selection standard by Dickson and Weber

Evaluation indicator	Investigation and classification by Dickson		Statistics on literature Review by Weber	
	Sort order	Relative important	Literature amount	Ratio
Quality	1	Very important	40	53%
Timely delivery	2	Quite important	44	58%
Historical performance	3	Quite important	7	9%
Guarantee and compensation	4	Quite important	0	0
Equipment and capacity	5	Quite important	23	30%
Price	6	Quite important	61	80%
Technical capacity	7	Quite important	15	20%
Financial status	8	Quite important	7	9%
Legal process	9	Quite important	2	3%
Communication system	10	Quite important	2	3%
Industry credibility and status	11	Important	8	11%
Urgency of transaction	12	Important	1	1%
Management and organization	13	Important	10	13%
Operation control	14	Important	3	4%
Maintenance service	15	Important	7	9%
Attitude	16	Important	6	8%
Impression	17	Important	2	3%
Packaging capacity	18	Important	3	4%
Record of labor relation	19	Important	2	3%
Geographic location	20	Important	16	21%
Previous transaction amount	21	Important	1	1%
Training help	22	Important	2	3%
Mutually beneficial arrangement	23	Not quite important	2	3%

Data source: Sun et al [13].

coordination capacity, technical capacity, industrial credibility and status, financial management status, historical performance, training help, purchasing information sharing, service efficiency, service attitude, after-sales service, credit, geographic location, guarantee and compensation.

56.3.2 Practice Evidence

Questionnaires were designed based on the 16 indicators and distributed to presidents of SMEs or corresponding directors of purchasing departments from Oct to Dec in 2011 (mainly Sichuan). 120 questionnaires were released, and 79 questionnaires were collected, of which there were 70 effective questionnaires. Recovery rate was 65.8%, and effective rate was 88.6%. Besides, 5-Liktert scale was used for evaluation indicator statistics (namely, 1: not important, 5: very important). Based on the classification of 70 effective questionnaires, SPSS17.0 statistical analysis software was used to analyze the credibility and validity.

(1) Validity analysis

KMO test and Bartlett test were used for the validity analysis while communalities of various questions were tested. The value of KMO statistics is the result of comparing sum of squares of simple correlation coefficient sum and sum of squares of partial correlation coefficient, which mainly explains the correlation among variables. KMO value is between 0 and 1. The value closer to 1 refers to higher correlation among variables, so the questionnaire is more suitable for factor analysis. KMO closer to 0 refers to weaker correlation among variables, so the original factors were more unsuitable for factor analysis.

KMO of the questionnaire is 0.814. According to the Kaiser's KMO Measuring Standard, (0.9: very suitable; 0.8: suitable; 0.7: intermediate; 0.6: not suitable; 0.5: very unsuitable), the KMO value of the questionnaire meets the requirement. Bartlett Degree of Sphercity Test: when the correlation coefficient matrix is unit matrix, Sig. value is 0.000, which is not statistically significant (0.05). There is correlation among variables suitable for factor analysis (see Table 56.2).

Table 56.2 KMO test and Bartlett Test on joint purchasing organization evaluation indicators

Bartlett Degree of Sphercity Test	Kaiser-Meyer-olkin Measurement on sampling sufficiency	.814
	Approximate Chi-square	544.259
	df	120
	Sig.	.000

(2) Credibility analysis

Cronbach's α is used as the test standard of credibility analysis. As a method to test the credibility, Cronbach's α, proposed by Lee Cronbach in 1951, is the commonest credibility analysis method in current social science study. According to Nunnally's (1978) research, the credibility evaluation standard of common explorative research is proposed. In common situation, Cronbach's α is over 0.6. The question for standard research with Cronbach's α of over 0.8 can be regarded as the questionnaire with high credibility.

Through Cronbach's α test, the coefficient of internal consistency is 0.895 (as shown in Table 56.3), which means the questions of the questionnaires are very ideal.

Table 56.3 Credibility statistics

Cronbach's α	Question number
.895	16

Table 56.4 Mean value, standard deviation and correlation coefficient of various evaluation indicators

Variable	Mean value	Sd	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1. Purchasing Price	4.0000	.96309	1															
2. Timely good delivery	4.1159	.75251	.380**	1														
3. Quality	4.4783	.71442	.253*	.517**	1													
4. Management coordination capacity	3.9130	.77533	.039	.291*	.494**	1												
5. Technical level	3.8406	.82748	.291*	.286*	.423**	.362**	1											
6. Industrial credit and status	3.9855	.80744	.112	.504**	.364**	.484**	.474**	1										
7. Financial management	3.9130	.82951	.236*	.364**	.437**	.529**	.444**	.496**	1									
8. Historical performance	3.6522	.83103	-.054	.250*	.305*	.448**	.488**	.468**	.587**	1								
9. Training help	3.3478	.81340	.259*	.100	.138	.439**	.405**	.272*	.431**	.458**	1							
10. Information sharing	3.6667	.86253	.314**	.216	.235	.347**	.210	.222	.405**	.142	.599**	1						
11. Service efficiency	3.9710	.85076	.265*	.413**	.524**	.348**	.549**	.379**	.407**	.416**	.329**	.362**	1					
12.Service attitude	3.9855	.77071	.254*	.503**	.539**	.313**	.383**	.326**	.270*	.286*	.262*	.276*	.596**	1				
13. After-sales service	4.08696775328330**			.579**	.631**	.302*	.428**	.303*	.417**	.272*	.205	.173	.619**	.730**	1			
14. Credit	4.1449	.76661	.137	.473**	.561**	.460**	.493**	.472**	.726**	.534**	.245*	.226	.540**	.494**	.540**	1		
15. Geographic location	3.5507	.95608	-.047	.153	.166	.026	.129	.104	.225	.259*	.052	.047	.216	.129	.229	.306**	1	
16. Guarantee and compensation	3.8507	1.01086253*		.444**	.481**	.286*	.496**	.506**	.630**	.392**	.291*	.363**	.423**	.377**	.497**	.554**	.324**	1

Note: * is significantly related (0.05) in horizontal level (double position), ** is significantly related (0.01) in horizontal level (double position).

(3) Test result

The main research objective is to find the most effective evaluation indicators for SMEs to choose or construct joint purchasing organization. Therefore, PCA (principal component analysis) is used to analyze the 16 questions involved in the research. However, the premise of PCA is that there is certain correlation among various questions. Therefore, before PCA, correlation of various questions shall be analyzed. Specific correlation among various questions is shown in Table 56.4.

Seen from Table 56.4, purchasing price is significantly related to timely goods delivery, product quality, technical level, information sharing and after-sales service; timely goods delivery has significant positive correlation with product quality, management coordination capacity, technical level, financial management, service efficiency, service attitude, after-sales service, credit, and guarantee and compensation; quality has significant positive correlation with management coordination capacity, technical level, industrial credibility and status, financial management, historical performance, service efficiency, service attitude, after-sales service, credit, and guarantee and compensation; management coordination capacity is significantly related to technical level, industrial credibility and status, financial management, historical performance, training help, information sharing, service efficiency, service attitude, after-sales service, credit, and guarantee and compensation; technical level has significant positive correlation with industrial credit and status, financial management, historical performance, training help, service efficiency, service attitude, after-sales service, credit, and guarantee and compensation. However, geographic location is not significantly related to other questionnaires.

56.4 Screening of Key Indicators

SPSS17.0 software is used in the paper for the validity analysis on the questionnaire. Bartlett statistical value is 544.259 (Sig. $0.000 < 0.05$). Therefore, there is correlation among various questions. After the correlation analysis, validity analysis is completed. According to the result, the joint purchasing organization had ideal evaluation indicators (Cronbach's $\alpha = 0.895$). Meanwhile, KMO value is 0.814. According to the Kaiser's measurement standard of KMO, original questions are suitable for factor analysis.

(1) Factor analysis

For simple and convenient factor explanation, variance maximization rotation is used. PCA is used to extract the factors based on the characteristic root > 1. The result is shown in Table 56.5.

As shown in Table 56.5, 66.828% of total variance is explained by purchasing price, timely goods delivery, product quality, and management coordination capacity. Meanwhile, total variance of each question is lower than 30%, leading to an ideal effect. 4 factors are extracted in the first time to explain 66.828% of total variance. Then, factor loading matrix is observed to find if there is the question with principal factor loading smaller than 0.5 but crossed loading greater than 0.4. If there is such a

Table 56.5 Explained total variance

	Initial characteristic value			Extract and load squares			Spin and load squares		
	Total	Variance	Accumulative	Total	Variance	Accumulative	Total	Variance	Accumulative
1	3.595	26.220	26.220	3.595	26.220	26.220	3.347	23.315	23.315
2	1.630	17.190	43.410	1.630	17.190	43.410	1.772	19.773	43.088
3	1.437	16.984	60.394	1.437	16.984	60.394	1.549	17.248	60.336
4	1.029	6.434	66.828	1.029	6.434	66.828	1.014	9.433	69.769
5	.912	5.702	72.530						
6	.804	5.024	77.554						
7	.640	4.003	81.557						
8	.546	3.411	84.968						
9	.521	3.259	88.226						
10	.434	2.715	90.941						
11	.351	2.192	93.133						
12	.298	1.863	94.995						
13	.271	1.696	96.692						
14	.220	1.375	98.067						
15	.191	1.194	99.262						
16	.118	.738	100.000						

Extract method: PCA

question, the question is not significantly related to the factor, which shall be deleted to simplify the question and increase the factor discrimination for better search of potential questionnaire type (dimension).

Table 56.6 Component matrix[a]

	Component			
	1	2	3	4
Purchasing price	**.665**	−.275	.343	.192
Timely goods delivery	**.646**	−.208	.033	−.116
Management coordination capacity	**.619**	.355	−.015	−.232
Financial management status	**.761**	.318	−.106	.097
Quality	−.319	**.710**	−.055	−.190
Technical capacity	.187	**.705**	.004	−.029
Purchasing information sharing	.177	**.724**	.285	.122
Industrial credibility and status	−.153	.170	**.667**	−.280
Credit	.292	−.006	**.797**	.014
Historical performance	.127	.325	**.659**	−.036
Training help	.014	.162	.226	**.621**
Service efficiency	.041	−.162	.068	**.736**
Service attitude	.179	−.399	.112	**.610**
After-sales service	.135	−.286	.015	**.712**
Guarantee and compensation	.122	.001	−.082	**.794**
Geographic location	.294	−.053	.765	−**.409**

Extract method: PCA, a. 4 components are extracted

Seen from Table 56.6, the last question shall be deleted. The second factor analysis is completed based on the deletion.

Table 56.7 KMO test and Bartlett Test on joint purchasing organization evaluation indicators

Bartlett Degree of Sphercity Test	Kaiser-Meyer-olkin Measurement on sampling sufficiency	.815
	Approximate Chi-square	540.024
	df	120
	Sig.	.000

As shown in Table 56.7, KMO value is still greater than 0.8. p value of Bartlett Degree of Sphercity Test is smaller than 0.001. The questions after the deletion still have good validity suitable for factor analysis.

Table 56.8 Explained total variance

	Initial characteristic value			Extract and load squares			Spin and load squares		
	Total	Variance	Accumulative	Total	Variance	Accumulative	Total	Variance	Accumulative
1	3.565	23.769	23.769	3.565	23.769	23.769	3.338	22.253	22.253
2	1.637	17.916	41.685	1.637	17.916	41.685	1.705	18.367	40.620
3	1.340	15.934	57.619	1.340	15.934	57.619	1.500	15.999	56.619
4	1.020	12.135	69.754	1.020	12.135	69.754	1.125	11.337	67.956
5	.833	5.551	72.305						
6	.696	4.638	77.942						
7	.606	4.037	82.980						
8	.532	3.550	87.530						
9	.424	2.827	90.357						
10	.359	2.394	92.751						
11	.285	1.900	94.650						
12	.270	1.798	96.448						
13	.224	1.494	97.942						
14	.190	1.266	99.208						
15	.119	.792	100.000						

Extract method: PCA

As shown in Table 56.8, 69.754% of total variance is explained by purchasing price, timely goods delivery, product quality, and management coordination capacity. Meanwhile, total variance of each question is lower than 30%, leading to an ideal effect. The same method is used to observe the factor loading matrix to find whether the extract result meets the requirement. Table 56.9 shows the rotated component matrix.

After 2 extractions, 4 extracted factors and the residual 15 questions meet the statistical requirements. Meanwhile, credibility analysis is carried out on the 15 questions, as shown in Table 56.10.

Table 56.9 Rotated component matrix[a]

	Component			
	1	2	3	4
Purchasing price	**.669**	.337	.299	.152
Timely goods delivery	**.664**	−.159	.370	.093
Management coordination capacity	**.593**	.292	−.286	.173
Financial management status	**.727**	.307	−.235	.078
Quality	−.150	**.749**	.199	.337
Technical capacity	.345	**.758**	.210	.155
Purchasing information sharing	.167	**.687**	−.030	.374
Industrial credibility and status	.134	−.166	**.616**	.238
Credit	−.122	−.056	**.850**	.145
Historical performance	.166	.076	**.637**	−.259
Training help	.363	.108	−.049	**.842**
Service efficiency	.263	.075	.153	**.759**
Service attitude	.198	−.091	.368	**.628**
After-sales service	.069	−.186	.382	**.743**
Guarantee and compensation	.210	.130	.013	**.794**

Extract method: PCA; rotation method: standard Kaiser's 4-rotation method: a. astringe after 6 iterations based on rotation

Table 56.10 Credibility statistics

Cronbach's α	Question number
.901	15

As shown in Table 56.10, the 15 questions have good credibility, so they can be regarded as the improved result of initial questionnaire. In other words, the questionnaire for the evaluation indicators of joint purchasing organization of SMEs have 4 dimensions consisted of 15 questions.

(2) Extraction of key indicators

Through the observation on the factor status of 15 questions, based on relevant professional knowledge of management, logistic management, and supply chain management, 4 factors are named as: operation management capacity, technical capacity, market influence capacity, and service capacity. As a result, various dimensions and indicators in the questionnaire for SMEs to evaluation the joint purchasing organization are shown in Table 56.11.

As shown in Table 56.11, purchasing price, timely goods delivery, management coordination capacity, and financial management status can be summarized into the operation management capacity of joint purchasing organization; product quality, information sharing, and technical level can be summarized into the technical capacity of joint purchasing organization; industrial credit and status, historical performance and credit can be summarized into the market influence of joint purchasing organization; training help, guarantee and compensation, service efficiency, service attitude, and after-sales service can be summarized into the service capacity of joint

Table 56.11 Joint purchasing organization evaluation dimension

Operation management capacity	Purchasing price Timely goods delivery Management coordination capacity Financial management status
Technical capacity	Quality Technical level Information sharing
Market influence capacity	Credit Industrial credit and status Historical performance
Service capacity	Training help Guarantee and compensation Service efficiency Service attitude After-sales service

purchasing organization. The 4 dimensions can be regarded as the key evaluation indicators for SMEs to choose or establish or improve joint purchasing organization.

Operation management capacity: financial management status directly influences the normal operation of joint purchasing organization. If the joint purchasing organization has poor financial status, many SMEs will refuse to participate in the organization for their fear of financial problem even when they are ready to participate in the organization. Financial management status is one of basic evaluation indicators. Purchasing price and timely goods delivery are acquired in the negotiation between the joint purchasing organization and suppliers, which are the key evaluation indicators evaluating the joint purchasing organization of SMEs. Management coordination capacity is the important reflection of work efficiency in joint purchasing organization [14]. The management coordination capacity of joint purchasing organization will influence the purchasing situation of SMEs and further influence the normal operation of SMEs.

Technical capacity: whether the joint purchasing organization can provide SMEs with products of reliable quality is the important indicator whether SMEs will continue to participate in or support joint purchasing organization, which reflects the technical situation of professional purchasing in the joint purchasing organization. Therefore, joint purchasing organization shall constantly supervise the product quality and further provide SMEs with steady product guarantee [15]. Informatization level of joint purchasing organization directly influences the information sharing degree in the joint purchasing degree, while smooth information communication influences the production decision of SMEs, so it is the soft indicator for the benefit evaluation. Technical level is the key evaluation indicator of technical capacity in joint purchasing organization.

Service capacity: training help refers to the training that the joint purchasing organization gives to staffs of SMEs on material performance and product knowledge.

Guarantee and compensation refers to a kind of support or compensatory service provided by the joint purchasing organization to the SMEs. When SMEs cannot pay for their purchasing due to temporary fund shortage, the joint purchasing organization can provide guarantee to them. When SMEs encounter serious problems in purchased products or service, the joint purchasing organization is responsible for these problems and investigates the responsibility of service or product suppliers for corresponding compensation [16]. Service efficiency is the evaluation on the timely response to demand of SMEs. The response speed directly influences the efficiency of production and operation decision in the enterprise. Service attitude is the important reflection of humanized service provided by joint purchasing organization to SMEs. After-sales service is one of factors evaluating the service capacity of joint purchasing organization for member enterprises.

Therefore, when SMEs choose the joint purchasing organization, they shall evaluate the joint purchasing organization from the 4 dimensions consisted of 15 indicators. If the 4 dimensions consisted of 15 indicators are ideal, the SMEs in West China shall participate in the organization; when the SMEs construct the joint purchasing organization, they shall improve the comprehensive capacity of the organization based on the 4 dimensions consisted of 15 indicators to further acquire more member enterprises, enhance the strength of joint purchasing organization, increase the bargaining power with suppliers, and better serve SMEs.

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Chapter 57
Pricing and Customer Returns Policies with Loss Averse Customers

Gulay Samatli-Pac and Wenjing Shen

Abstract Customer returns policies are common after sale services offered by a retailer in order to boost sales, improve customer satisfaction and diminish customer fit uncertainty. With such a service, the retailer accepts the return of a product after the sale has occurred, if it does not satisfy the customer's expectations. This paper studies a retailer's return policy problem when the market consists of loss-averse customers who are more sensitive to losses than gains. We examine the situation in which a seller makes price and quantity decisions and also designs an appropriate returns policy in order to maximize his profit. The seller may offer either a full-refund or a partial-refund policy if he decides to accept returns or chooses not to accept any returns. With the full-refund policy, the seller reimburses the consumer the full price of the product if it does not fit the customer's preferences. With a partial-refund policy, the seller offers a refund which is strictly less than the purchase price. We assume that customers are strategic customers aiming to maximize her utility of the product. Under this setting, this study analyzes the impact of loss aversion on the seller's price and order quantity decisions.

Keywords Consumer returns · Loss-averse customers · Pricing

57.1 Introduction

A store's return policy becomes an important factor in a consumer's purchasing decision as many products exhibit "personal fit uncertainty". For example, nowadays it is not uncommon at the retail level that a customer hesitates before buying a dress or a PC game since she is unsure if the dress will match her existing wardrobe or

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whether she will enjoy the PC game. Moreover, there exist cases such that a consumer purchasing a pair of shoes online is not happy with her purchase even it is in perfect condition because she was unable to realize the exact attributes like size, color, material from its description. Most of products like shoes, kitchen appliances, game controllers, DVD players need to be "experienced" by the consumers before they can be sure of their preferences. Such items are often referred to as "experience goods" [2]. The uncertainty about the benefits of this kind of a product decreases the willingness of a customer to purchase it, or may motivate a customer to search for a store offering a lower price and extra services. One such service is to accept the return of a product after the sale has occurred, if it does not satisfy the customer's expectations. Indeed, customer returns policies are pervasive in today's retail business environment. The value of goods returned by buyers in the U.S. during 2009 exceeded \$180 billion, about 8% of total sales (National Retailer Federation, 2009). Most returns are due to a mismatch between buyers' expectations and actual experiences. It is contended that between 11% and 20% of all the electronic items purchased are returned, though only about 5% of them are truly defective [8].

There are many types of return policies implemented in practice. Policies such as exchange only, all sales final, store credit, money back and charging restocking fees, are all commonly used these days by retailers. A money back guarantee allows customers to return a product and receive a full price refund. By offering this return policy, a seller provides customers information about the value of the product. Customers who have valuations greater than the purchase price will keep the product. The rest of the customers will return it. With such a guarantee, a retailer loses not only the potential revenue from returned products, but also may incur nonrefundable shipping and handling costs that increase its total costs. A mitigating feature of a money back policy is to charge a restocking fee to cover any processing and other related costs. In this case, the customer's risk due to product misfit and the firm's risk of excess inventory due to returned items are shared between the buyer and the seller.

Return policies tend to protect customers against product misfits and increase customer satisfaction. Thus, such policies may stimulate purchases. Customers are more likely to buy products from a retailer with a generous return policy. On the other hand, returns cause immediate operational consequences which may have a negative effect on retailer's revenue. They lead to an increase in inventories and handling costs. In addition, they are usually re-sold at discounted prices. In view of such tradeoffs, establishing return policies can be a delicate task for a retailer. The retailer's aim is to balance the benefits and costs of returns. Thus, the retailer needs to carefully select the price, if it is not exogenous, while simultaneously design a return policy to attract customers and reduce their risks without resulting in excessive return related costs to the firm. The problem of modeling consumer returns policies from the seller's perspective has received attention both in academic and in practice. These studies assume that consumers are risk-neutral while making their purchasing decisions. However, there exist many situations in which consumers focus more on possible losses than gains and show tendency to avoid any losses. In the literature, studies like Kahneman and Tversky [6], Thaler [12] and Kahneman et al [5] show that consumers are more sensitive to losses than gains so they are strongly prefer avoiding losses to acquiring gains. This implies that a person who losses \$100 lose more satisfaction than another person who gain \$100 windfall. This phenomenon which is called loss-aversion is empirically well-established under different settings and observed that it affects prominently how consumers behave when making decisions. For example, Putler [10] analyzes the effect of loss-aversion by studying the consumers' response to egg price changes and finds that the price-increase elasticity is about two and half times higher than the price-decrease elasticity. Furthermore, during the period that the credit-card companies charged transaction fees to each card purchase, Thaler [12] noted that the credit-card companies insist that any price difference between cash and card purchases should be labeled a cash discount rather than a credit surcharge since the same price difference is perceived as a gain in the former case but as a loss in the latter. He shows that from a customer point of view, it is always easier to give up a discount than to accept a surcharge. This is the reason why "late registration fee" is advertised more often than "discount for early registrations" to encourage early registrations for events.

Return policies may stimulate purchases since they protect customers against product misfits and increase customer satisfaction. On the other hand, returns may have a negative effect on a seller's revenue. They cause an increase in inventories and handling costs. In addition, returned products are usually sold at discounted prices. In view of such tradeoffs, establishing return policies for a seller can be a difficult task. The goal of a firm is to offer a return policy which attracts customers and reduces their risks without resulting in excessive return related costs to the firm.

In this paper, we examine the situation in which the seller sells a product to loss-averse consumers. The seller makes price and quantity decisions and also designs an appropriate returns policy in order to maximize his profit. We analyze the case where the seller offers either a full-refund or a partial-refund policy if he decides to accept returns or chooses not to accept any returns. With the full-refund policy, the seller reimburses the consumer the full price of the product if it does not fit the customer's preferences. With a partial-refund policy, the seller offers a refund which is strictly less than the purchase price. The difference between the full price and the refund amount may be interpreted as a restocking fee or a non-refundable charge that the seller imposes on consumers. A partial-refund policy introduces a new decision variable to the seller's problem. The seller's policy about returns and pricing directly influence consumers' purchase decisions. Each consumer who purchases at most one product faces an uncertainty in product valuation before she experiences the product. Like the seller, a consumer aims to maximize her utility of the product in question. We assume that consumers are loss-averse. Being loss-averse indicates that consumers are more sensitive to losses than gains. So, the utility function is much steeper for losses than gains. Before purchasing, a consumer cannot evaluate the product's utility which is a piecewise-linear decreasing function of the price. The return policy that the seller offers affects a consumer's purchasing decisions via her expected utility. Under this setting, we explore the following research questions

- What is the impact of loss aversion on the seller's price and order quantity decisions?

- How does loss aversion affect the equilibrium return policy?

The key contribution of this paper is to study consumer return policies with loss-averse customers. The model will help to understand that loss averse customers should not be treated like risk neutral consumers since both groups show different purchasing behavior and ignoring loss averse consumers might hurt the seller's profit.

The rest of this paper is organized as follows: Sect. 57.2 provides a related literature review and Sect. 57.3 introduces the basic model. In Sect. 57.4, we explore the equilibrium outcome when the seller chooses a no-refund, a full-refund or a partial-refund policy with loss-averse consumers. Sect. 57.5 summarizes the results and suggests future research extensions.

57.2 Literature Review

Our work is closely related to two research streams in the existing body of literature: consumer returns policies and loss-averse customers. A comprehensive review of the literature on returns policies is presented in [11].

A common assumption in the consumer return literature involves risk-neutral customers. However, it is well supported that in many situations customers are motivated by avoiding a loss than acquiring a similar gain. Kahneman and Tversky [6] is the first to study individual's evaluation of potential losses and gains. The paper models how people make choices when they face with alternatives that involve risk. From the empirical study, it is found that gains are evaluated differently losses and outcomes received by certainty are preferred more relatively to uncertain outcomes. Thaler [12] consider the same idea presented by Kahneman and Tversky [6] for decisions involving riskless choices. He observes that people often demand much more to give up and object than they would be willing to pay to acquire it. In other words, people put a higher value on objects that they own than that they do not. Thaler [12] labels this discrepancy as the endowment effect since the value of the object changes once it is incorporated in one's endowment. Loss-aversion term was first used by Kahneman and Tversky [7] to label the phenomenon that the disutility of giving up an object is greater than the utility associated with acquiring it.

Loss-aversion is the one of characteristics of consumer preferences which is observed in a variety of experimental situations like monetary gambles and the risky or riskless decisions. However, despite this broad literature, its effect on operational decisions has not been investigated. There are only couples studies which examine the effect of loss-aversion on pricing. Popescu and Wu [9] study the effect of loss-aversion on dynamic pricing strategies. Heidhues and Köszegi [3] investigate the monopolist's pricing strategy of a firm selling to loss-averse consumers, then extend the model to accommodate price competition with differentiated products [4].

In this study, we attempt to start filling the gap that the impact of loss-averse consumers on a seller's inventory and pricing decisions. We extend the classical newsvendor model in which a seller faces random market demand. We assume that the seller faces loss-averse consumers and determine whether to offer a return policy for consumers whose true valuation turns to be low after experiencing the product.

57.3 Model Development

We consider the classical newsvendor model on a single-period in which a seller faces random market demand x with the distribution function F. Each consumer in the market purchases at most one product or chooses not to buy it. A consumer does not evaluate the valuation of product until she experiences it. We assume that random valuations v are identically and independently distributed with the distribution G. The valuation is not known before the customer experiences the product. After she experiences the product, the true valuation is realized and she may decide to return the product for a refund if her valuation is lower than the refund. Thus, consumers make two sequential decisions. First, they decide whether to purchase the product. Then, consumers who buy the product decide whether to keep it after realizing the actual valuation. We consider that consumers are loss averse. Loss aversion reflects that consumers are more sensitive to losses than to gains. This characteristic of consumers' purchasing behavior results in a utility function that is steeper for losses than for gains. We consider a piecewise-linear loss aversion utility function as follows:

$$U = \begin{cases} v - p, & \text{if } v \geq p, \\ \lambda(v - p), & \text{if } p > v \geq r, \\ \lambda(r - p), & \text{otherwise,} \end{cases} \tag{57.1}$$

where $\lambda \geq 1$ indicates the degree the of loss aversion. A higher value of λ indicates consumers are more loss averse. If $\lambda = 1$, then consumers are risk neutral. We assume that consumers are homogeneous with the same degree of loss aversion. Consumers aim to maximize expected utilities. Studying the consumer's utility reveals that like in the case of risk neutral consumers, the consumer will keep the product if her realized valuation is at least as high as the refund. So, if the market demand is assumed as a mass of infinitesimal consumers, the probability of consumers who will return the product is equal to $G(r)$.

The seller determines the price p, order quantity q and return policy to maximize his expected profit at the beginning of selling season. A constant production cost, c is paid per each unit. All unsold items as well as returned items are salvaged in a secondary market with a salvage value $s < p$. The seller's profit function is as follows:

$$\begin{aligned} \pi(p,q,r) &= [pG(r) + (p - r + s)G(r)]E\min(x,q) + s(q - E\min(x,q)) - cq \\ &= [(p - s)G(r) + (p - r)G(r)]E\min(x,q) - (x - s)q. \end{aligned} \tag{57.2}$$

The profit function consists of profit from sold products, salvage from excess inventory and returns, refund paid for returns and production cost. In Equation (57.2), each unit sold and keep by the consumer yields profit p, whereas each returned item yields $(p-r)$ from the consumer and s from salvaging it. Each unsold unit also yields s. The last term is the seller's production cost.

The chronology of events is as follows. First, the seller determines the price p, order quantity q, and refund r if he chooses to offer a partial-refund policy. Second, stochastic market demand x is realized and $\min(x,q)$ units are sold. Then, consumers who purchase the product observe their individual valuations and decide whether to keep it or to return it if the seller offers any return policy. Finally, all unsold and returned products are salvaged.

The key difference of our model is that we study the effect of loss averse consumers on the seller's decisions when the latter offers a no-refund, a full-refund or partial-refund policy. The existing literature about consumer returns assumes that consumers are risk neutral. Recently, Su [11] studies partial-refunds for risk neutral consumers. In this paper, we adopt Su [11]'s model as a benchmark and demonstrate how loss-aversion changes the seller's optimal price and quantity.

57.4 Consumer Returns for Loss Averse Customers

57.4.1 No-refund Policy

We begin our analysis with the case in which the seller does not offer any return policy to consumers when the product does not fit their needs. In other words, the refund r is set to zero. So, the seller's problem includes only determining the optimal price and order quantity.

When returns are not accepted, the customer buys the product if only if her expected utility is positive, i.e. $EU(p;e=0) = Ev - p + (\lambda - 1)\int_0^p (x-p)dG(v)$, where Ev is the expected consumer valuation. Since, EU is monotonically decreasing in p, there exists a $p^N_{(\lambda)}$ such that $EU(p^N_{(\lambda)}) = 0$. This price is the highest price consumers are willing to pay. Thus, under a no-refund policy, it is optimal to charge $p^N_{(\lambda)}$ and order the news vendor quantity q^N such that $F(q^N_{(\lambda)}) = (p^N_{(\lambda)} - c)/(p^N_{(\lambda)} - s)$.

We begin to analyze the impact of loss aversion on the firm's purchasing price and order quantity. The following lemma shows that the relation between loss aversion and price and order quantity.

Lemma 57.1. *A firm charges a lower price and orders less quantity as customers get more loss averse.*

All proofs are provided in the appendix. Lemma 57.1 indicates that if the seller wants to sell to loss averse customers, then it should charge a lower price than to risk neutral customers. Since, loss averse customers pay more attention to losses, for a given price the expected utility for a loss averse customer is lower than that for a risk neutral which hinders the seller to charge higher prices. As a result of a lower selling price, the seller orders less quantity for loss averse customers.

57.4.2 Full-refund Policy

When the seller offers a full price refund, i.e. $r = p$ in case of misfit, a consumer utility is $v - p$ if $v \geq p$ zero otherwise. The utility is independent of a customer's degree of loss aversion. So, the analysis becomes the same for both loss averse and risk neutral customers as in [11].

The main question for the seller considering to accept returns as an option is whether it is profitable to allow returns with a full price refund instead of adopting an all-sales-final policy. Su [11] shows that if consumers are risk neutral, the seller prefers full-refund to no-refund only when the salvage value is sufficiently high, or when the production cost c is sufficiently high. However, as consumers get more loss averse, this proposition is violated for some customers, i.e. for some loss-aversion degree, and the seller becomes better off with a full-refund policy for all salvage value or production cost. With the following lemma, we show that there always exists a threshold $\bar{\lambda}$ such that a full-refund policy yields a higher profit than a no-refund policy for more loss averse consumers.

Lemma 57.2. *There exists a $\bar{\lambda}$ such that if $> \bar{\lambda}$, then the seller's profit with a full-refund policy is always higher than that with a no-refund policy.*

Lemma 57.2 proves that if consumers' loss-aversion is high, then the full-refund policy is always a better choice for the firm regardless of the salvage value or the cost. This result shows that when the market is full of lose averse customers then the firm needs to offer an aggressive refund policy to compensate consumers' respond than when the market includes risk neutral consumers. There are two variables that may affect the firm's refund decision with respect to consumers' type, in other words the threshold value of loss aversion: salvage value and production cost. When the firm's salvage opportunity gets higher $\bar{\lambda}$, decreases. Thus, the full-refund policy becomes more profitable for a wide range of consumers. On the other hand, the production cost does not affect $\bar{\lambda}$ since the prices do not depend on it. The following lemma summarizes the behavior of $\bar{\lambda}$ with respect to salvage value and the cost.

Lemma 57.3. *$\bar{\lambda}$ decreases as salvage value increases, whereas it is not affected by the cost.*

Next, we will provide numerical example to show the effect of salvage value and the production cost on the seller's optimal profit under a no- and full-refund policy.

Numerical example with no-refund and full-refund policies

We assume that the consumer valuations are uniformly distributed between 0 and 1, i.e., $v \sim U(0,1)$. The unit cost of the product is set to 0.2. The aggregate demand function is also assumed to be a uniform distribution between 0 and 1, i.e., $x \sim U(0,1)$. The uniform valuation function will allow us to have a closed form for price and quantity variables. So, we will be able to make a comparison. Su [11] shows that when consumers are risk-neutral, the seller prefers the no-refund policy to the full-refund policy either product cost is sufficiently low, or salvage value is sufficiently low. Here, we will investigate numerically whether this result is valid when consumers are loss averse. Fig. 57.1 shows the seller's optimal profits with

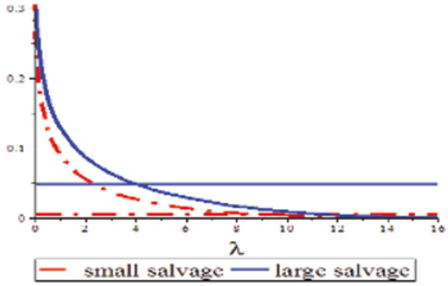

Fig. 57.1 The seller's optimal profits with no-refund and partial-refund

no-refund and partial-refund policies for a small and large salvage value, $s = 0$ and $s = 0.15$ respectively when $c = 0.2$. As seen in the figure, when consumers are less loss averse, e.g. small λ, the no-refund policy yields a higher profit than the full-refund policy. On the other hand, the full-refund policy dominates if consumers' loss aversion is high, e.g. large λ. This result is true for both small and large salvage values.

57.4.3 Partial-refund Policy

In this section, we will allow the seller to choose a refund between zero and the selling price. A partial-refund policy represents the case in which the seller imposes a restocking fee or a non-refundable charge on customers. Under this policy, the partial-refund amount r is incorporated as a new decision variable in the model.

The seller maximizes his expected profit given by Equation (57.2) subject to the participation constraint $EU(p;r) \geq 0$ so that consumers are willing to buy the product. To induce consumers to buy, the highest price that the seller can charge is $p^p_{(\lambda)}$ that binds the participation constraint. Thus, the optimal price $p^p_{(\lambda)}$ is the solution of $EU(p^p_{(\lambda)};r) = 0$. Given the optimal price, the seller's problem of determining the optimal refund and the order quantity becomes separable decisions. The seller maximizes the expression $(p^p_{(\lambda)} - s)\bar{G}(r) + (p^p_{(\lambda)} - r)G(r)$ to find the optimal refund r^p. Finally, solving the resulting seller's profit in q provides the optimal order quantity q^p such that $F(q^p_{(\lambda)}) = (p^p_{(\lambda)} - c)/(p^p_{(\lambda)} - s)$. The following lemma characterizes the seller's optimal decisions under a partial-refund policy.

Lemma 57.4. *The seller's optimal price, $p^p_{(\lambda)}$, solves the following equation:*

$$EU(p^p_{(\lambda)};r) = \ Ev - p^p_{(\lambda)} + (\lambda - 1)\int_0^{p^p_{(\lambda)}} (v - p^p_{(\lambda)})dG(v) + \lambda \int_0^r (r - v)dG(v)$$

and the optimal refund, r^p, and quantity, q^p, are obtained by:

$$r^p = argmax_r[(p^p_{(\lambda)} - s)\bar{G}(r) + (p^p_{(\lambda)} - r)G(r)], \tag{57.3}$$

$$\bar{F}(q^N_{(\lambda)}) = \frac{(c-s)}{(p^p_{(\lambda)}-s)\bar{G}(r)+(p^p_{(\lambda)}-r)G(r)}. \tag{57.4}$$

To gain more insight about how the loss aversion changes optimal price and order quantity, we analyze how the loss-aversion degree changes price and order quantity.

Lemma 57.5. *The optimal price and quantity are decreasing in λ for a given refund.*

Lemma 57.5 shows that the optimal price and order quantity decrease as the degree of loss aversion for any refund amount r. The seller charges a lower price and orders less quantity with a partial-refund policy than when customers are loss averse than when they are risk neutral. This result is not surprising since loss averse consumers are more concerned about their losses and their willingness to pay are lower than risk neutral consumers. So, the seller needs to charge a lower price to attract these consumers if he is not willing to change the refund. If the seller optimizes the refund along with the price and quantity, then his respond to change in customer behavior will not necessarily be the same as stated in Lemma 57.5. In Sect. 57.4.3, we will analyze the seller's behavior for uniformly distributed customers valuations and uniform demand.

Lemma 57.6. *The optimal refund is greater than the salvage value.*

In the following section, we will investigate the impact of offering partial-refund on the seller's decision variables and we compare them with the full-refund policy.

Numerical example with partial-refund policy

For the numerical example, we will use the same setting that used in Sect. 57.4.2. Table 57.1 shows the optimal prices, quantities, profits and refund amount for partial-refund and full-refund policies. Like Su [11] showed for risk-neutral consumers, the profit and the order quantity under the partial-refund policy are always higher than those with the full-refund policy since the partial refund is strictly less than the full price. These results are valid for all consumers type with different loss-aversion degree. As seen in Table 57.1, the difference between the partial- and full-refund profits diminishes as consumers' loss aversion increases. In addition, the optimal refund under the partial-refund policy converges to the optimal price as loss-aversion degree increases. In other words, as consumers become more sensitive to their loss, the seller begins to offer more generous refunds with the partial-refund. Meanwhile, an increase in the refund amount has a positive effect on the price. So, both the price and refund amount rise as consumers get more loss averse. The partial refund amount can rise up to the refund amount equal to the price. Thus, for a comparatively large loss-aversion degree, a partial-refund becomes almost as same as the full-refund policy.

The following lemma shows that there exists a threshold loss-aversion degree such that the partial-refund policy converges to the full-refund policy.

Lemma 57.7. *There exist a $\tilde{\lambda}$, such that if $\lambda > \tilde{\lambda}$, then the refund amount and the purchase price becomes equal. Thus, the partial-refund policy converges to the full-refund policy. $\tilde{\lambda}$ decreases with the salvage value, whereas is not affected by the unit cost.*

Table 57.1 The optimal prices, quantities, profits and refund for partial-refund (PR) and full-refund (FR) policies

Small salvage						
	$\lambda = 3$		$\lambda = 10$		$\lambda = 50$	
	PR	FR	PR	FR	PR	FR
p	0.366	0.500	0.446	0.500	0.485	0.500
r	0.000	0.500	0.410	0.500	0.480	0.500
q	0.450	0.200	0.280	0.200	0.220	0.200
Π	0.038	0.005	0.011	0.005	0.006	0.005
Large salvage						
	$\lambda = 3$		$\lambda = 10$		$\lambda = 50$	
	PR	FR	PR	FR	PR	FR
p	0.461	0.575	0.540	0.575	0.563	0.575
r	0.340	0.575	0.520	0.575	0.560	0.575
q	0.800	0.723	0.750	0.723	0.730	0.723
Π	0.078	0.047	0.055	0.047	0.049	0.047

Another result that can be seen from Table 57.1 is the behavior of the optimal price and refund. In Lemma 57.5, we show that the optimal price and quantity decrease with an increase in loss-aversion if the seller is not willing to change his refund amount. This result is no longer valid if the seller optimizes the refund along with the price and quantity. As seen in the Table 57.1, the optimal refund rises as consumers become more loss averse. In addition, the optimal price increases due to the increase in the refund. This behavior is shown analytically for uniform valuation in appendix. However, the revenue from returns does not increase. In addition, either the optimal quantity or the profit is not positively affected by the increase in price and refund.

57.5 Conclusions

In this paper, we study consumer returns policies when consumers are more sensitive to losses than gains. We examine the situation where loss averse consumers face uncertainty in their valuations of the product until they experience it. When a consumer has a return option, she keeps the product only if she has a positive utility of it. Thus, the presence of a return policy and a consumer's loss averse behavior directly affects her expected utility of the product. The seller decides to offer a return policy or not and determines the purchasing price and order quantity for the corresponding setting. If the seller decides to offer a partial-refund policy instead of a no-refund or a full-refund policy, he needs to determine the optimal refund along with the price and order quantity. We adopt Su [11]'s model as a benchmark and demonstrate how loss-aversion changes the seller's optimal price and quantity. Our major findings are summarized below:

- Regardless of return policies, the seller needs to compensate consumers' sensitivity to losses by lowering the purchasing price.
- Loss-aversion forces the seller to keep fewer inventories.
- As consumers get more loss-averse, the full-refund policy becomes more profitable to the seller if a partial-refund is not option.
- Under the partial-refund policy, the seller needs to offer a larger refund if consumers are loss-averse than is they are risk neutral.
- The seller needs to offer a larger partial-refund amount when consumers are loss-averse.
- Under the partial-refund policy, the optimal refund converges to the optimal price as loss aversion degree increases.
- The optimal refund and price may rise as consumers become more loss averse while the optimal quantity and profit decrease.

There are several possible extensions of our research. Future research may focus on reducing uncertainty about product utility and ft. One way to reduce the uncertainty is to better inform the consumer before purchase, or to offer a trial period so that the consumer has less hesitation to purchase the product. In addition, our model can be extended to study a supply chain scenario. A manufacturer which supplies a product to a retailer may contract with the retailer which chooses its retail price and return policy. The effects of the manufacturer's contract type on the performance of the supply chain can then be studied. Ignoring the impact of ignoring loss averse customers in a monopoly and competition are other extensions that can be examined.

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Appendix

Proof of Lemma 57.1:

Proof. It is sufficient to show that p^N and q^N are decreasing in λ. $p^N_{(\lambda)}$ is the unique solution of:

$$EU(p;R=0) = Ev - p + (\lambda-1)\int_0^p (v-p)dG(v).$$

The implicit function theorem yields:

$$-\frac{\partial p}{\partial \lambda}(1+(\lambda-1)G(p)) + \int_0^p (v-p)dG(v) = 0.$$

Since $\int_0^p (v-p)dG(v) \le 0$ and $1+\int_0^p (v-p)dG(v) > 0$, $\frac{\partial p}{\partial \lambda} \le 0$ Similarly, for $c \ge s$,

$$-\frac{\partial q^N_{(\lambda)}}{\partial \lambda} = \frac{\partial p^N_{(\lambda)}}{\partial \lambda} \cdot \frac{c-s}{(p^N_{(\lambda)}-s)^2 f(q^N_{(\lambda)})} \le 0.$$

□

Proof of Lemma 57.2:

Proof. The profit of full-refund policy is independent of λ whereas the optimal profit of no-refund policy monotonically decreases. That is:

$$\frac{\partial \pi F}{\partial \lambda} = 0,$$
$$\frac{\partial \pi N}{\partial \lambda} = \frac{\partial p^N_{(\lambda)}}{\partial \lambda} E\min(X,q) + \frac{\partial q^N_{(\lambda)}}{\partial \lambda}((p^N_{(\lambda)}-s)\bar{F}(q^N_{(\lambda)}) - (c-s)) \le 0.$$

When $\lambda = 1$ and salvage value is small, no-refund policy yields a higher profit than the full- refund policy [11]. As λ increases, the optimal price with a no-refund policy decreases and converges to the unit cost of the product which yields zero profit to the seller. Thus, there exist a $\bar{\lambda}$ such that for $\lambda \leq \bar{\lambda}$, the no-refund policy profit yields a higher profit than the full-refund policy and for $\lambda > \bar{\lambda}$, the profit with a full-refund policy is higher than that with a no-refund policy. Thus, $\bar{\lambda} = 1$. In fact, for any salvage value, the threshold point is the unique solution of $H(\lambda, s) = (p^F - s)G(p^F) - (p^N_{(\lambda)} - s) = 0$. $\square$

Proof of Lemma 57.3:

Proof. For a given λ, $H(\lambda, s)$ increases with the salvage value, i.e. $\frac{\partial H(\lambda,s)}{\partial s} = -\bar{G}(p^F) + 1 \geq 0$. Therefore, $\bar{\lambda}$ should decrease in order to have a larger p^F and satisfy $(p^F - s)\bar{G}(p^F) - (p^N_{(\lambda)} - s) = 0$.

On the other hand, since $(p^F - s)\bar{G}(p^F)$ and $p^N_{(\lambda)}$ are independent of the cost c, $\bar{\lambda}$ does not change with c. $\square$

Proof of Lemma 57.4:

Proof. The firm's expected profit is $[(p-s)\bar{G}(r) + (p-r)G(r)]E\min(x,q) - (c-s)q$. The optimal price and refund maximizes the expression $[(p-s)\bar{G}(r) + (p-r)G(r)]$, subject to $EUp(v,p) \geq 0$. The firm will charge the maximum price that consumers are willing to pay such p^p that:

$$EU(p^p; r) = Ev - p^p + (\lambda - 1)\int_0^{p^p} (v - p^p)dG(v) + \lambda \int_0^r (r - v)dG(v) = 0.$$

The first order derivative of $[(p-s)\bar{G}(r) + (p-r)G(r)]$ for the refund is $\frac{\partial p^p}{\partial r} - G(r) - g(r)(r-s)$. So, the optimal refund r^p is the solution of $\frac{\partial p^p}{\partial r} - G(r) - g(r)(r-s) = 0$. Finally, the optimal order quantity q^p such that $F(q^p) = \frac{p^p_{(\lambda)} - c}{p^p_{(\lambda)} - s}$ is obtained by solving the seller's profit in q. $\square$

Proof of Lemma 57.5:

Proof. $p^p_{(\lambda)}$ is the solution of:

$$EUp(p;r) = \int_0^{\infty} (v-p)dG(v) + \lambda \int_r^p (v-p)dG(v) + \lambda \int_0^r (r-p)dG(v) = 0.$$

With the implicit theorem,

$$-\frac{\partial p^p}{\partial \lambda}(1 + (\lambda - 1)G(p)) + \int_r^p (v-p)dG(v) + \int_0^r (r-p)dG(v) = 0.$$

So, $\frac{\partial p^p}{\partial \lambda} \leq 0$. Similarly,

$$\frac{\partial q^p}{\partial \lambda} = \frac{\partial p^p_{(\lambda)}}{\partial \lambda} \frac{(c-s)}{((p^p_{(\lambda)} - s)\bar{G}(r) + (p^p_{(\lambda)} - r)G(r))^2} f(q^p_{(\lambda)}).$$

$\square$

Proof of Lemma 57.6:

Proof. Since

$$\frac{\partial p^p}{\partial r} = \frac{\lambda G(r)}{\lambda G(p) + G(p)}$$

from the implicit function theorem applied to $EUp(p;r) = 0$, the first order condition for r can be written as:

$$G(s)\frac{\lambda G(r)}{\lambda G(p) + G(p)} - g(r)(r - s) \leq 0.$$

At $r = s$, the first order condition, i.e. $G(s)\frac{\lambda G(r)}{\lambda G(p)+G(p)}$, is greater than zero. Thus, the optimal refund is not equal to s. Indeed, it should be larger than s. □

Proof of Lemma 57.7:

Proof. When $\lambda = 1$, $q^p_{(\lambda)} > q^F$ [11]. The price of a partial-refund policy monotonically decreases and converges the partial-refund amount as λ increases. Thus, the partial-refund becomes as same as the full-refund policy. Let $\tilde{\lambda}$ be the solution of:

$$H(\lambda, s) = (p^F - s)\bar{G}(p^F) - ((p^p_{(\lambda)} - r)G(r) + (p^p_{(\lambda)} - s)\bar{G}(r)) = 0,$$

then for $\lambda > \tilde{\lambda}$, the partial-refund amount will be equal to the price. For a given λ, $H(\lambda, s)$ increases with the salvage value. Thus, $\tilde{\lambda}$ decreases with the salvage. On the other hand, $\tilde{\lambda}$ does not change with the cost since the cost does not affect $(p^F - s)\bar{G}(p^F)$ or $p^p_{(\lambda)}$. □

Behavior of the optimal price and refund of the partial-refund policy: Assume consumers' valuations are uniformly distributed in $[0,1]$. Then, the optimal price of a partial refund is given by:

$$p^p = \frac{-1 + \sqrt{\lambda^2 r^2 + \lambda - \lambda r^2}}{\lambda - 1}.$$

Observing the derivative of the optimal price with respect to the refund amount, it can easily be seen that the price increases as the refund amount and decreases with the λ for a given refund.

The first order condition for the optimal refund is derived from the Equation (57.3) as follows $\frac{\partial p^p}{\partial r} + s - 2r = 0$.

Applying the implicit function theorem with respect to λ to the first order condition for the optimal refund is equal to $\frac{\partial^2 p^p}{\partial r \partial \lambda} > 0$, which can be easily be seen by observing the optimal price.

$\frac{\partial^2 p^p}{\partial r \partial \lambda} > 0$ means that as the optimal refund increases as λ. Hence, the optimal price increases as λ, too.

Chapter 58
Research Review and Prospect of Corporate Social Responsibility and Consumers' Purchase Intention

Yachun Xu, Weiping Yu and Yan He

Abstract Since the late 1990s, with the international community paying more and more attention to Corporate Social Responsibility (CSR), academic circles keep a watchful eye on the influence of CSR on consumers' attitude and behavior. Previous studies show there is complex relationship between CSR and Consumers' Purchase Intention. Before 2001, scholars found that CSR influenced Consumers' Purchase Intention indirectly. In 2001, they proved that the performance levels of CSR had a direct impact on Consumers' Purchase Intention. But this kind of direct influence was limited by some factors such as the degrees that consumers trusted on CSR and corporate ability as well as the ones that the consumers supported CSR behavior. This paper analyzed and summarized the concepts of CSR, indirect and direct influences, influencing factors along with influencing mechanism, then pointed out the limitations and the future directions of the research.

Keywords Corporate social responsibility · Consumers' purchase intention · Influencing mechanism

58.1 Introduction

Since the 1999 s, the CSR movement are set off all over the world. Being the most important stakeholders, consumers are influenced by CSR measures mostly. Con-

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sumers' views and responses to CSR have important influence on promoting corporates to assume CSR positively. In order to be understood better the relationship between CSR and Consumers' Purchase Intention, it may be necessary to define CSR firstly.

Definitions of CSR

CSR is a broad concept and it is a concept that has no universally accepted definition [1]. Bowen has been acknowledged as the first scholar to have written a manuscript on the topic of corporate responsibilities [2]. He claimed that businesses have the obligation to "pursue those policies, to make those decisions, or to follow those lines of action which are desirable in terms of the objectives and values of our society". Mohr et al [3] grouped the definitions into two general types: (1) multidimensional definitions and (2) definitions based on the concept of societal marketing. Multidimensional definitions delineate the major responsibilities of companies [3].

The societal marketing concept can be used to define CSR at a more abstract level. Kotler [4] defined the societal marketing concept as doing business in a way that maintains or improves both the customer's and society's well-being. Petkus and Woodruff [5] extended this concept, defining CSR to include both avoiding harm and doing-good. Table 58.1 shows us the definitions of CSR:

Of these, Carroll's work [2, 6] has received the most attention. He suggests that CSR includes four kinds of responsibilities or dimensions like Table 58.2: economic, legal, ethical and philanthropic.

58.2 Effects of CSR on Consumers' Purchase Intention

58.2.1 Relationship between CSR and Consumers' Purchase Intention

Over the years, studies of relationship between CSR and Consumers' Purchase Intention have become hot spot in academic circles [7, 8].

A study by Walker research finds that 88 percent of U.S. consumers are more likely to buy from a company that is socially responsible [9]. Similarly, a survey by the Council on Foundations indicates that 16 percent of U.S. consumers claim to seek do-gooders when shopping while another 40 percent find corporate citizenship to be a tie breaking activity (Council on Foundations, 1996).

The 2002 Corporate Citizenship poll conducted by Cone Communications finds that "84% of Americans say they would be likely to switch brands to one associated with a good cause, if price and quality are similar." Similarly, a 2001 Hill & Knowlton/Harris Interactive poll reveals that "79% of Americans take corporate citizenship into account when deciding whether to buy a particular company's product and 36% consider corporate citizenship an important factor when making purchasing decisions [10]."

Table 58.1 Definitions of CSR

Researchers (year)	Definitions of CSR
Bowen (1953)	The obligations of businessmen to pursue those policies, to make those decisions, or to follow those lines of action which are desirable in terms of the objectives and values of the society.
Friedman (1962)	CSR is simply carrying out actions that increase profits while respecting the rules of the game.
McGuire (1963)	Firms have responsibilities towards their environment that go beyond their legal and economic obligations.
Davis (1973)	The firm's considerations of, and response to, issues beyond the narrow economic, technical, and legal requirements of the firm to accomplish social benefits along with the traditional economic gains which the firm seeks.
Wood (1991)	A business organization's configuration of principles of social responsibility, processes of social responsiveness, and policies, programs, and observable outcomes as they relate to the firm's social relationship.
Petkus and Woodruff (1992)	A company's commitment to minimizing or eliminating any harmful effects and maximizing its long-run beneficial impact on society.
Carroll (1999)	Social economic (to be profitable), legal (to obey the law), ethical (to adopt moral values) and philanthropic (to be a good citizen-corporate) responsibilities.
McWilliams and Siegel (2001)	A company's voluntary activities "that appear to further some social good, beyond the interests of the firm and that which is required by law"
Mohr and Harris (2001)	A company's commitment to minimizing or eliminating any harmful effects and maximizing its long-run beneficial impact on society.
Commission of the European Communities (2001)	A concept whereby companies integrate social and environmental concerns in their business operations and in their interaction with their stakeholders on a voluntary basis.
Carroll and Buchholtz (2002)	CSR encompasses the economic, legal, ethical, and philanthropic expectations placed on organizations by society at a given point in time.
Smith (2003)	Obligations of the firm to society, or more specifically, the firm's stakeholdersłthose affected by corporate policies and practices.
Berens et al (2005); Salmones et al (2005)	Moral obligations that maximize the positive influence of the firm on its social environment and minimize the negative influence.
Falck and Heblich (2007)	CSR is that the corporation "cares and wants to do good things". And "can do well by doing good".
Sorsa (2008)	CSR refers to some defined specific social relations (the social), with some specific normative foundations (the responsibility), of business (the corporate).

[a] Source: collected from relevant data.

Table 58.2 Four domains of CSR

Domains of CSR	Description of responsibility
Economic	Generating profit by producing goods and services and effectively managing the business
Legal	Complying with minimum standards of behavior set in law (which is a system of codified ethics)
Ethical	Acting according to societal norms, standards and expectations in regard to what is seen as moral or just behavior
Philanthropic	Undertaking philanthropic activities that go beyond legal and ethical societal expectations in order to be a good corporate citizen

[a] Source: adapted from Carroll [2, 6].

These polls suggest that a positive relationship exists between a company's CSR actions and Consumers' Purchase Intention [11], and the positive link of CSR to consumer patronage is spurring a company to devote greater energies and resources to CSR initiatives. Further, these findings are corroborated by a growing body of academic research that attests to the generally positive influence of CSR on consumers' company evaluation and purchase intention [12].

58.2.2 Indirect Effect of CSR on Consumers' Purchase Intention

Before 2001, some scholars found that CSR influenced Consumers' Purchase Intention indirectly. Interesting findings are brought about by Brown and Dacin [11] who demonstrate in an experiment that negative corporate responsibility associations have a detrimental effect on overall product evaluation, whereas positive corporate responsibility associations can enhance product evaluations. Different CSR grades lead to different evaluations. A high CSR grade leads to a higher corporate evaluation. Consumers evaluate the companies with the higher grade of CSR more highly than the lower grade of CSR, and the evaluation results affect consumers evaluate the company's product significantly, hereby affect Consumers' Purchase Intention [13].

Simultaneously, Brown and Dacin [11] find that consumers' view on CSR can affect their beliefs and the attitudes to the new products. Ethical behaviors of a firm are important considering factors when consumers decide to buy something. Consumers will reward ethical behaviors by paying higher prices for an ethical company's products although they may buy an ethical company's ones; they want to do so at lower prices which, in effect, punishes an unethical action [14]. The descriptions of unethical behaviors (i.e., employing child labor) lead to negative attitudes toward the firm regardless of whether products' quality is described as high or low. That's to say, firms' moral behaviors influence consumers' attitudes. Generally speaking, CSR behaviors have three types: the commitment to family, community and countries.

They cause consumers to support enterprises, so as to influence Consumers' Purchase Intention [15].

Table 58.3 Indirect effect of CSR on consumers' purchase intention

Researcher	Title of composition	Independent variable	Dependent variable	Mediating Variable
Brown and Dacin (1997)	The company and the product: Corporate associations and consumer product responses	Corporate Associations	Consumers' Response	Consumers' Beliefs
Lafferty and Goldsmith (1999)	Corporate Credibility's Role in Consumers' Attitudes and Purchase Intentions	Consumers' Attitudes	Purchase Intention	Corporate Credibility
Handelman and Arnold (1999)	The Role of Marketing Actions With a Social Dimension	CSR Behaviors	Consumers' Purchase Intention	Consumers' Support

[a] Source: collected from relevant data.

To summarize the researches before 2001, scholars found that CSR influenced Consumers' Purchase Intention indirectly. The studies show that (1) Most of consumers appreciate and support firms' ethical behaviors; (2) Firms' CSR behaviors can affect Consumers' Purchase Intention partially, CSR has an indirect impact on Consumers' Purchase Intention by intermediate variables like Product Evaluation, Brand Image, and Customer Loyalty, and so on.

58.2.3 Direct Effect of CSR on Consumer Purchase Intention

In 2001, Sen and Bhattacharya's study [12] is very important. They prove that the performance levels of CSR have a direct impact on Consumers' Purchase Intention, but this kind of direct influence is limited by some factors such as consumers trust, and corporate ability (CA) as well as consumers support.

Becker-Olsen's study show the fit rates of CSR activities, enterprise products and brand image affect on consumer attitude and purchase intention. They find that low-fit initiatives impact consumer beliefs, attitudes, and purchase intentions negatively no matter what the firm's motivation is, and that high-fit initiatives that are profit-motivated have the same impact. Furthermore, consumers consider the timing of the social initiative as an informational cue, and only the high-fit, proactive initiatives lead to an improvement in consumer beliefs, attitudes and purchase intentions [8].

Yeosun [16] prove this, CSR activities can improve company image when consumers think company's motives are sincere, however, CSR activities can damage company reputation when insincere motives are perceived. When the information of products is not clear, consumers try to evaluate new products through CSR information. When consumers evaluate CSR activities positively, they evaluate enterprise's products highly.

Some scholars [12] find some consumers are more likely to respond to CSR record when they identify with the company. It is more sensitive for consumers to evaluate the company with negative CSR information than positive one. More than that, but consumers are more sensitive to "irresponsible" than to "responsible" corporate behaviors. There is an asymmetric effect on "doing bad" hurts more than "doing good" helps.

Most consumers are unwilling to pay a price premium for the products of a socially responsible company, certain consumers do acknowledge a willingness to pay more:"When you go in to Kay Jeweler's and buy something, you spend another 20 dollar more $\cdots$ you're prompted to spend more because you think it's going to go for a good cause" [17].

Nevertheless, Mario's empirical study show consumers are willing to choose products which firms engage in CSR, in some cases consumers pay for higher price willingly [18]. Bonini [19] shows that records of enterprises solving environmental and climate change issues not only make consumers to trust enterprise, but also make them be willing to buy this kind of firms' products. Vanhamme and Grobben [20] finds that consumers are more willing to buy and support the products of companies with long CSR history than with short one. On the contrary, consumers suspect firms with a short CSR history.

Chinese scholars like Zhou find CSR activities (including treating employees kindly, environment protection and charity donation, etc.) are different, the effect of CSR on Consumers' Purchase Intention is significant [27]. From the above, scholars think generally that the relationship between CSR and Consumers' Purchase Intention is correlated positively, firms' irresponsible behaviors influence on Consumers' Purchase Intention negatively [3, 15], firms' responsible behaviors influence on consumers evaluation to industry and consumer purchase intention positively. CSR activities are beneficial to build consumers' trust, thus CSR behaviors affect on consumers' purchase intention directly or indirectly, so we suggest companies should take the relationship between CSR and Consumers' Purchase Intention seriously and fulfill social responsibility in order to improve the enterprise competitiveness.

58.3 Main Influencing Factors of the Relationship between CSR and Consumers' Purchase Intention

58.3.1 Price

Scholars find consumers will choose responsibility products under the same price condition. When prices are rising, Consumers' Purchase Intention will be changed accordingly. One study shows that even if consumers' social responsibility consciousness is high, they are sensitive to price. It means that the degree of consumers'

Table 58.4 Direct effect of CSR on consumer purchase intention

Researchers (year)	Title of composition	Independent variable	Dependent variable	Mediating variable
Sen and Bhattacharya (2001)	Does Doing Good Always Lead to Doing Better? Consumer Reactions to Corporate Social Responsibility	CSR Initiatives	Consumers' Response	Consumers' Individual characteristics, CSR-CA Beliefs, CSR- Support
Bhattacharya and Sen (2004)	Doing Better at Doing Good: When, Why and How Consumers Respond to Corporate Social Initiatives	Corporate Social Initiatives	Consumer Reactions	Perceived Motives
Mohr and Webb (2005)	The Effects of Corporate Social Responsibility and Price on Consumer Responses	CSR and Price	Consumer Responses	Consumer Evaluation
Becker-Olsen ret al (2006)	The impact of perceived corporate social responsibility on consumer behavior	Perceived CSR	Consumer Behavior	Perceived Motivation
Yoon et al (2006)	The Effect of Corporate Social Responsibility (CSR) Activities on Companies With Bad Reputations.	CSR Activities	Companies With Bad Reputations	Perceived Motives
Siltaaja (2006)	Value Priorities as Combining Core Factors Between CSR and Reputation-A Qulitative Study	CSR	Companies' Reputation	
Bonini et al (2008)	Addressing consumer concerns about climate change	CSR Activity	Consumers' Purchase Intention	Consumer Trust
Vanhamme and Grobben (2009)	Too Good to be True! The Effectiveness of CSR History in Countering Negative Publicity	CSR History	Negative Publicity	

[a] Source: collected from relevant data.

CSR-support becomes weak when consumers need to pay for high price [21]. When the price of products match the quality of products, consumers choose responsibility products. When responsibility products are at a premium, Consumers' Purchase Intention will be reduced. When choosing the products of enterprises with different levels of CSR, consumers consider the price at first. So the price is one of the most important influencing factors of the relationship between CSR and Consumers' Purchase Intention [24].

58.3.2 Levels of CSR

Handelman and Amold [15] shows that the levels of CSR (contribution to family, community and country) in the industry has a significant effect on the consumers' support degree. Consumers value the companies with the higher level of CSR more highly than the companies with the lower level of CSR. The results affect consumers' evaluation to product significantly, thus do Consumers' Purchase Intention [11]. The lower level of CSR is, the lower Consumers' Purchase Intention is, and vice versa. Chinese scholars' studies has the same result [27]. Long Long Ma's empirical study shows positive CSR levels arouse consumers more purchase intentions than negative CSR levels [22].

58.3.3 Fit Degree

Becker-Olsen et al [8] shows that the fit degrees of between CSR and corporate product lines, brand images are one of the most important factors influencing Consumer attitudes and Purchase Intentions. Their findings are that low-fit initiatives impact consumer beliefs, attitudes and intentions negatively no matter what the firm's motivation is, and high-fit initiatives that are profit-motivated have the same impact. Furthermore, consumers consider the timing (proactive versus reactive) of the social initiative as an informational cue, and only the high-fit, proactive initiatives lead to an improvement in consumer beliefs, attitudes, and intentions. When the matching degree is high, consumers think CSR behaviors belong to altruism attribution which influences consumers' attitudes and purchase intention positively; when the matching degree is low, consumers think CSR behaviors belong to self-interest attribution which influences consumers' attitudes and purchase intention negatively.

58.3.4 Consumer Characteristics Variables

Consumer Characteristics Variables refer to CSR-CA Beliefs and Consumer Supports mainly here.

CSR-CA Beliefs are defined to the degree of consumers' belief on CSR and corporate ability. Sen and Bhattacharya [12] divide the consumers into High CSR-CA Beliefs and Low CSR-CA Beliefs ones according to the degree of their beliefs on CSR and corporate ability. They find that consumers with High CSR - CA Beliefs prefer to buy the products that the companies engage in CSR positively than don't engage in CSR. Meanwhile, they divide the consumers into High CSR-Support and Low CSR-Support ones according to the degree of their support to CSR. Consumers with different support degrees show different purchase intentions facing to different products' qualities.

Mohr and Webb [7] suggest that consumers with different support degrees perceive purchase intentions and corporate image differently. High CSR-Support consumers identifying with companies engaging in CSR activities and their purchase intentions are much stronger than Low CSR-Support consumers do. Furthermore, Mohr et al [3] find consumers with different demographic characteristics have different CSR perception levels. They find that a certain type of consumers regard buying CSR products as a kind of measuring standards of their life ways and moral levels in real life, but some consumers don't think so.

In addition, consumers with different genders, ages, educations and income levels have different awareness of CSR, their purchase intentions are different [23].

Table 58.5 Main influencing factors

Factors	Contents
Price	Consumers will choose responsibility products under the same price condition. When prices are rising, Consumers' Purchase Intention will be changed accordingly.
Levels of CSR	Different levels of CSR has a significant effect on consumers' support and Consumers value, affect Consumers' Purchase Intention
Fit Degree	Low-fit initiatives impact consumer beliefs, attitudes and intentions negatively no matter what the firm's motivation, and high-fit initiatives that are profit-motivated have the same impact.
Consumer Characteristics Variables	Consumer Characteristics Variables refer to CSR- CA Beliefs and Consumer Supports mainly here.

[a] Source: collected from relevant data.

58.4 Limitations and Directions for Future Research

58.4.1 Research Object

Consumers in developed countries are the main objects in the present research, while only a few scholars' study focus on ones in developing countries like China, most of which is to follow foreign researches, and belong to qualitative and normative analyses researches.

Generally speaking, people's social responsibility awareness in developed countries is relatively stronger than one in developing countries because of different social background and social values. Buying products, consumers in developed countries pay more attention to social responsibility characteristics of the products than in developing countries. For example, Mohr and Webb [7] find that consumers have different susceptibility to the price when the levels of CSR are different, but his study is aimed at consumers in the United States. American's social responsibility awareness is relatively stronger than Chinese's. Although China has achieved great development for recent years, the feature of Chinese dual economy is obvious, China market still belongs to the developing market, everyone's social responsibility awareness is very different from each other. So, how consumers in developing countries cognize CSR and how their cognition affects the consumers on product evaluation and purchase intentions is needed to study further.

58.4.2 Research Domain

- Most of the scholars treat CSR as a whole variable when studying the effect of CSR on Consumers' Purchase Intention although several scholars study how part dimensions of CSR impact on Consumers' Purchase Intention, the scholars are only limited to study the influence of two dimensions of CSR like charity and environment on Consumers' Purchase Intention, which makes Research Domains be narrow. And it is unbeneficial to guide the marketing activities of firms. In fact, CSR is a broad concept as Part 1 is said. It will be interesting to study whether various dimensions of CSR like Community Responsibility have a significant impact on Consumers' Purchase Intention or which dimension in the specific industry influences on Consumers' Purchase Intention in the future research.
- Some present studies suggest that high or low overall CSR levels impact on Consumers' Purchase Intention [7] while studies of high or low relative CSR levels in the industry impacting on Consumers Purchase Intentions are less. In the actual operation, it is difficult for people to evaluate CSR levels objectively; however it is easier to grasp the relative levels in the industry. And CSR activities undertook by enterprises in different industries are different because of different characteristics of each industry, so it is more significant to measure CSR with the relative levels in industry.

58.4.3 Research Method

Many researchers use the experimental research methods about the topic, but the results in experimental scenarios are different from the ones in real scenarios. Because the cost of answering questions is lower than the cost of actual behavior, surveys probably overestimate the potential impact of CSR on purchase decisions [3], so we should try our best to study the effect of CSR on Consumers Purchase Intentions in real scenarios in the future research.

Simultaneously, many researchers use virtual enterprises as the research objects. Because it is very difficult to avoid consumer existing bias using the real enterprises, but its external validity will be questioned. So we choose real enterprises to study in the future research.

58.4.4 Sample Selection

Universities students (including MBA students) are chosen as samples in most of present researches about the topic, obviously, sample selection is not complete. We know different types of consumers' responses to CSR activities have significant heterogeneity. CSR activities working in one consumers' market may not be suitable for another consumers' market. That is to say, it is possible that the present researches may not show the real characteristics of effect of CSR on Consumers' Purchase Intention completely. So we should choose more kinds of people as our samples in the future research in order to pursue for the integrity of the study.

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Chapter 59
Study of the Product Symbiotic Interface Optimization Strategy Path with the Technology Paradigm Shift

Longan Deng

Abstract In the environment of technology paradigm shift, it's necessary for company to optimize product symbiotic interface by integrating the value of modules. The important mechanism of achieving product symbiotic interface optimization is to control the best ratio combinations of elements investment. Also, products symbiotic interface optimal path can be obtained by the establishment of optimal control model.

Keywords Technology paradigm shift · Value module integration · Product symbiotic interface · Combination of factor inputs · Optimal control

59.1 Introduction

When disruptive technology and technology reaching the "natural limit" arise in an industry, the technology paradigm will shift [1]. The technology paradigm shift will release the product symbiotic interface, and will reduce the function, relatively, and compatibility of product, then affect the enterprises' value activities nested in the product symbiotic interface structure. But by integrating value module, controlling the design and manufacturing of the key components nested in the product system, we can optimize product symbiotic interface and improve product's user demand [2]. However, enterprises' value module integration is realized by putting into relevant factor, and the relevant factor inputs in different enterprise and different period is uncertain. So, in seeking technology paradigm shift, the product symbiotic interface optimization strategy path with the technology paradigm shift has important theoretical and practical significance.

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59.2 The Technology Paradigm Shift and Product Symbiotic Interface Optimization

(1) The technology paradigm shift and product symbiotic interface release

Paradigm means that those generally accepted scientific achievements provide typical questions and answers for practical community over a period. While Technology paradigm is module to solve the chosen tech-economic problem, and the solution to the problem based on the principle of natural science [1]. Technology paradigm shift mainly refers to the continuous implementation of the market technological opportunities in a given technological track. Technology paradigm shift crack the improvement path of technology determined by the previous paradigm.

In other words, the shift of technology paradigm will make the product symbiotic interface on original technology trajectory release. And the release of the product symbiotic interface will make the function and reliability of product fail to reach the user demand of a certain market level temporarily [2, 3].

(2) Product symbiotic interface release and the change of enterprise value module

In the environment of technology paradigm shift, enterprises will take countermeasures, solve problems, ask for customers' opinion, respond to competitors' competition and strive for maximizing the profit. An enterprise is the indispensable part in complete product symbiosis interface structure, because their products are usually graded into or used in other symbiotic products as a component in a certain way, and ultimately belong to the actual system [4]. Thus, different enterprise module or value chain consist of the modules in the same enterprise are always nested in the complete product nested interface structure, and these value modules are the main manufacturing parts of different levels' component in product interface system.

So, when the products symbiotic interface release, the enterprise value module nested in the product symbiotic interface system will change, even the whole industry network structural migration will be caused.

(3) Enterprises' value module integration and product symbiotic interface optimization

The result of technology paradigm shift is the value structure's symbiotic interface of the original trajectory replaced by the value structure's symbiotic interface redefined by the new paradigm. The main approach to improve the product function is to integrate the value chain module nested in the product system and to optimize the control of product symbiotic interface according to the product architecture release and the changing situation of enterprises' value chain In the environment of technology paradigm shift [2, 3]. Because enterprise value module integration can control the design and manufacturing of each key component in the product system. Especially when the function and reliability of product fail to reach the users demand of a certain market level, manufacturers with the proprietary framework can launch the product to meet the needs of users, to form a competitive advantage by integrating all the product symbiotic interface of different performance in the value chain module vertically. When the product already have fully function and reliability, the focus of competition will be on the launch speed and corresponding degree of demand of product. At this time, for a multitude of specialized enterprises in subcontract, their producing and integrated business model is not so important, while the dispersible business model will account for a huge proportion [4]. That is to say, in the environment of technology paradigm shift, it is necessary to integrate value chain module and optimize product symbiotic interface.

59.3 The Strategy of Symbiotic Interface Optimization in the Environment of Technology Paradigm Shift

About the issue of integrating module to optimize product symbiotic interface, Christensen, after investigating the microcomputer industry's development history of 22 years (1978-1990), drew a conclusion that when the function and reliability of product is not so good, failing to meet customers' needs, manufacturers with the proprietary framework can form a competitive advantage by integrating the module interfaces of the value chain. He also thinks that in the environment of uncertain industrial generic technology and market demand, the symbiotic interface of product's internal structure is uncertain [4]. In essence, the product symbiotic interface can be optimized by integrating value module for two reasons: (1) Enterprises' value module integration, ensure the continuity and good operation of symbiotic interface optimization. (2) Enterprises' value module integration, which can do better in coordinating and controlling the key component's design and manufacturing of the product system, thus realizing the coordination and compatibility of the product symbiotic interface.

Through the analysis of the possibility that value module integration optimizing product symbiotic interface, this study believes that in the environment of technology paradigm shift, enterprises' value module integration has optimization effect for product symbiotic interface, and can improve the product value function. If enterprises conduct integrated control over value chain module specially, they can realize the optimization of product symbiotic interface in the environment of technology paradigm shift. According to R. Ray Lattice Harry's theory of developing new product [5–7], the enterprises' value module integration control activities based on the aim of optimizing product symbiotic interface mainly include R&D, Market development, Production and so on.

Thus, by integrated controlling the activities such as R&D, Market development and Production of value module, enterprises can optimize the product symbiotic interface.

If we assume that the optimization effect of product symbiotic interface is Y, the input function is $Y = (R, M, P, \cdots)$. Based on the above proof (as a result, this study believes that if enterprises conduct integrated control over value chain module specially, they can realize the optimization of product symbiotic interface in the environment of technology paradigm shift), thus:

$$\frac{\partial Y}{\partial R} > 0,\ \frac{\partial Y}{\partial M} > 0,\ \frac{\partial Y}{\partial P} > 0, \cdots \tag{59.1}$$

In other words, the best proportion of factor combination input in enterprises' value module integration control is consistent with the optimization effect of product symbiotic interface.

So, the best proportion combination of activities such as R&D, Market development and Production of value module, is the main strategy of realizing the optimization of product symbiotic interface.

59.4 The Path of Product Symbiotic Interface Optimization Strategy with the Technology Paradigm Shift

According to above research hypothesis, to explore the issue of product symbiotic interface optimization with the technology paradigm shift, we have to find out the best proportion combination of activities such as R&D, Market development and Production of value module. By building optimum control model, this problem can be solved.

59.4.1 Building Optimum Control Target Functions

First of all, from the above research on product symbiotic interface optimization, the state variable of symbiotic interface optimal control can be determined, which is r&d inputs, production inputs and market development inputs. In the assumption of time t, enterprise i has a control coefficient C_t^i, the target function of optimal control strategy is:

$$\max Y = \max\left[\sum_{t=0}^{T-1}\sum_{i\in I} C_t^i R_t^i + \sum_{t=0}^{T-1}\sum_{i\in I} C_t^i P_t^i + \sum_{t=0}^{T-1}\sum_{i\in I} C_t^i M_t^i\right]. \tag{59.2}$$

Among this, Y can be signed with the sales growth rate of new product (the reason is that the sales growth rate of new product is based on the customers' purchase of constantly improve on new product's symbiotic interface).

59.4.2 Building Optimal Control State Variable's Variation Function

However, control state variables in a certain moment are uncertain, they are changing with the influence of many factors. Thus, building control state variable variation function is the premise of forming symbiotic interface optimal control model. According to optimal control theory and the study of product symbiotic interface optimization, we can build the following optimal control state variable variation function:

(1) The variation function of R&D inputs:

$$R_{t+1} = R_t + V_t - \lambda_t \bar{R}_t. \tag{59.3}$$

Supposing:

R_t : the vector quantity of R&D inputs in symbiotic interface optimization in t year;

V_t : the vector quantity of R&D inputs absorbed in symbiotic interface optimization within t years;

λ_t : the diagonal matrix of R&D inputs ration's waste in symbiotic interface optimization in t year;

$\bar{R}_t$: the average of the variable T_t.

(2) The variation function of production inputs:

$$P_{t+1} = P_t + U_t - u_t \bar{P}_t. \tag{59.4}$$

Supposing:

P_t : the vector quantity of production inputs in symbiotic interface optimization in t year;

U_t : the vector quantity of production inputs absorbed in symbiotic interface optimization within t years;

u_t : the diagonal matrix of production inputs ratio's waste in symbiotic interface optimization in t year;

$\bar{P}_t$: the average of the variable P_t.

(3) The variation function of market development inputs:

$$M_{t+1} = M_t + W_t - \bar{u}_t \bar{M}_t. \tag{59.5}$$

Supposing:

M_t: the vector quantity of production inputs in symbiotic interface optimization in t year;

W_t: the vector quantity of production inputs absorbed in symbiotic interface optimization within t years;

$\bar{u}_t$: the diagonal matrix of production inputs ratio's waste in symbiotic interface optimization in t year;

$\bar{M}_t$: the average of the variable M_t.

59.4.3 The Path of Realizing Product Symbiotic Interface Optimization Strategy in the Environment of Technology Paradigm Shift

Put Equations (59.2), (59.3), (59.4), (59.5) together we can get the product symbiotic interface optimal control model in the environment of technology paradigm shift, which is:

$$R_{t+1} = R_t + V_t - \lambda_t \bar{R}_t,\ \ P_{t+1} = P_t + U_t - u_t \bar{P}_t,\ \ M_{t+1} = M_t + W_t - \bar{u}_t \bar{M}_t. \quad (59.6)$$

To control the development function of state variable, taking:

$$\max Y = \max \left[\sum_{t=0}^{T-1} \sum_{i \in I} C_t^i R_t^i + \sum_{t=0}^{T-1} \sum_{i \in I} C_t^i P_t^i + \sum_{t=0}^{T-1} \sum_{i \in I} C_t^i M_t^i \right] \quad (59.7)$$

as optimal control model of target function. By controlling the development function of state variable (59.6) we can get the optimal control trajectory of target function (59.7), then the result of optimal control. Based on the analysis of getting the result, the best proportion of R&D inputs, production inputs and market development inputs in the condition of the optimal product symbiotic interface can be determined, thus forming the product symbiotic interface optimal control strategy in the environment of technology paradigm shift. The path of optimal control strategy can be showed in Fig. 59.1. Thus, this study believe that in the environment of technology paradigm shift, the optimal control strategy formed by enterprises according to the above model can release the product symbiotic interface optimization.

59.5 Conclusion

The research, by the theory of the destruction of technology paradigm shift to product symbiotic interface and the change of enterprise value activity made by the change of product symbiotic interface, deeply reveals that the inner link among technology paradigm shift — product symbiotic interface release — the change of enterprise value chain, and provides theoretical principle for the further discovery on process of technology paradigm shift, of product symbiotic interface release and of changes in the enterprise value chain. Simultaneously, the research, use the theory of new product development, formed the optimizing mechanism of product symbiotic interface when technology paradigm shifted, providing the theoretical foundation for discovering the optimization of product symbiotic interface. Furthermore, by the optimal control theory, the research formed the optimal control model of product symbiotic interface when technology paradigm shifted, providing the methodological foundation for actual enterprise to optimize product symbiotic interface.

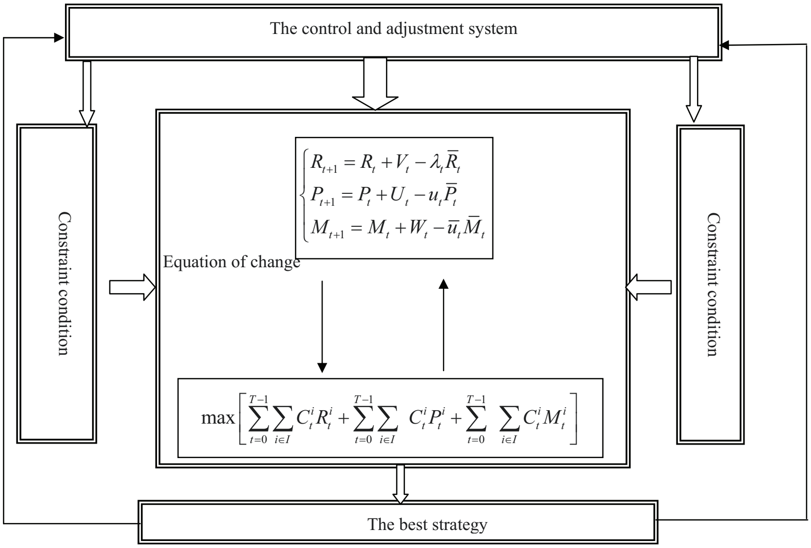

Fig. 59.1 The path of product symbiotic interface optimization in the environment of technology paradigm shift

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Chapter 60
Multi-Objective Inventory Planning under Stochastic Availability of Complement in Fuzzy Environment

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Abstract Effective inventory planing is instrumental in reducing costs and lead-time. In this paper, a multi-objective inventory planing model is proposed with imprecise demand, lead time and inventory costs. An inventory policy is proposed to minimize the costs using man-machine interaction. The fuzzy parameters of lead-time, inventory costs and demand are expressed through linear non-linear membership functions.The fuzzy parameters are first transformed into corresponding interval numbers and then following the interval mathematics, objective function of average cost is changed into respective multi-objective functions. An interactive fuzzy decision making method is used to minimize these functions and solve for Pareto-optimum solutions. The proposed model is illustrated numerically and the results are presented in tabular forms.

Keywords Multi-objective optimization · Fuzzy lead-time · Fuzzy inventory cost parameters · Inventory planing · Interactive fuzzy decision making method

60.1 Introduction

Inventory management is a very important function that determines the health of the supply chain as well as the impacts the financial health of the balance sheet. Every organization constantly strives to maintain optimum inventory to be able to meet its requirements and avoid over or under inventory that can impact the financial figures. Inventory is always dynamic. Inventory management requires constant and careful evaluation of external and internal factors and control through planning and review. A numbers of paper have been published in this direction [1–3]. Recently Hayya et al [4] studied the impact of stochastic lead time reduction on inventory

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cost under order crossover. Yu et al [5] developed a deteriorating repairable system with stochastic lead time and replaceable repair facility. Abginehchi and Farahani [6] studied the determination of optimal suppliers under stochastic lead times. But in real life situations, the lead time is normally vague and imprecise,i.e.uncertain in the non-stochastic sense. It will be more realistic to consider the lead-time as fuzzy in nature. Very few research papers have been produced in this direction [7, 8]. As stated in Tersine [9], lead time usually consists of the following components: order preparation, order transit, supplier lead time, delivery time and setup time. In most of the literature dealing with inventory problems considered lead time as an uncontrollable variable, while, in some practical cases, lead time can be reduced by controlling some or all of its components.The benefits gained with efforts to reduce lead time, such as lower production cost, reduce the loss caused by stock out, increase the service level to the customer, and gain the competitive strength in business.

The fuzzy sets concept was initially introduced by Zadeh [10] in 1965. As well, in the literature, there are several researchers presented various types of fuzzy inventory models For example, Petrovic and Sweeney [11] fuzzified the demand, lead time and inventory level into triangular fuzzy numbers in an inventory control model. Vujosevic et al [12] extended the EOQ model by introducing the fuzziness of ordering cost and holding cost. Chen and Wang [13] fuzzified the demand ordering cost, inventory cost, and backorder cost into trapezoidal fuzzy numbers in EOQ model with backorder. Roy and Maiti [14] presented a fuzzy EOQ model with demand-dependent unit cost under limited storage capacity. Gen et al [15] considered the fuzzy input data expressed by fuzzy numbers, where the interval mean value concept is used to help solving the problem. Chang et al [16] presented a fuzzy model for inventory with backorder, where the backorder quantity was fuzzified as the triangular fuzzy number. Lee and Yao [17] and Lin and Yao [18] discussed the production inventory problems, where Lee and Yao [17] fuzzified the demand quantity and production quantity per day, and Lin and Yao [18] fuzzified the production quantity per cycle, all to be the triangular fuzzy numbers. Ouyang and Yao [19] presented a mixture inventory model involving variable lead time, where the annual average demand was fuzzified as the triangular fuzzy number and as the statistic-fuzzy number.

Up to now, most multi-objective inventory models have put their emphasis on deteriorating items. Padmanabhan and Vrat [20] solved a multi-objective inventory of deteriorating items with stock-dependent demand by a nonlinear goal programming method. Agrell [21] presented a decision support system for multi-criteria inventory control. The solution procedure embedded is an interactive method with preferences extracted progressively in decision analysis process to determine batch size and security stock. Roy and Maiti [22] formulated a multi-objective inventory model of deteriorating items with stock-dependent demand under limited imprecise storage area and total cost budget. The objectives therein are to maximize the profit and to minimize the wastage cost where the profit goal, wastage cost and storage area are fuzzy in nature. The problem was solved by Fuzzy Non-Linear Programming (FNLP) and Fuzzy Additive Goal Programming (FAGP). Mahapatra and Maiti [23] considered a multi-objective inventory model of stochastically deteriorating items and incorporated the impact of quality level into the demand and deterioration function.

60.2 Problem Statement

Inventory planing is a major issue in the field of industrial engineering and operational research. As an essential activity for any enter-prise, inventory planning tries to determine the decisions about when to order and how much should order for different control mechanisms. In competitive market place are required companies to operate at lowest cost. For this purpose optimization of production cost, continues supply of inventory [maintain inventory] and also maintain and improve their quality and strength. In an inventory situation, shortcoming occurs during the cycles. Due to increase in seasonal demand shortage of items occurs. There is poor communication between inventory management and suppliers. Manufacturers have limited supply of complement. They are not able to overcome such uncertain shortage of items. According to this reason, the lead time period of order increase, sudden replenishment become expensive and decrease the average profit and enterprisers also lose the quality of and strength in the competitive market. A scenario is describe in Fig. 60.1. According to this figure a order is placed before the shortage of inventory. Such kind of uncertain order causes the trouble in continues supply of inventory and also increase the lead time of supply.

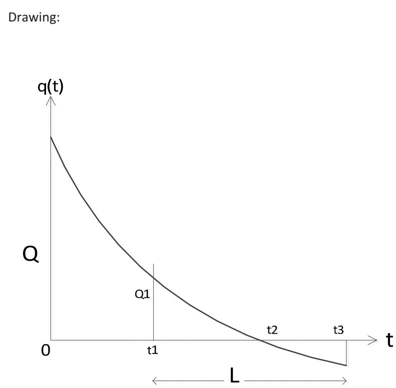

Fig. 60.1 An example of scenario where next order is placed at the time before beginning the shortage

60.3 Model Formulation

60.3.1 Assumptions and Notations

Some assumptions are considered before developing the mathematical model.

- Inventory system has only one item.
- Stuff of item change according to seasonal demand.
- Shortages are allowed but backlogged partially.
- Supply of complements are constant.
- The lead time has mutually independent components each having different production cost for reducing lead time.

Parameters

$\widetilde{D}$: average annual demand;
A : ordering cost;
P : production cost;
c : unit item cost;
h : inventory holding cost;
t_1 : reordering time during cycle;
j : number of cycle, $j = 1, 2, \cdots, N$;
$\widetilde{Q}$: order quantity;
$\widetilde{L}$: lead time;
t_2 : inventory shortage time.

60.3.2 Mathematical Model

Chief objective of industrial engineering is to minimize the operational cost. Following Equation (60.1) is to minimize the expected total relevant cost annually.

$$\min\ P(Q, \delta Q) = \frac{A\widetilde{D}}{\widetilde{Q}} + hc\left(\frac{\widetilde{Q}}{2}\right) + \frac{A\delta\widetilde{D}}{\widetilde{Q}}, \tag{60.1}$$

$$\min\ \frac{dq(t)}{dt} = \begin{cases} -f(t), & \text{for } \ \widetilde{T}_j \le t \le \widetilde{T}_j + t_2, \\ -\delta f(\widetilde{T}_j + t_2), & \text{for } \ \widetilde{T}_j + t_2 \le t \le \widetilde{T_{j+1}} \end{cases} \tag{60.2}$$

with boundary condition:

$$Q \ge 0, \tag{60.3}$$
$$D \ge Q, \tag{60.4}$$
$$0 \le k \le D/\sigma_L, \tag{60.5}$$
$$t_1 \le t_2, \tag{60.6}$$
$$q(t) = Q \text{ at } t = 0, \tag{60.7}$$

$$q(t) = 0 \text{ at } t = t_2, \tag{60.8}$$
$$q(t) = Q_1,\ t = t_1. \tag{60.9}$$

The first part of Equation (60.1) $\frac{A\widetilde{D}}{\widetilde{Q}}$ shows the order cost per cycle multiplied by the number of annual cycles. The second part $hc(\frac{\widetilde{Q}}{2})$ shows the holding cost, which is half of the order quantity. While the third part $A\delta\widetilde{Q}$ shows order uncertain quantity demand during cycles multiplied by the number of cycles. In Equation (60.2), $f(t)$ is the deterministic ramp type demand per unit time, which increases quadratically with time and $\delta f(\widetilde{T}_j + t_1)$ is demand during shortage period is partially backlogged. While $\frac{dq(t)}{dt}$ is the rate of change of inventory withe respect to demand.

The solution of differential Equation (60.2) with the help of Equations (60.7) and (60.8) are as follow:

$$d(t) = \begin{cases} Q - D_0 t + \frac{a}{b}(1 - e^{-bt}), & 0 \le t \le t_2, \\ \delta(t_2 - t) f(t_2), & t_2 \le t \le t_3. \end{cases}$$

Using the conditions (60.7), (60.8) and (60.9), we get from the above expression.

$$Q = D_0 t_2 - \frac{a}{b}(1 - e^{-bt_2}),\ Q_1 = Q - D_0 t_1 + \frac{a}{b}(1 - e^{-bt_2}). \tag{60.10}$$

The total inventory carrying cost of the system is given by:

$$\widetilde{C}_H = \widetilde{C}_1 \int_o^{t_2} q(t)dt = \widetilde{C}_1 \left\{ \widetilde{Q}t_2 - \frac{\widetilde{D}_0 t_2^2}{2} + \frac{a}{b}t_2 - \frac{a}{b^2}(1 - e^{-bt_2}) \right\}. \tag{60.11}$$

The shortage cost of the system is given as follow:

$$\widetilde{C}_S = -\widetilde{C}_1 \int_{t_2}^{t_3} q(t)dt = \frac{i}{2}\delta\widetilde{C}_2 f(t_2) \left\{ (t_1 - t_2)^2 - 2(t_2 - t_1)L + L^2 \right\}. \tag{60.12}$$

The total average cost for the proposed model is as follow:

$$\widetilde{F}(t_1, t_2) = \frac{\left(\frac{A\widetilde{D}}{\widetilde{Q}}\right) + \widetilde{C}_H + \widetilde{C}_S}{t_3}. \tag{60.13}$$

60.3.3 Deterministic Representation of the Proposed Model

Following Grzegorzewski [24], the fuzzy numbers are now transformed to interval numbers and the expression (60.13) is expressed as follow: $\widetilde{F}(t_1, t_2) = [F_L, F_R]$. Therefore, the proposed model can be stated as:

$$\min\ \{F_L(t_1, t_2), F_R(t_1, t_2)\}. \tag{60.14}$$

Usually, the multi-optimization problem (60.14), in the subject of minimization problem, is formulated in a conservative sense as follow:

$$\min\ \{F_C(t_1,t_2), F_R(t_1,t_2)\}, \tag{60.15}$$

where $F_C = (F_L + F_R)/2$. Here the interval problem (60.13) is represented as follow:

$$\min\ \{F_L(t_1,t_2), F_C(t_1,t_2), F_R(t_1,t_2)\}, \tag{60.16}$$

where $t_{1L} \leq t_1 \leq t_{2R}$ and $t_{2L} \leq t_2 \leq t_{2R}$ and t_{2L}, t_{2R} are the lower and upper bounds of t_1 and t_2, respectively.

The Equation (60.16) gives the better approximate solution than those of Equation (60.15). Furthermore, by the Equation (60.16) the decision maker does have the freedom to choose any one of the three functions F_L, F_C, F_R for minimization problem.

60.4 Interactive Approach

In order to consider the imprecise nature of decision maker's judgement, decision maker's may have different fuzzy or imprecise goals for each of the objective functions and therefore interactive approach is used for the man-machine interaction.

To derive the membership functions $\mu_{F_L}, \mu_{F_R}, \mu_{F_C}$ for the objective functions F_L, F_R, F_C respectively from decision maker's view point. First we calculate individual minimum (i.e. $F_L^{\min}$, $F_R^{\min}$, $F_C^{\min}$) and individual maximum (i.e. $F_L^{\max}$, $F_R^{\max}$, $F_C^{\max}$) by a non linear optimization technique.

By the help of individual minimum and maximum, the decision maker's can choose any one from among the following two type of member ship functions.
(i) Linear membership functions.
(ii) Quadratic membership functions.

The membership functions μ_{F_L}, μ_{F_R} and μ_{F_C} for the corresponding objective functions F_L, F_R and F_C can be written as follow.

$$\mu_{F_K} = \begin{cases} 1, & \text{if } F_K \leq F_K^1, \\ d_K, & \text{if } F_K^1 \leq F_K \leq F_K^0, \\ 0, & \text{if } F_K \geq F_K^0, \end{cases} \tag{60.17}$$

where F_K^1 and F_K^0 are to be selected such that $F_K^{\min} \leq F_K^1 \leq F_K^0 \leq F_K^{\max}$ and d_K is directly monotonic decreasing continuous function of F_K that can be linear or non linear.

60.4.1 Linear Membership Function

(Type-I) For each objective function, the corresponding linear membership functions are as follow:

$$\mu_{F_K} = \begin{cases} 1, & \text{if } F_K \leq F_K^1, \\ 1 - \frac{F_K - F_K^1}{P_K}, & \text{if } F_K^1 \leq F_K \leq F_K^0, \\ 0, & \text{if } F_K \geq F_K^0, \end{cases} \tag{60.18}$$

where F_K^1 and F_K^0 are to be selected such that $F_K^{\min} \leq F_K^1 \leq F_K^0 \leq F_K^{\max}$ and $P_K = F_K^0 - F_K^1$ is the tolerance of kth objective function F_K (Fig. 60.2).

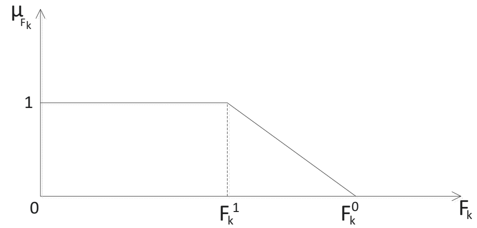

Fig. 60.2 Pictorial representation of linear μ_{F_K}

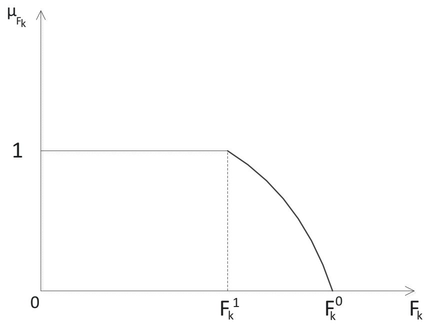

Fig. 60.3 Pictorial representation of exponential μ_{F_K}

60.4.2 Quadratic Membership Function

(Type-II) For each of the objective functions, the required quadratic functions is as follow:

$$\mu_{F_K} = \begin{cases} 1, & \text{if } F_K \le F_K^1, \\ 1 - \left(\frac{F_K - F_K^1}{P_K}\right)^2, & \text{if } F_K^1 \le F_K \le F_K^0, \\ 0, & \text{if } F_K \ge F_K^0, \end{cases} \tag{60.19}$$

where F_K^1 and F_K^0 are to be selected such that $F_K^{\min} \le F_K^1 \le F_K^0 \le F_K^{\max}$ and $P_K = F_K^0 - F_K^1$ is the tolerance of kth objective function F_K (Fig. 60.3).

60.4.3 Fuzzy Decision Making Method

After finding the different linear or non-linear membership function(MF) for each of the objective functions. Following Bellman and Zadeh [25] and Zimmermann [26], the given problem (60.16) can be formulated as:

$$\begin{cases} \max \lambda, \\ \text{s.t.} \begin{cases} \lambda \le \mu_{F_L}, \\ \lambda \le \mu_{F_C}, \\ \lambda \le \mu_{F_R}, \\ t_{1L} \le t_1 \le t_{1R}, \\ t_{2L} \le t_2 \le t_{2R}, \\ 0 \le \lambda \le 1. \end{cases} \end{cases} \tag{60.20}$$

With the help of two different type of membership functions give by Equations (60.18) and (60.19), the above problem can be restated for a particular choice of DM as follow:

$$\begin{cases} \max \lambda, \\ \text{s.t.} \begin{cases} \lambda \le 1 - \frac{F_L - F_L^{1}{}'}{P_L}, & \text{if the MF of the first objective} \in \text{Type-I}, \\ \lambda \le 1 - \frac{F_C - F_C^{1}{}'}{P_C}, & \text{if the MF of the first objective} \in \text{Type-II}, \\ \lambda \le 1 - g\frac{F_R - F_R^{1}{}'}{P_R}, & \text{if the MF of the first objective} \in \text{Type-II}, \\ t_{1L} \le t_1 \le t_{1R}, \\ t_{2L} \le t_2 \le t_{2R}, \\ 0 \le \lambda \le 1. \end{cases} \end{cases} \tag{60.21}$$

DM choose the the above membership functions for the proposed objective functions. Therefor, the above problem can be solved by a non-linear optimization method and optimal solution of λ say λ^* is obtained.

Now after obtaining λ^*, the DM choose the most important objective function from among the objective functions F_L, F_R and F_C. Here F_R is selected as DM would like to minimize his worst case then the problem becomes (for $\lambda = \lambda^\star$):

$$\begin{cases} \min F_R, \\ \text{s.t.} \begin{cases} F_L \le m_L,\ F_C \le m_C,\ F_R \le m_R, \\ t_{1L} \le t_1 \le t_{1R},\ t_{2L} \le t_2 \le t_{2R}, \\ 0 \le \lambda \le 1, \end{cases} \end{cases} \tag{60.22}$$

where

$$m_L = F_L^1 + P_L(1-\lambda^*), \text{ if the MF of the first objective} \in \text{Type I}, \tag{60.23}$$
$$m_C = F_C^1 + P_C(1-\lambda^*), \text{ if the MF of the first objective} \in \text{Type II}, \tag{60.24}$$
$$m_R = F_R^1 + P_R\sqrt{1-\lambda^*}, \text{ if the MF of the first objective} \in \text{Type II}. \tag{60.25}$$

60.4.4 Pareto-optimal Solutions

Now, Pareto-optimal test is performed after deriving the optimum decision variables. Let the decision vector t_1^*, t_2^* and the optimum values $F_L^* = F_L(t_1^*, t_2^*), F_R^* = F_R(t_1^*, t_2^*)$ and $F_C^* = F_R(t_1^*, t_2^*)$ are obtained from Equation (60.22). With these values, following problem is solve by using a non-linear optimization technique;

$$\begin{cases} \min\ V = (\omega_L + \omega_C + \omega_R), \\ \text{s.t.} \begin{cases} F_L + \omega_L = F_L^*, F_C + \omega_C = F_C^*, F_R + \omega_R = F_R^*, \\ \omega_L, \omega_C, \omega_R \ge 0, \\ t_{1L} \le t_1 \le t_{1R}, t_{2L} \le t_2 \le t_{2R}, \\ 0 \le \lambda \le 1. \end{cases} \end{cases} \tag{60.26}$$

The optimal solution of Equation (60.26), say, $\overline{t_1}, \overline{t_2}, \overline{Q}, \overline{Q_1}, \overline{F_L}, \overline{F_R}$ and $\overline{F_C}$ are called the strong Pareto-optimal solutions of the problem (60.16) provided V is very small, otherwise it is weak Pareto-optimum.

60.5 Numerical Example

In order to illustrate the feasibility of inventory management model, consider the following input data.

Input data: $\delta = 0.56$, $b = 0.65$, $t_{1L} = 1.2$, $t_{1R} = 1.4$, $t_{2L} = 1.36$, $t_{2R} = 1.78$ in proper units. $\widetilde{C_1} = (1.6, 2.2, 3)$, $\widetilde{C_2} = (3.6, 4.2, 4.8)$, $\widetilde{C_3} = (210, 230, 255)$, $\widetilde{L} = (0.68, 0.75, 0.90)$, $\tilde{a} = (0.55, 0.60, 0.68)$, $\widetilde{D_0} = (200, 215, 220)$.

60.5.1 Solution

The above parameters are considered as Triangular fuzzy numbers (TFN), the nearest interval approximations according to Grzegorzewski [24] are $\widetilde{C_1} = [1.9, 2.3]$, $\widetilde{C_2} = [3.9, 4.5], \widetilde{C_3} = [220, 242.5], \widetilde{L} = [0.715, 0.825], \widetilde{a} = [0.575, 0.64], \widetilde{D_0} = [207.5, 217.5]$.

Following Equation (60.19) and Equation (60.20), the problem (60.16) is solved and the results are presented in Tables 60.1 and 60.2. At the beginning, the analysis is performed to find the optimum value of λ with the membership functions F_L, F_C as linear and F_R as quadratic. The optimum value is present in Table 60.3. With this value of $\lambda^\star$, the objective function F_R is optimize and the optimum results are presented in the Table 60.4. The optimal results in Table 60.4 are tested for Pareto-optimally and Pareto-optimal results are presented in Table 60.5.

Table 60.1 Individual minimum and maximum of objective functions

Objective functions	Minimum	Maximum
F_L	310.8224	340.0792
F_C	427.7443	456.8443
F_R	544.6661	570.5674

Table 60.2 Input data for F_K^1, F_K^0

F_L^1	F_L^1	F_C^1	F_C^1	F_R^1	F_R^1
310.8224	340.0792	427.7443	456.8443	544.6661	570.5674

Table 60.3 Optimal value of λ

Maximum λ	
$\lambda^\star$	.995

Table 60.4 Optimal result when F_R is chosen as the important objective function

$t_1^\star$	$t_2^\star$	$[Q_L^\star, Q_R^\star]$	$[F_L^\star, F_R^\star]$	$F_C^\star$
1.2	1.5	[306.4778, 410.8114]	[306.7663, 550.3941]	428.5880

Table 60.5 Optimal result when F_R is chosen as the important objective function

$\bar{t}_1$	$\overline{t_2}$	$[\overline{Q_L}, \overline{Q_R}]$	$[\overline{F_L}, \overline{F_R}]$	$\overline{F_C}$	V
1.2	1.5	[306.4774, 410.8111]	[306.7663, 550.3941]	428.5880	.0003

The value of V, in Table 60.5 are very very small and therefore, the optimum results in Table 60.4 are strong pareto-optimum and can be accepted. If the DM is not satisfied with these results, he or she may perform the above analysis again re-choosing the membership functions for F_L, F_C and F_R as linear and quadratic. If the second time analysis haven't give you desired result, the DM cam perform the analysis with other possible different combinations of the membership functions and can choose the most suitable optimum result.

60.6 Conclusion

The present paper proposed a solution procedure for inventory inventory planing model under stochastic availability of component in fuzzy environment. The parameters of demand function, inventory cost parameters and lead-time are taken as fuzzy numbers. Here, shortages are allowed and backlogged partially. The lead-time and planning horizon are described by a triangular type membership function and are approximated to equivalent interval numbers. An interactive fuzzy solution method is used to obtain the solution of deterministic multi-objective inventory planing problem. This type of demand is applicable to all type of products that has seasonal demand. The presented model and solution method are very quite general. The proposed solution procedure here can also be applicable to solve the problems in others areas like services analysis, pollution, structural analysis, etc which involve the fuzzy parameters in model formulation.

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Chapter 61
The Analysis of Two Kinds of Promotion Ways of Complementary Products

Xin Liu and Ruikun Xie

Abstract Considering the features of complementary products, this paper establishes an optimal model group of complementary products involved experience sampling and bundling sampling. The simulation results indicate that the both promotion ways can accelerate the diffusion of complementary products, but the effect of experiential sampling is better than that of the bundling sampling, the optimal promotion way is combining the two methods. But for the incomplete complementary products, the best promotion way is just introducing the experiential sampling. The firm's profit drops as the price of bundle sampling increases, but the experiential sampling level remains unchanged. The experiential sampling level and the bundling sampling level are anti-dependence.

Keywords Complementary products · Experiential sampling · Bundling sampling · Product diffusion · Numerical simulation

61.1 Introduction

Complementary products have an impact on the market. There is consume a dependence relationship between the complementary products, the sales of one product has a positive-going effect on the other product. Patrick and James [1] describes a system dynamics model created to investigate the vehicle-infrastructure phenomenon currently inhibiting the growth of hydrogen transportation system, and indicate the most effective approach for rapid vehicle-infrastructure adoption is simultaneously encouraging both the purchase of hydrogen vehicles and the building

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of hydrogen infrastructure. Jeffrey and Nei [2] analyze when the two complementary products (software and hardware) entered the market in the monopoly and oligopoly market. In the product diffusion mechanism, Bass model [3] is one of the most classic models. Peterson and Mahajan [4]divide the products in the market into independent, competitive, complementary and derivative relationship based on the Bass Model. Zhou [5] point that the competitive advantage of complementary products is: (1) to increase the value of the product, make products discrepancy, and (2) to get synergistic effect.

Experience sampling and bundling sampling are the two kinds of sampling ways, experience sampling can make consumers earlier feel and know the product. Bundling sampling means the firms sale two or more of the commodity as one unit one customers. Jain et al [6] point sampling is not only free, but has a cost, sampling too little can't get the expected effect, and offering too many free samples is a waste of a firm's resources. Lammers [7] points out that sampling is an effect way of promotion, and it can enhance the sales volume in a short time, keeps customer loyalty. Heiman et al [8] think sampling has two effects, the first is the short-term effect of sampling which reflects the change in the probability of a consumer purchasing a product immediately after having being sent free samples, and the second is the long-term effect of sampling which increase the consumers cumulative goodwill formation. Hu at al [9] make an analysis of free samples of complementary products incorporated consumer purchasing behavior and pricing strategies, they conclude that free samples can accelerate the complementary product diffusion, and launching the free samples before launching the product is the best time.

The research of bundling sampling is limited, Yan and Subir [10] find if a firm uses a bundling strategy to sell its products, it should combine highly complementary products, and the value of a bundling strategy always increases with the size of market and price sensitivity. Chandrashekaran [11] find that product bundling per se does not influence innovation activities and that, when a product is enjoying a high rate of diffusion, competition does not hasten the arrival of innovations. Liu et al [12] analyze the bundling sampling by the view of psychological, find the sampling has a great impact on the consumers recently purchased the product. Wei [13] analyze the problem of the optimal strategy of bundling of seasonal products. Peng et al [14] analyze the bundling sales of information products, and the discriminatory pricing policy is used. Lu and Li [15] believe that not all the products can be bundled, it is depended on the degree of matching and style of the products.

Most of the research of bundling is based on the complementary products. From above literatures, the research of promotion ways of complementary products is deficient. So this paper builds an optimal model group of two kind promotion ways of complementary products. Both the promotion ways are discussed and the parameters in the model are analyzed. The conclusions are showed to direct the sales manager's promotion decision. This paper is organized as follows: Sect. 61.2 states the problem and presents the basic model and assumptions. Sect 61.3 presents the numerical simulation computation for the optimal model group and sensitive analysis. And the last section is reserved for conclusions and suggestions for further research and the underlying approach.

61.2 Modeling

This section gives the problem statement of complementary firstly, then based on the Bass model, considering the experience sampling and bundling sampling, an optimal model group is established.

61.2.1 Problem Statement

There are few independent products in the market nowadays, complementary products is one of the common styles, firms produce complementary products to occupied the market. Michael [16] point the value of each product used separately is very small, combined with other products can obtain a larger income. For firms, the competitive advantage of complementary products is mainly reflected in the following two aspects: (1) enhance the value of product, such as the Microsoft attracts a large number of application software firms to develop applications for its system, in order that it enhance the value of its products. (2) Obtain the synergistic effect, such as Coca-Cola and McDonald's cooperation, the good reputation of the two companies to ensure the credibility of cola drinks and hamburg combined package of complementary products to customers.

Based on the analysis above, we make some assumptions for the model group:

- The diffusion of one innovation is not independent on the complementary product. And there is a complementary influence between the complementary products.
- The geographic boundaries of the social system do not change during the diffusion process.
- The diffusion process is binary. The models assume that potential adopters of an innovation either adopt or do not adopt the innovation.
- Nature of an innovation does not change during the diffusion process.

The key notations and symbols are shown as follows:

t	:	Period (0 to T);
$\overline{N}_i$	:	Market potential of products i ($i = 1,2,3$);
$N_i(t)$	:	Cumulative purchasers of product i by period t ($i = 1,2,3$);
a_i	:	The coefficient of external influence of product i ($i = 1,2,3$);
b_i	:	The coefficient of internal influence of product i ($i = 1,2,3$);
$S_i(t)$	:	The sales volume of product i in period t ($i = 1,2,3$);
σ_i	:	The coefficient of influence on each other among the three products ($i = 1,2,3$);
$\frac{N_{fi}(t)}{n_{fi}(t)}$	:	The cumulative/non-cumulative of sampling amount of product i in period t ($i = 1,2$);
γ_{ni}	:	The non-adoption ratio of the people who get the free sample in period t ($i = 1,2$);

γ_b : The first-adoption ratio in the people who get the free sample ($i = 1,2$);
i_r : The discount rate.

61.2.2 Model Development

This section builds the model by considering the experience sampling and bundling sampling.
(1) Basic model

Bass model is based on the independent product, but there is a few independent products in the reality, the mainly product style in the market is multiple products, therefore, this model has some limitations. Peterson et al [4] build the model of complementary products based on the Bass model:

$$\begin{cases} N_1(t+1) - N_1(t) = (a_1 + b_1 N_1(t) + \sigma_1 N_2(t))(\overline{N}_1 - N_1(t)), \\ N_2(t+1) - N_2(t) = (a_2 + b_2 N_2(t) + \sigma_2 N_1(t))(\overline{N}_2 - N_2(t)), \end{cases} \tag{61.1}$$

where $\sigma_1 N_2(t)$ and $\sigma_2 N_1(t)$re the positive complementary influence on the other product, this paper only consider the positive impact factors between the products ($\sigma_1 N_2(t) > 0$, $\sigma_1 N_2(t) > 0$).
(2) The impact of experience sampling

Experience sampling is one of the most common promotion ways, firms send free samples when they launch a new product, especially for the beverages, biscuits, washing clothes and other non-durable goods, it can make the consumers know the product better. Experience sampling is an effective promotion way, it can increase the number of customers, maintain a customer purchase loyalty, and encourage customers to repeat purchase. Jain et al point firms can establish reputation effect consumers innovative products by the free samples, and through the oral communication between products, to accelerate the diffusion speed of the product [6].

In the sampling period, there are part of consumer need the product i, so the experience sampling just affects the consumer who need the product, firms cannot get the ideal sampling effect, so introduce γ_{bi}, which means rate of the potential consumers in the whole market. In the sampling process, some consumers get more than one experience sampling, there is no effect on the diffusion, so introduce $\gamma_{ni}(t)$, which means the non-adoption ratio of the people who get the free sample in period, when $\gamma_{ni}(t) = 1$, all the consumer who get the experience sampling never used the product before. Therefore, there is:

$$\gamma_{ni}(t) = 1 - (N_i(t) + N_{fi}(t))/\overline{N}_i. \tag{61.2}$$

And the diffusion model is changed into:

$$\begin{cases} N_1(t+1) = [a_1 + b_1(N_1(t) + N_{f1}(t)) + \sigma_1(N_2(t) + N_{f2})][\overline{N}_1 - (N_1(t) + N_{f1}(t))], \\ N_2(t+1) = [a_2 + b_2(N_1(t) + N_{f1}(t)) + \sigma_2(N_2(t) + N_{f2})][\overline{N}_2 - (N_2(t) + N_{f2}(t))], \end{cases} \tag{61.3}$$

where $N_i(t)+N_{fi}(t)$ is the diffusion quantity with the effect of product sampling in period t.

In the whole diffusion process, the amount of diffusion products is consisted of sale volume and sampling amount, and they cannot exceed the upper limit of the potential adopters:

$$\begin{cases} N_1(t)+N_{f1}(t) \le \overline{N}_1, \\ N_2(t)+N_{f2}(t) \le \overline{N}_2. \end{cases} \tag{61.4}$$

(3) The impact of bundling sampling

In the complementary product sales process, to enhance the attractive of the primary products, or to accelerate the poor sales of complementary products, firms bundle the two products as one unit to sale, and consumer can get the two products, but only need to pay the price to less than the sum of the two products. The both two products can be seen as one product (bundling product).

When bundling sampling, since the bundling product can be seen as one, the diffusion process is likely to the Bass model describes, in the purchase process, the consumers get the bundling product may affect the consumers who only want buy the primary product, or the complementary product, and vice versa. The consumers who get the bundling product would not buy the primary product or complementary product, so the potential consumers of primary product A and complementary product B are: $\overline{N}_1-\overline{N}_3$, $\overline{N}_2-\overline{N}_3$. The adopters in the whole diffusion process can be divided into three kinds: the adopters of the primary product A, the adopters of the complementary product B, and the adopters of bundling product. The model (61.3) is changed into:

$$\begin{cases} N_1(t+1) = [a_1+b_1(N_1(t)+N_{f1}(t))+\sigma_1(N_2(t)+N_{f2}(t) \\ \qquad\qquad +N_3(t))][\overline{N}_1-\overline{N}_3-(N_1(t)+N_{f1}(t))], \\ N_2(t+1) = [a_2+b_2(N_1(t)+N_{f1}(t))+\sigma_2(N_2(t)+N_{f2}(t) \\ \qquad\qquad +N_3(t))][\overline{N}_2-\overline{N}_3-(N_2(t)+N_{f2}(t))], \\ N_3(t+1) = [a_3+b_3N_3(t)+\sigma_3(N_1(t)+N_{f1}(t)+N_2(t) \\ \qquad\qquad +N_{f2}(t))](\overline{N}_3-N_3(t)), \end{cases} \tag{61.5}$$

where $N_i(0)=0$. Since the form of the bundling product is changed, the coefficient of external influence and coefficient of internal influence are changed into: $a_3 = a_1+(1-\theta)a_2$, $b_3 = b_1+(1-\theta)b_2$, θ is the parameter of bundling product price based on the primary product A and complementary product B ($p_3 = p_1+\theta p_2$).

Then, the amount of diffusion products is consisted of sale volume and sampling amount cannot exceed the upper limit of the whole potential adopters minus the potential adopters of bundling product:

$$\begin{cases} N_1(t)+N_{f1}(t) \le \overline{N}_1-\overline{N}_3, \\ N_2(t)+N_{f2}(t) \le \overline{N}_1-\overline{N}_3. \end{cases} \tag{61.6}$$

(4) The objective function

Although experience sampling and bundling sampling are the effective promotion ways, they can accelerate the diffusion process, to obtain a high profit, but for firms, sampling too much may be a waste of resources, so firms need determine an appropriate amount of sampling. Then one can get the objective function of the model of the sampling, which represents the maximization of net present value (NPV). And the objective function is

$$\begin{aligned}\max(\pi_1+\pi_2+\pi_3) = &\sum_{i=1}^{2}\{\sum_{t=0}^{T} 1(1+i_r)^t[(p_i(t)-c_i)S_i(t)-(h_i+c_i)n_{fi}(t)]\}\\ &+\sum_{t=1}^{T} 1(1+i_r)^t[(p_3(t)-c_1-c_2)S_3(t)],\end{aligned} \tag{61.7}$$

where p_i and c_i are the price and the cost of product i, $c_{fi}(< c_i)$ is the cost of experience sampling, h_i is the cost of handling the experience sampling per unit, it contains material cost of wrapping, shipping and handling the sampling, p_3 is the price of bundling sampling.

(5) The optimal model group

Considering the experience sampling and bundling sampling of complementary products, an optimal model group is established:

$$\begin{cases}\max(\pi_1+\pi_2+\pi_3),\\ \text{s.t.}\begin{cases}N_1(t+1)=[a_1+b_1(N_1(t)+N_{f1}(t))+\sigma_1(N_2(t)+N_{f2}(t)\\ \qquad +N_3(t))][(\overline{N}_1-\overline{N}_3)-(N_1(t)+N_{f1}(t))],\\ N_2(t+1)=[a_2+b_2(N_1(t)+N_{f1}(t))+\sigma_2(N_2(t)+N_{f2}(t)\\ \qquad +N_3(t))][(\overline{N}_2-\overline{N}_3)-(N_2(t)+N_{f2}(t))],\\ N_3(t+1)=[a_3+b_3N_3(t)+\sigma_3(N_1(t)+N_{f1}+N_2(t)\\ \qquad +N_{f2})](\overline{N}_3-N_3(t)),\\ N_1(0)=0,\quad N_2(0)=0,\quad N_3(0)=0.\end{cases}\end{cases} \tag{61.8}$$

There are two decision variables in the model group: $F_3(=\overline{N_3}/\min(\overline{N_1},\overline{N_2}))$ decides the scale of bundling sampling, it value in [0, 1], the levels of experience sampling of primary product A $(F_1(t)(=n_{f1}(t)/(\overline{N_1}-\overline{N_3})))$ and complementary product B $(F_2(t)(=n_{f2}(t)/(\overline{N_2}-\overline{N_3})))$.

61.3 Analysis

The model group (61.8) is a nonlinear optimization model group, based on the modeling; this section analyzes the experience sampling and bundling sampling problems by numerical simulation. The parameters refer to the parameters of literature [6, 17].

61.3.1 The Analysis of Totally Experience Sampling ($\overline{N}_3 = 0$) and Totally Bundling Sampling ($n_{fi}(t) = 0$)

The experience sampling is the most common promotion way for firms, when $\overline{N}_3 = 0$ in the model group (61.8), it means there is no demand of bundling products, all the consumers in the market are sent the experience sampling, Hu et al point: the best time to send experience sampling is before the complementary products are launched into the market[9]. So the experience sampling levels are $F_1(0)$ and $F_2(0)$ to do the numerical simulation. The simulation results are shown in the Fig. 61.1 and Table 61.1.

Table 61.1 The sales peak and profit under different promotion strategies

Promotion strategies	NPV	The bundling sampling level	The experience sampling level	
			Product A	Product B
No promotion	291.42	0	0	0
Experience sampling	328.63	0	0	12%
Bundling sampling	300.53	10%	0	0
Experience sampling and bundling sampling	335.04	10%	0	11%

When the firm sends experience sampling as a promotion way before launching the complementary sampling, because of the low cost of the experience sampling of complementary product, it chooses to send the experience sampling of complementary product, and the sampling level is 12% (Table 61.1). The consumers who get the experience sampling buy the complementary product right now, and the diffusion speed of primary product A is enhanced by the impact of complementary product B, the peak of the sales volume of two products reach in period 4, and reduce to 0 in period 20 (Fig. 61.1). The result shows: the experience sampling can accelerate the diffusion of the whole system of the complementary product.

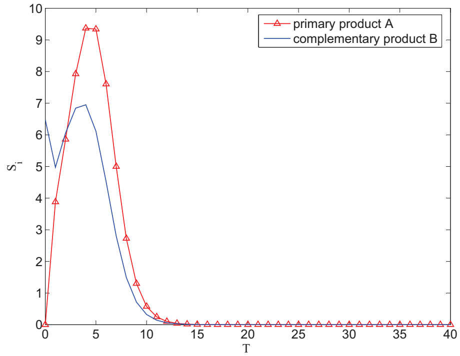

Fig. 61.1 The impact of experience sampling on the diffusion

When the firm sends the bundling sampling as a promotion way, the speeds of the diffusion of the primary product A and the complementary product B are all enhanced, and the sales peaks are reached earlier about one period, and the sales peaks are significantly increase (Fig. 61.2). Because of the enter of the bundling sampling, the consumers can know the two products simultaneously, and buy them earlier. The primary product A and the complementary product B diffuse to 0 in period 14 and period 15, although there is a huge advantage of the price of bundling product, it diffuses to 0 until period 27, since each consumer has rational consumption concept when they buy it.

The two kinds of promotion ways can accelerate the diffusion, and the firm can get the higher profit. Comparing with the NPV under no promotion, the NPV increases about 12.77% when the firm chooses the experience sampling; and 1% when choosing the bundling sampling (Table 61.1). How about sending both the sampling?

When the firm sends both the experience sampling and bundling sampling, it can get the highest profit, the NPV of sanding both samples is 2% more than that of sending experience; and 12% more than that of bundling sampling, and the experience sampling rate decreases 1% (Table 61.1). For the firm, producing different standards products is difficult, but when the impact is small, the firm can send both the experience sampling and bundling sampling, in order to get a higher profit.

61.3.2 *The Analysis between Complete Complementary Products and Incomplete Complementary Products*

In the market, the products always adopted as a fixed proportion are called as complete complementary products, such as the spectacle frames and glasses are adopted as a ratio of 1 : 2, screws and nuts are adopted as a ratio of 1 : 1. It means the amount of the potential consumers of these products are the same ($\overline{N}_1 = \overline{N}_2$). The case of

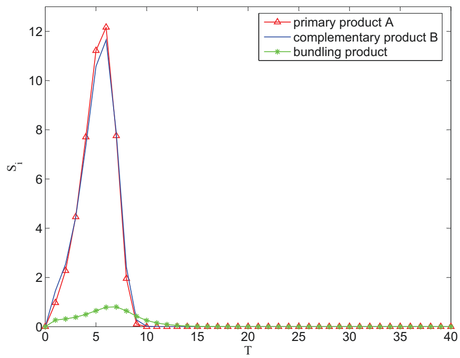

Fig. 61.2 The impact of bundling sampling on the diffusion

$\overline{N}_1 \neq \overline{N}_2$ is called as incomplete complementary products, such the Coca-Cola and hamburger in McDonald's, they can be sold as packages and separate.

When the two products are complete complementary products, the case of both sending experience sampling and bundling sampling can get the highest profit; the case of sending experience sampling follows; and the case of sending bundling sampling get the lowest profit, and all the profits of these three cases are higher than that of without sampling (Table 61.1). When the two products are incomplete complementary products, the best promotion way is just sending experience sampling, the case of sending two sampling follows, but the case of without sampling is better than that of just sending bundling sampling (Tables 61.2 and 61.3). Comparing the case of complementary products, when the firm just sends the experience sampling, to accelerate the diffusion of the whole system, it need not only send the complementary product B, but also primary product A; and when sending the two sampling, it requires a higher sampling level of complementary product B (Comparing Tables 61.2 and 61.3).

Table 61.2 The sales peak and profit under different promotion strategies ($\overline{N}_1 > \overline{N}_2 > \overline{N}_1$)

Promotion strategies	NPV	The bundling sampling level	The experience sampling level	
			Product A	Product B
No promotion	220.54	0	0	0
Experience sampling	251.04	0	1%	16%
Bundling sampling	251.04	10%	0	0
Experience sampling and bundling sampling	251.04	10%	0	20%

Table 61.3 The sales peak and profit under different promotion strategies ($\overline{N}_1 > \overline{N}_2 = \overline{N}_1$)

Promotion strategies	NPV	The bundling sampling level	The experience sampling level	
			Product A	Product B
No promotion	159.46	0	0	0
Experience sampling	184.43	0	6%	15%
Bundling sampling	184.43	10%	0	0
Experience sampling and bundling sampling	153.40	10%	7%	0

When the firm sends the both sampling, the experience sampling level changes, it is 20% in the case of $\overline{N}_2 > \overline{N}_1$, 7% in the case of (Comparing Tables 61.2 and 61.3). Since when the potential consumer of product B is more than that of bundling product, because of the low cost of the experience sampling of product B, it deserved sending plenty of it; when $\overline{N}_2 = \overline{N}_1$, the effect of the bundling sampling is large enough to meet the consumer's demand of product B, so it need less experience sampling.

61.3.3 The Sensitive Analysis

a_i, b_i, σ_i and θ are the main parameters in the model group. Hu et al have do the sensitive analysis of a_i, b_i, σ_i [9], so this paper just make the sensitive analysis of θ. Since the most complementary products in the market are complete complementary products, the case of incomplete complementary products are not considered here.

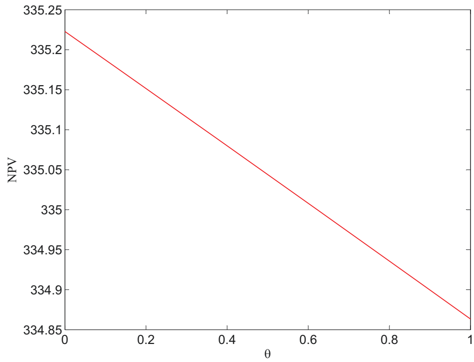

Fig. 61.3 The sensitive analysis between θ and NPV

θ decides the price of the bundling product, when $\theta = 0$, the price of the bundling product is the same as the primary product, and the complementary product is sold for free; when $\theta = 1$, the price of the bundling sampling is the same as the sum of primary product and complementary product. The NPV reduces as increases (Fig. 61.3). Since there is little price advantage of the bundling product as increases, and the demand of the bundling product declines, this leads to the long diffusion periods, the firm gets a low profit.

Therefore, the experience sampling levels do not change as increases, the experience sampling level of primary product A maintains at 0, and 11% of complementary product B (Fig. 61.4). It means the experience sampling levels do not change no matter the price of the bundling sampling, and the firm need not change the decision of experience sampling when the price of bundling product changes.

Experience sampling and bundling sampling are the main promotion ways. The experience sampling of product A does not change as bundling sampling level increase; the experience sampling level of product B decrease as the bundling sampling level increase, and it fluctuates when the bundling sampling level is high enough (Fig. 61.5). But firms always do not send a high bundling sampling level, so the experience sampling of product B decrease as the increase of bundling sampling level.

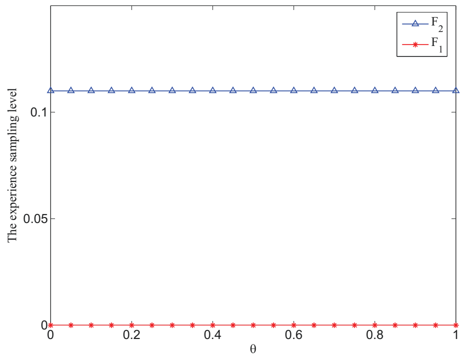

Fig. 61.4 The sensitive analysis between θ and the experience sampling level

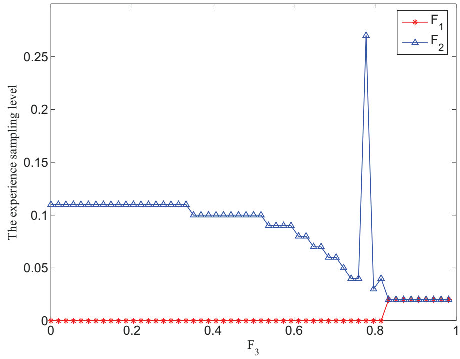

Fig. 61.5 The sensitive analysis between the bundling sampling level and the experience sampling level

61.4 Conclusions

The diffusion of complementary products are common in the market diffusion mechanism, considering the characteristic of complementary products, based on the common experience sampling and the bundling sampling which is specified in complementary products, an optimal model group of diffusion of complementary products is established. The two kinds of promotion ways are analyzed. The study implies that: (1) For the complete complementary products, both the experience sampling and bundling sampling can accelerate the diffusion of complementary products, the best promotion way is sending both the sampling, and the effort of sending experience sampling is better than that of sending bundling sampling. (2) For the incomplete complementary products, the best promotion way is just sending the experience sampling. (3) With the price of bundling sampling increasing, firm's profit decreases, but the experience sampling levels do not change. (4) The experience sampling level decreases as the bundling sampling level increase.

To discuss the essence of the problem, the paper just introduce the two common promotion strategies, there are pricing strategy, advertisement strategy in the marketing of firms, these can be discussed in the future. And the consumer purchasing behavior can be discussed too.

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Chapter 62
Information Fusion for Multi-sensor System with Finite-time Correlated Process Noises

Fan Li and Wujia Zeng

Abstract When the process noises are finite-time correlated in multi-sensor system for engineering monitoring and management, a systematic way to handle the corresponding distributed estimation fusion problem is proposed in this paper. A distributed fusion algorithm based on Kalman filtering is developed, in which the traditional state estimation method to deal with correlated noises by augmenting the state vector of systems is avoided so as not to increase the dimension of state vector. The proposed distributed estimation fusion algorithm guarantees the optimality in the sense of being equivalent to the optimal centralized estimation fusion. The optimality of the new distributed fusion algorithm in multiple-step correlated process noises cases is also analyzed. Comparisons with the existing distributed estimation fusion algorithms are given to demonstrate the performance of the new algorithm.

Keywords Multi-sensor system · Estimation fusion · Distributed fusion · Finite-time correlation

62.1 Introduction

In recent years, many engineering equipment consist of lots of subsystems or modules, integrated system have been playing an increasingly critical role in the development of future engineering systems. However, the engineering management for integrated systems is a complicated task, due to the complexity of the system structures and the systems environment [1, 2].

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With the rapid development of multiprocessor systems and integrated sensor network [3], the multi-sensor systems with the capability of information fusion for system monitoring and management have received great attention, where data are processed in a distributed manner and decisions or estimators are made at the individual processors, and processed data (or first-level compressed) are then transmitted to a central processor to fuse where the final global decision or estimate is made. The fusion module in the integrated systems management has many advantages over one with a single processor. These include an increase in the reliability, robustness and effectiveness of the module.

There are two basic approaches to information fusion or data fusion [4]. In the centralized fusion or measurement fusion, the fusion center can obtain the original information of measurements from local sensors. Although it can provide globally optimal fused estimates always, the fusion center must have excessive ability of computation and high demands on communication bandwidth. Moreover, on account of the existing decentralized network structures and limited communication bandwidth, the distributed fusion becomes a nature alternative in which the optimal estimates or processed data output from all local sensors are communicated to fusion center to be fused. It is important clearly to pursue the optimality in the sense that the distributed fusion algorithm has the same performance as the centralized fusion algorithm. In general, the performance of distributed estimation fusion depends on the fusion strategies and local estimates [5]. There were many works and results about the optimal distributed fusion problems. Especially, the decentralized or parallel Kalman filtering was provided for the dynamical systems with white noises which has the aforementioned optimality [6, 7].

However, the correlated noises are commonly encountered in practical systems such as sensor networks, sensor array and sensor monitoring system. The optimal distributed fusion problem for dynamical systems with correlated process noises or measurement noises has been widely studied [8–10]. In addition, the conditions in the distributed Kalman filtering fusion so as to keep the optimality have also been investigated for the systems with cross-correlated measurement noises from sensors [11]. When process noises are temporally correlated, the traditional methods need to augment the system state so that the noises in modified system are uncorrelated. The shortcomings include: the model of noises is assumed to be known but it usually can not be given exactly in practice; and for the multi-sensor systems, the computational complexity in all local sensors and the communications from local sensors to fusion center are also increased. In this paper, we present a distributed estimation fusion algorithm in correlated noises scenario where the non-augmented Kalman filtering discussed in [13] is used in each sensor to obtain its local optimal estimates. The proposed distributed Kalman filtering (DKF) fusion provides the same optimality as the centralized Kalman filtering (CKF) fusion in the sense of minimizing the mean square error. Then the new algorithm is then expanded to a case with multiple-step correlated noise.

The paper is organized as follows. Sect. 62.2 formulates the multi-sensor estimation fusion problem for systems with correlated process noises. Sect. 62.3 presents the distributed optimal fusion algorithm in the one-step correlated process noise case and then the result is expanded to a case with multiple-step correlated noise. Numerical simulations are given in Sect. 62.4 to demonstrate the performance of the proposed algorithm. Sect. 62.5 provides conclusions and future work. Some derivations are given in the Appendix.

62.2 Problem Formulation

Consider the following l-sensor distributed dynamical systems:

$$x_{k+1} = \Phi_k x_k + v_k, \tag{62.1}$$
$$y_k^i = H_k^i x_k + w_k^i, i = 1, 2, \cdots, l, \tag{62.2}$$

where, $x_k \in R^n$ are the state to be estimated, Φ_k and H_k^i are transmission matrices and measurement matrices with the order $n \times n$ and $N_i \times n$ respectively, y_k^i are $N_i \times 1$ measurement vectors, v_k are additive zero-mean q-step temporally correlated process noises $(q \geq 1)$, i.e.,

$$E[v_k] = 0,\ E[v_j v_k^T] = V_k \delta_{k-j} + \sum_{\tau=1}^{q} V_{j,k} \delta_{k-\tau-j},\ \delta_{k-j} = \begin{cases} 1, k = j, \\ 0, k \neq j \end{cases} \tag{62.3}$$

and are uncorrelated with initial state x_0, w_k^i are zero-mean white measurement noises uncorrelated with v_j for any time j. Assume that measurement noises are not cross-correlated between sensors.

If the fusion center obtains all raw measurements from l local sensors, then the stacked measurement equation at the fusion center can be written as:

$$y_k = H_k x_k + w_k, \tag{62.4}$$

where, $y_k = [y_k^{1^T}, \cdots, y_k^{l^T}]^T$, $H_k = [H_k^{1^T}, \cdots, H_k^{l^T}]^T$, $w_k = [w_k^{1^T}, \cdots, w_k^{l^T}]^T$, and the covariance matrix of the noise w_k are given by:

$$R_k = \mathrm{Var}(w_k) = \mathrm{diag}(R_k^1, \cdots, R_k^l),$$
$$R_k^i = \mathrm{var}(w_k^i),\ i = 1, 2, \cdots, l, \tag{62.5}$$

where $R_k > 0$, i.e. $R_k^i > 0$, for $i = 1, 2, \cdots, l$.

Let $x_{k|k}$ and $P_{k|k}$ be the optimal estimate of state and its estimation error covariance matrix at time instant k respectively using all measurements up to time instant k. For the sake of simplicity, we suppose the process noises are one-step correlated, i.e., $q = 1$, then the centralized Kalman filtering fusion for all raw data received from the local sensors can be expressed as follows:

The global measurement-update

$$x_{k|k} = x_{k|k-1} + K_k \Delta y_k = x_{k|k-1} + K_k (y_k - H_k x_{k|k-1}), \tag{62.6}$$

$$K_k = P_{k|k-1} H_k^T L_k^{-1}, \tag{62.7}$$

$$P_{k|k} = (I - K_k H_k^T) P_{k|k-1}, \tag{62.8}$$

$$L_k = H_k P_{k|k} H_k^T + R_k. \tag{62.9}$$

The global time-update

$$x_{k|k} = \Phi_{k-1} x_{k-1|k-1} + V_{k-2,k-1}^T H_{k-1}^T L_{k-1}^T \Delta y_{k-1}, \tag{62.10}$$

$$\begin{aligned} P_{k|k-1} = \; & \Phi_{k-1} P_{k-1|k-2} \Phi_{k-1}^T + V_{k-1} + \Phi_{k-1} V_{k-2,k-1} + (\Phi_{k-1} V_{k-2,k-1})^T \\ & -(\Phi_{k-1} P_{k-1|k-2} + V_{k-2,k-1}^T) H_{k-1}^T L_{k-1}^T H_{k-1} (\Phi_{k-1} P_{k-1|k-2} \\ & + V_{k-2,k-1}^T)^T, \end{aligned} \tag{62.11}$$

where, $x_{k|k-1}$ is the one-step prediction which represents the estimation at time k using the measurements until time $k-1$, $P_{k|k-1}$ is the estimation error covariance matrix.

The above centralized estimation fusion is actually the same as standard Kalman filter except the one-step prediction $x_{k|k-1}$ and its error covariance $P_{k|k-1}$. It is just the globally optimal recursive filtering for the systems with one-step $(q = 1)$ correlated process noises case using non-augmented strategy presented in [12].

The aim of distributed estimation fusion is to construct the optimal state estimation by utilizing the local estimate or locally processed data which received from each sensor. The optimality of distributed fusion here means the equivalence to the centralized estimation fusion.

62.3 Distributed Optimal Fusion

In order to demonstrate the novel approach clearly, the distributed estimation fusion algorithm for the one-step correlated process noises case is presented firstly.

62.3.1 One-step Correlated Process Noises

Similar to the CKF, let $x_{k|k}^i$ be the local estimate of sensor i at instant k, then the local Kalman filtering at the i-th sensor is:

$$x_{k|k}^i = x_{k|k-1}^i + K_k^i (y_k^i - H_k^i x_{k|k-1}^i), \tag{62.12}$$

$$K_k^i = P_{k|k}^i {H_k^i}^T {R_k^i}^{-1} = P_{k|k-1}^i {H_k^i}^T {L_k^i}^{-1} \tag{62.13}$$

with covariance matrix of estimate error given by:

$$P_{k|k}^i = (I - K_k^i H_k^i) P_{k|k-1}^i \tag{62.14}$$

or

$$P^{i}_{k|k}{}^{-1} = P^{i}_{k|k-1}{}^{-1} + H^{i}_{k}{}^{T} R^{i}_{k}{}^{-1} H^{i}_{k}, \tag{62.15}$$

where

$$L^{i}_{k} = H^{i}_{k} P^{i}_{k|k-1} H^{i}_{k}{}^{T} + R^{i}_{k}, \tag{62.16}$$

the one-step prediction $x^{i}_{k|k-1}$ and its error covariance $P^{i}_{k|k-1}$ are given by:

$$x^{i}_{k|k-1} = \Phi_{k-1} x^{i}_{k-1|k-1} + V^{T}_{k-2,k-1} H^{i}_{k-1}{}^{T} L^{i}_{k-1}{}^{-1} \Delta y^{i}_{k-1}, \tag{62.17}$$

$$\begin{aligned} P^{i}_{k|k-1} = \; & \Phi_{k-1} P^{i}_{k-1|k-2} \Phi^{T}_{k-1} + V_{k-1} + \Phi_{k-1} V_{k-2,k-1} + (\Phi_{k-1} V_{k-2,k-1})^{T} \\ & -(\Phi_{k-1} P^{i}_{k-1|k-2} + V^{T}_{k-2,k-1}) H^{i}_{k-1}{}^{T} L^{i}_{k-1}{}^{-1} H^{i}_{k-1} \\ & (\Phi_{k-1} P^{i}_{k-1|k-2} + V^{T}_{k-2,k-1})^{T}. \end{aligned} \tag{62.18}$$

For the sensor i, the local estimation is also the optimal filter when the process noises are correlated [13]. Owing to the fact that the process noises are not uncorrelated any more, the distributed fusion algorithm is thus designed to achieve the best perform as the CKF (62.6) $\sim$ (62.11). It is easy to see that at instant k, besides $x_{k|k}$ and $P_{k|k}$, the one-step prediction $x_{k|k-1}$ and its error covariance $P_{k|k-1}$ are given by using all of the raw sensor measurements, therefore, the distributed estimation fusion needs to take the four terms $x_{k|k}$, $P_{k|k}$, $x_{k|k-1}$ and $P_{k|k-1}$ into account. In addition, from the time-update (62.10) $\sim$ (62.11), the one-step prediction and its error covariance in the CKF have actually two terms $H^{T}_{k-1} L^{-1}_{k-1} \Delta y_{k-1}$ and $H^{T}_{k-1} L^{-1}_{k-1} H_{k-1}$, which need to use the raw measurement information from the local sensors. In this situation, for expressing the centralized filtering in terms of the local filtering, we need to utilize local estimates, predictions and corresponding error covariance matrices to eliminate unprocessed data y_k and H_k. For presentation clarity, our results for the optimal DKF fusion in the one-step correlated process noises setting can be summarized as following.

If $P^{i}_{k|k-1} > 0$, $R^{i}_{k} > 0$ for $k = 1, 2, \cdots$ and $i = 1, 2, \cdots, l$, then the optimal distributed estimation fusion for the system (62.1) $\sim$ (62.2) can be given as:

$$x_{k|k} = P_{k|k} \left[(P_{k|k-1})^{-1} x_{k|k-1} + \sum_{i=1}^{l} \left(P^{i}_{k|k}{}^{-1} x^{i}_{k|k} - P^{i}_{k|k-1}{}^{-1} x^{i}_{k|k-1} \right) \right], \tag{62.19}$$

$$P_{k|k}{}^{-1} = P_{k|k-1}{}^{-1} + \sum_{i=1}^{l} \left(P^{i}_{k|k}{}^{-1} - P^{i}_{k|k}{}^{-1} \right), \tag{62.20}$$

$$\begin{aligned} x_{k|k-1} = \; & \Phi_{k-1} x_{k-1|k-1} + V^{T}_{k-2,k-1} S_{k-1} \cdot \Bigg[\sum_{i=1}^{l} (P^{i}_{k-1|k-1}{}^{-1} x^{i}_{k-1|k-1} - P^{i}_{k-1|k-2}{}^{-1} \\ & x^{i}_{k-1|k-2}) - \sum_{i=1}^{l} (P^{i}_{k-1|k-1}{}^{-1} - P^{i}_{k-1|k-2}{}^{-1}) x_{k-1|k-2} \Bigg], \end{aligned} \tag{62.21}$$

$$P_{k|k-1} = \Phi_{k-1} P_{k-1|k-2} \Phi^{T}_{k-1} + V_{k-1} + \Phi_{k-1} V_{k-2,k-1} + (\Phi_{k-1} V_{k-2,k-1})^{T}$$

$$
\begin{aligned}
&-(\Phi_{k-1}P_{k-1|k-2}+V^T_{k-2,k-1})S_{k-1}\left(\sum_{i=1}^{l}\left({P^i_{k-1|k-1}}^{-1}-{P^i_{k-1|k-2}}^{-1}\right)\right)\\
&\cdot(\Phi_{k-1}P_{k-1|k-2}+V^T_{k-2,k-1})^T, \qquad (62.22)
\end{aligned}
$$

where

$$
\begin{aligned}
S_{k-1} = \ & I-\left(\sum_{i=1}^{l}\left({P^i_{k-1|k-1}}^{-1}-{P^i_{k-1|k-2}}^{-1}\right)\right)\\
&\left[P^{-1}_{k-1|k-2}+\sum_{i=1}^{l}\left({P^i_{k-1|k-1}}^{-1}-{P^i_{k-1|k-2}}^{-1}\right)\right]^{-1}. \qquad (62.23)
\end{aligned}
$$

From the above distributed estimation fusion formulas, it can be seen that the optimal distributed fusion is also a weighted linear fusion, which uses the fusion center's one-step prediction as well as the local estimates of sensors and their one-step predictions. The correlation matrices of the noise are exploited to avoid the difficulties in precisely estimating the dynamic transmission model of the noise. However, the update of the one-step prediction and its error covariance are difference from the traditional DKF fusion. From (62.19) $\sim$ (62.23), it can be seen that $x^i_{k-1|k-1}$, $x^i_{k-1|k-2}$, $x_{k-1|k-2}$ and $P_{k-1|k-2}$, $P^i_{k-1|k-1}$, $P^i_{k-1|k-2}$, which are the results at previous time, need to be exploited in the update equations, and the reason is because the process noises are no longer temporally uncorrelated, which result in more correlations need to be utilized.

Moreover, the above results demonstrate that the CKF can be explicitly expressed using local filtering, thus, the proposed DKF fusion is equivalent to the CKF fusion on the condition that the correlated statistical properties of the noise are known. Therefore, the above DKF fusion formulas can guarantee optimality in the sense of being equivalent to the optimal centralized estimation fusion when the process noises are one-step correlated.

62.3.2 Multiple-step Correlated Process Noises

To develop the optimal distributed fusion algorithm when process noises are multiple-step correlated, we also consider the multi-sensor systems (62.1) $\sim$ (62.2) with process noises in (62.3). For the correlated process noises (62.3), the local estimation at the sensor can also be yielded by exploiting the globally optimal Kalman filtering [12] with the multiple-step correlated process noises to avoid raising the dimension of the state vector. As denoted in [12], there are some added recursive terms need to be used, so the following notations are introduced:

$$
N_{k,\tau} = (\theta_k-\theta_{k|k-\tau-1})(\theta_{k-\tau}-\theta_{k-\tau|k-\tau-1})^T,\ \tau=0,1,\cdots,q, \qquad (62.24)
$$

$$
T_{k,\tau} = (x_k-x_{k|k-\tau})(x_k-x_{k|k-\tau})^T,\ \tau=1,\cdots,q. \qquad (62.25)
$$

It can be found that the two terms are actually the correlation matrices of optimal prediction errors.

In fact, the effect of the correlated process noises on the Kalman filtering is reflected in the one-step prediction and its error covariance which need to exploit the state transmission model. Therefore, the measurement-update equations of the local optimal Kalman filtering can also be obtained by (62.6) $\sim$ (62.9), but the time-update equations have the following expression.

$$
\begin{aligned}
x^i_{k|k-1} = {}& \Phi_{k-1}x^i_{k-1|k-1} + \sum_{\tau=1}^{q}(N^i_{k,\tau} - \Phi_{k-1}N^i_{k-1,\tau-1})H^i_{k-\tau}{}^T L^i_{k-\tau}{}^{-1}\Delta y^i_{k-\tau},\\
P^i_{k|k-1} = {}& T^i_{k,q} - \sum_{\tau=1}^{q-1} N^i_{k,\tau}H^i_{k-\tau}{}^T L^i_{k-\tau}{}^{-1} H^i_{k-\tau}N^i_{k,\tau}{}^T,
\end{aligned}
$$

where,

$$
N^i_{k,l} = \Phi_{k-1}N^i_{k-1,q-1} + V^T_{k-q-1,k-1},\ k > q, \tag{62.26}
$$

$$
\begin{aligned}
N^i_{k,\tau} = {}& \Phi_{k-1}\cdots\Phi_{k-\tau}T^i_{k-\tau,q} + B_{k,\tau} - \sum_{j=1}^{q-1} N^i_{k,\tau+j}\\
& H^i_{k-\tau-j}{}^T L^i_{k-\tau-j}{}^{-1} H^i_{k-\tau-j}N^i_{k-\tau,j}{}^T,\ \tau = q-1,\cdots,1,
\end{aligned} \tag{62.27}
$$

$$
\begin{aligned}
T^i_{k,q} = {}& \Phi_{k-1}T^i_{k-1,q}\Phi^T_{k-1} + V_{k-1} + \Phi_{k-1}B^T_{k,1} + B_{k,1}\Phi^T_{k-1}\\
& -N^i_{k,q}H^i_{k-q}{}^T L^i_{k-q}{}^{-1} H^i_{k-q}N^T_{k,q},
\end{aligned} \tag{62.28}
$$

$$
B_{k,\tau} = \sum_{j=1}^{\tau}\Phi_{k-1}\cdots\Phi_{k-(j-1)}\begin{bmatrix} V_{k-\tau-1,k-j}\\ V_{k-\tau-2,k-j}\\ V_{k-\tau-2,k-j}\\ \vdots\\ V_{k-q-1,k-j}\end{bmatrix}\begin{bmatrix} I\\ \Phi^T_{k-\tau-1}\\ \Phi^T_{k-\tau-2}\Phi^T_{k-\tau-1}\\ \vdots\\ \Phi^T_{k-(q-1)-j}\cdots\Phi^T_{k-\tau-1}\end{bmatrix}. \tag{62.29}
$$

Unlike one-step correlated noises cases, there are additional terms which need to be used for computing the time-update equations. It can be found that the CKF fusion also meets the same situation when the process noises are multiple-step correlated. Hence, to obtain the optimal distributed fusion, the added terms need to be expressed in terms of local filtering. The statistic properties of noises (62.3) and (62.5) imply that the measurement noises are supposed to be white and uncorrelated with the process noises and independent between the local sensors. Under these conditions and combined with the derivation process of the Appendix, it is not difficulty to reach that the global state estimate and its estimation error covariance can be established in terms of the one-step predictions, local estimates and their error covariances, moreover, the form of the weighted linear fusion is not changed regardless of the process noise correlation step. Therefore, for the process noises are finite-step correlated temporally only, the measurement-update equations of the optimal DKF fusion can be given by (62.19) $\sim$ (62.20). Using the aforementioned technique in one-step correlated case, we can derive the one-step prediction and its error covariance through local filtering, i.e.,

$$
\begin{aligned}
x_{k|k-1} = {} & \Phi_{k-1}x_{k-1|k-1} + \sum_{\tau=1}^{q}(N_{k,\tau} - \Phi_{k-1}N_{k-1,\tau-1})S_{k-1} \\
& \cdot\left[\sum_{i=1}^{l}({P^i_{k-\tau|k-\tau}}^{-1}x^i_{k-\tau|k-\tau} - {P^i_{k-\tau|k-\tau-1}}^{-1}x^i_{k-\tau|k-\tau-1})\right. \\
& \left. - \sum_{i=1}^{l}({P^i_{k-\tau|k-\tau}}^{-1} - {P^i_{k-\tau|k-\tau-1}}^{-1})x_{k-\tau|k-\tau-1}\right], \qquad (62.30) \\
P_{k|k-1} = {} & T_{k,q} - \sum_{\tau=1}^{q-1}N_{k,\tau}S_{k-\tau}\left(\sum_{i=1}^{l}({P^i_{k-\tau|k-\tau}}^{-1} - {P^i_{k-\tau|k-\tau-1}}^{-1})\right)N^T_{k,\tau},
\end{aligned}
$$

where

$$
\begin{aligned}
S_{k-\tau} = {} & I - \left(\sum_{i=1}^{l}({P^i_{k-\tau|k-\tau}}^{-1} - {P^i_{k-\tau|k-\tau-1}}^{-1})\right) \\
& \left[{P^i_{k-\tau|k-\tau-1}}^{-1} + \sum_{i=1}^{l}({P^i_{k-\tau|k-\tau}}^{-1} - {P^i_{k-\tau|k-\tau-1}}^{-1})\right]^{-1}. \qquad (62.31)
\end{aligned}
$$

By using the results of the local estimations, the recursively computed formulas for the additional terms (62.6) $\sim$ (62.7) can be further given as follows:

$$
\begin{aligned}
N_{k,l} = {} & \Phi_{k-1}N_{k-1,q-1} + V^T_{k-q-1,k-1},\ k > q, \qquad (62.32) \\
N_{k,\tau} = {} & \Phi_{k-1}\cdots\Phi_{k-\tau}T_{k-\tau,q} + B_{k,\tau} - \sum_{j=1}^{q-1}N_{k,\tau+j}S_{k-\tau-j} \\
& \left(\sum_{i=1}^{l}({P^i_{k-\tau-j|k-\tau-j}}^{-1} - {P^i_{k-\tau-j|k-\tau-j-1}}^{-1})\right)N_{k-\tau,j}, \\
& \tau = q-1,\cdots,1, \qquad (62.33) \\
T^i_{k,q} = {} & \Phi_{k-1}T_{k-1,q}\Phi^T_{k-1} + V_{k-1} + \Phi_{k-1}B^T_{k,1} + B_{k,1}\Phi^T_{k-1} \\
& -N_{k,q}S_{k-q}\left(\sum_{i=1}^{l}\left({P^i_{k-q|k-q}}^{-1} - {P^i_{k-q|k-q-1}}^{-1}\right)\right)N^T_{k,q}. \qquad (62.34)
\end{aligned}
$$

The above results demonstrate that the CKF can be explicitly expressed by using the local filtering, thus, the optimal distributed estimation fusion for the system (62.1) $\sim$ (62.3) is composed of (62.19) $\sim$ (62.20), and (62.30) $\sim$ (62.34).

From the above fusion algorithm, only the correlation matrices of the noises are exploited in the recursive computing formulas, thus in the local sensors and the central processor, the noise correlations are supposed to be known in advance. In summary, when the process noises are multiple-step correlated, q recursive terms

$N_{k,\tau}$ $(\tau = q-1,\cdots,1)$ and $T_{k,q}$ need to be added to compute the time-update, namely the global one-step prediction as well as its error covariance. Then, the measurement-update is the linear weighted fusion of the one-step prediction and the local estimations.

62.4 Numerical Simulation

In this section, we consider a numerical example in multi-sensor monitor system, where the dynamical system process is modeled as an object signal changing in its own trajectory. Suppose that 3 sensors are used to monitor the system state simultaneously, thus, the object system and measurements are modeled as follows:

$$\begin{aligned} x_{k+1} &= \Phi x_k + v_k, \\ y_k^i &= H^i x_k + w_k^i, i = 1,2,3, \end{aligned} \tag{62.35}$$

where

$$\Phi = \begin{bmatrix} \cos(2\pi/300) & \sin(2\pi/300) \\ -\sin(2\pi/300) & \cos(2\pi/300) \end{bmatrix}, \; H^i = \begin{bmatrix} 1 & i \\ 1 & -i \end{bmatrix}, \; i = 1,2, \; H^3 = \begin{bmatrix} 1 & 3 \\ -1 & 3 \end{bmatrix}. \tag{62.36}$$

are the transmission matrix and the measurement matrices respectively.

We assume that $v_k = 0.9\xi_k + 0.5\xi_{k-1}$, where ξ_k are Gaussian white noises with zero-mean and unity covariance matrices, thus, the correlated matrices are

$$V_k = \begin{bmatrix} 1.06 & 0 \\ 0 & 1.06 \end{bmatrix}, \; V_{k-1,k} = \begin{bmatrix} 0.45 & 0 \\ 0 & 0.45 \end{bmatrix}. \tag{62.37}$$

The covariances R_k^i of the measurement noises are diagonal, given by $R_k^i = I_2$ for $i = 1,2,3$.

Using Monte Carlo method of 50 runs, we illustrate the average squares of track errors of each sensor local estimate, the fused estimates by the CKF and DKF respectively in Fig. 62.1, where the initial values are set as $x_{0|0} = [50,0]^T$, $P_{0|0}^i = ({H^i}^T H^i + 0.1I)^{-1}$.

From the Fig. 62.1, we can see that the DKF fusion has the better performance than the estimates of local sensors which also use the non-augment optimal Kalman filtering, because more useful information from sensors can be used. On the other hand, the distributed fusion algorithm can almost perform as best as the centralized fusion which declare the optimality of our method. For the above system with one-step correlated process noises, if the existing DKF fusion given in [6, 7] based on white noises assumption is adopted, in other word, the system corrupted with correlated noises may usually be mistaken as the system with white noise. In this simulation, we compare the existing DKF fusion algorithm for white noises with the

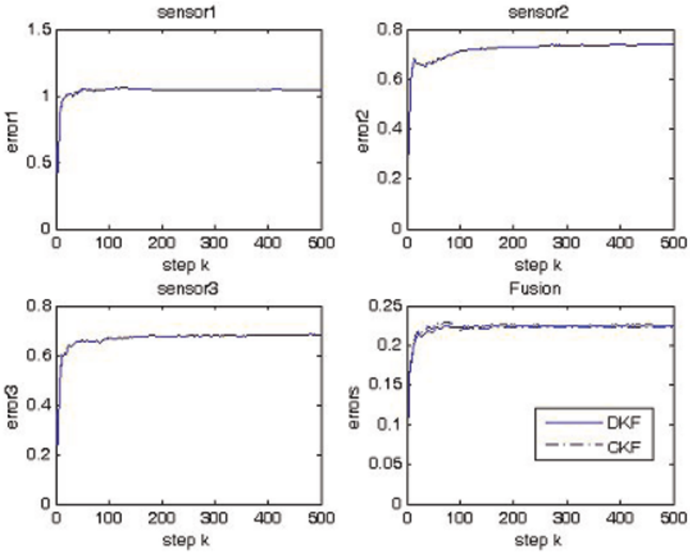

Fig. 62.1 The tracking errors of local estimates, the CKF fusion and the DKF fusion

proposed DKF fusion algorithm which exploits the correlated statistic properties of noises in Fig. 62.2.

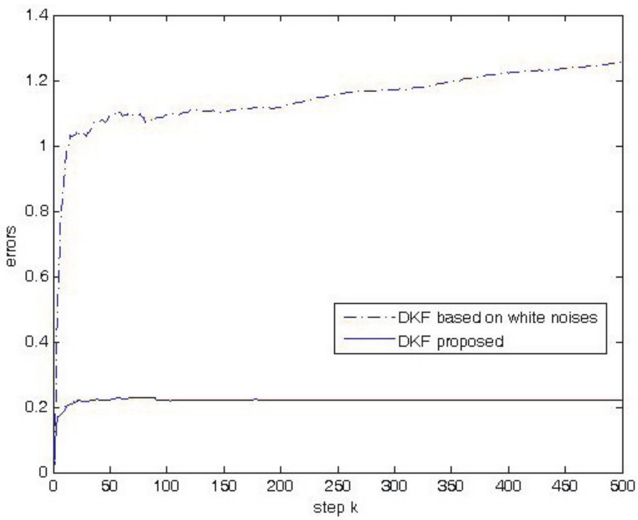

Fig. 62.2 The tracking errors of the existing DKF fusion based on white noises and the proposed DKF fusion

From Fig. 62.2, we can see that for the systems with correlated noises, using the existing DKF fusion based on white noises assumption, the correlated statistic properties of noises are ignored completely so that it has worse estimation performance than our presented method.

62.5 Conclusion

The distributed estimation fusion for the systems with finite-time correlated process noises was designed, which does not increase the dimension of the state vector, thus, is more suitable for multi-sensor systems. Its optimality has been rigorously proved. Further research work includes designing the distributed fusion algorithm for systems with correlated process noises and cross-correlated measurement noises.

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Chapter 63
Analysis of Sampling on the Diffusion of Complementary Product under Dynamic Market Potential

Bing Han, Wei Lu and Zhineng Hu

Abstract This paper develops an optimization model group for the diffusion effects of free sampling products presented to complementary products under dynamic changes in potential market based on the characteristics of the complementary product. The simulation analysis shows that sampling has a positive role in promoting the diffusion of complementary product but it can not affect the final cumulative adopters of the complementary product. The sampling effect of dynamic changes in potential market is superior to the static potential market's. The cumulative adopters of the complementary product decreases with the increase of the changing rate of the potential market, and the NPV increases firstly and then decreases gradually with the increasing of the changing rate of the amount potential market. In the case of limited production capacity of sampling products, both main product and complementary product appear continuous sampling. Finally, the influencial factors between main products and complementary products have a positive role in promoting the product diffusion.

Keywords Complementary products · Product sampling · Dynamic potential market · Product diffusion

63.1 Introduction

Bass model [1] is the most classical model in the research of product diffusion mechanism. RA Peterson and Mahajan [2] divided the products relationship into independent products, competitive products, complementary products, and contigent products in the study of the diffusion of variety products. Ende [3] developed the model of the optimal level of participation of the enterprise group producing complementary products based on the degree of innovation of the enterprise group and

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complementary products. Wei [4] established five different price decision-making model and developed optimal pricing model of complementary products in different price models under the situation of duopoly mode and only one retailer in the supply chain using game theory. Zhou [5] pointed out that the competitive advantage of the complementary products to the company manifested in: (1) increasing the value of the product; (2) to obtain synergies.

Lammer [6] pointed out that "free samples" can increase the number of customers to buy in a short period time and maintain the loyalty of customers. Heiman [7] further pointed out that sampling does not only make the customer immediately buy but also increase customers' propensity to buy the product. Jain [8] established the optimal sampling level model before products put into the market. Hu [9–11] had a research on the impact of free samples to the diffusion of the independent product under different pricing strategies.

Mahajan [12, 13] pointed out that the the static potential adopters is unreasonable, on the contrary potential adopters should be dynamic. The purpose of company marketing is to affect the potential market which is a function of the number of households. Sharif [14] pointed out that the market potential is a function of the growth of the population. Guseo [15, 16] pointed out that the product diffusion are two different processes of communication-acception and the dynamic changes in the communication network which is not fixed is a determine factor of potential market.

This article develops an optimization model group considering the factors of free samples, dynamic changes in potential market and repeat purchase based on the model of complementary products. Then, this article does a comparative analysis to the impact of dynamic change and static change in potential market to the diffusion of the complementary products. More critical factors are analyzed in the model which has been of great significance for the marketing.

63.2 Modeling

And then based on the Bass model, this paper discusses the diffusion model of complementary products and establishes the optimization model group under the premise of the dynamic market potential and the characteristics of the complementary products.

63.2.1 Problem Statement

Bass model mainly aimed at the diffusion of the independent products. However, in the real market, the independent products hardly appears and the complementary products is one of the main forms of the market.

Due to the dynamic change of the product diffusion, the consumers in the market are also changing. This process can be expressed as: Part of the original unadopters will generate demand for the product and become potential adopters, while part of the original adopters will no longer generate demand for the product and quit the market potential. We consider the crowd entering the potential market equal to the crowd exiting the potential market. Based on the analysis above, some assumptions for the model group are presented below:

- The diffusion of the complementary products can promote with each other;
- The geographic boundaries of the social system do not change over the diffusion process;
- Nature of a product does not change over time;
- Diffusion process includes two stages: the unknown, the adoption;
- The productive cost of unit main product and complementary product remain the same during the diffusion process and the company can produce instantaneous supply;
- Consumers get only one sample once time, perhaps with repeat purchase or multiple-unit purchase.

63.2.2 Model Development

The notations of the problem are shown below:

i : 1, 2 (1represents main product, 2 represents complementary product).
T : Period (1 to T);
$\overline{N_i}$: Number of i^{th} product's potential adopters;
a_i : Coefficient of external influence of i^{th} product;
b_i : Coefficient of internal influence of i^{th} product;
$N_i(t)$: Cumulative adopters of i^{th} product through diffusion by time t;
$n_i(t)$: Adopters of i^{th} product through diffusion by time t;
$N_{fi}(t)$: Cumulative adopters of j^{th} product through sampling by time t;
$n_{fi}(t)$: Adopters of i^{th} product through sampling by time t;
$U_i(t)$: Unadopters of i^{th} product by time t;
$u_i(t)$: The changing unadopters of i^{th} product by time t;
δ_i : Influential factors between main products and complementary products;
γ_{ui} : The changing rate of i^{th} product;
r_i : The repeat purchase rate of i^{th} product;
γ_{ni} : The ratio of new adopters in the market who get the free sample but never adopted i^{th} product before;
γ_{bi} : The ratio of i^{th} product potential adopters in the total market;
τ_i : The service life of i^{th} product;
$s_i(t)$: Sales volume of i^{th} product in period t;
i_t : The discount rate.

(1) The basic model

According to Bass model and features of the complementary products, the diffusion process of the product are affected by internal influence and external influence. While the main products and complementary products will affect each other during the diffusion process. Therefore, Mahajan established the basic diffusion equation based on the characteristics of the complementary products:

$$\begin{cases} n_1(t+1) = N_1(t+1) - N_1(t) = (a_1 + b_1 N_1(t) + \delta_2 N_2(t))U_1(t), \\ n_2(t+1) = N_2(t+1) - N_2(t) = (a_2 + b_2 N_2(t) + \delta_1 N_1(t))U_2(t), \end{cases} \tag{63.1}$$

where $U_i(t) = \overline{N_i} - N_i(t)$. $\delta_2 N_2(t)$ and $\delta_1 N_1(t)$ are influential factors to the complementary products when consumers get one product in period t. The influential factors here only consider positive influential factors between them.

(2) The impact of dynamic change in potential market

As mentioned above, the number of potential consumers in the market is dynamic changing that non-potential consumers which accounted for a certain percentage of the market potential $\overline{N}$ will change into potential consumers in each period. At the same time, the current adopters $N(t)$ and unadopters $U_(t)$ will quit the market potential in the same proportion. Therefore, the Equation (63.1) changes into:

$$\begin{cases} n_1(t+1) = N_1(t+1) - (1-\gamma_{u1})N_1(t) \\ \qquad\qquad = (a_1 + b_1(1-\gamma_{u1})N_1(t) + \delta_2(1-\gamma_{u2})N_2(t))U_1(t), \\ n_2(t+1) = N_2(t+1) - (1-\gamma_{u2})N_2(t) \\ \qquad\qquad = (a_2 + b_2(1-\gamma_{u2})N_2(t) + \delta_1(1-\gamma_{u1})N_1(t))U_2(t), \\ u_i(t+1) = r_{ui}\overline{N_i} - n_i(t+1), \end{cases} \tag{63.2}$$

where $0 \le r_{ui} \le 1$. When $r_{ui} = 0$, The Equation (63.2) degenerates into Equation (63.1).

(3) The impact of the sampling

Sampling is a common promotional way. Consumers change into adopters after get the sample and then promote the diffusion of products through oral communication. The more samples, the faster the product diffuse. However, too many samples will also result in increased costs of the company, it is necessary to determine a suitable sampling level that makes the largest product revenue. Therefore, the Equation (63.2) considers sampling changes into:

$$\begin{cases} n_1(t+1) = N_1(t+1) - (1-\gamma_{u1})N_1(t) = (a_1 + b_1(1-\gamma_{u1})(N_1(t) + N_{f1}(t)) \\ \qquad\qquad + \delta_2(1-\gamma_{u2})(N_2(t) + N_{f2}(t)))U_1(t), \\ n_2(t+1) = N_2(t+1) - (1-\gamma_{u2})N_2(t) = (a_2 + b_2(1-\gamma_{u2})(N_2(t) \\ \qquad\qquad + N_{f2}(t)) + \delta_1(1-\gamma_{u1})(N_1(t) + N_{f1}(t)))U_2(t), \\ u_i(t+1) = r_{ui}\overline{N_i} - n_i(t+1) - \gamma_b\gamma_n n_f(t+1), \end{cases} \tag{63.3}$$

where $\gamma_{bi}\gamma_{ni}(t+1)n_{fi}(t+1) = N_{fi}(t+1) - (1-\gamma_{ui})N_{fi}(t)$, $\gamma_{ni}(t+1) = 1 - U_i(t+1)/\overline{N_i}$, $N_{fi}(0) = \gamma_{bi}\gamma_{ni}(0)n_{fi}(0)$, $\gamma_{ni}(0) = 1$. Especially, $\gamma_{ni}(t) = 1$ means all of the consumers got the free samples are those who have not purchased i^{th} product $(i = 1,2)$ yet.

Hence, during the whole diffusion process, the potential market can be divided into two parts: adopters and unadopters. Further, the adopters of the new product can be divided into two parts: the purchasers and the consumers who get the free samples; obviously,

$$N_i(T) + N_{fi}(T) \leq \overline{N_i}. \tag{63.4}$$

(4) The impact of the repeat purchase

Every product has a life cycle. Indeed, repeat purchase exists widely. Meade and Islam [17] summarized literatures on the phenomenon of repeat purchase, especially for non-durable products. Each product has a life cycle τ and consumers may purchase the product repeatly when they consume the product $r \leq 1$ and have demand on them. The repeat purchase rate of new products and can not reach one (1) generally. When $t \geq \tau_i$, the potential repeat purchaser of i^{th} product in period t will be cumulative adopters in period $t - \tau_i$ minus the consumers who have purchased the product repeatly from period $t + 1 - \tau_i$ to period $t - 1$. Then, the potential repeat purchasers should be:

$$R_i(t) = \begin{cases} N_i(t-\tau_i) + N_{fi}(t-\tau_i) - r_i \sum\limits_{j=1}^{\tau_i - 1} R_i(t-j), & \tau_i > 1, t > \tau_i, \\ N_i(t-\tau_i) + N_{fi}(t-\tau_i), & \tau_i = 1, t > \tau_i, \\ 0, & t \leq \tau_i. \end{cases} \tag{63.5}$$

Therefore, considering repeat purchase, sales volume of I^{th} product in period $t + 1$ should be composed by two parts: the current purchase volume and the repeat purchase volume:

$$S_i(t+1) = n_i(t+1) + r_i R_i(t+1).$$

(5) Objective function

Although sampling is an effective way to accelerate the diffusion of the product in a short period of time, for companies, too many samples is a waste of resources. Therefore, it is the key to the problem to determine what kind of sample level is best. To achieve maximum profits for the company, the net present value is the best measure criterion. Therefore, the objective function can be expressed as follows:

$$\begin{aligned} &\max(\pi_1 + \pi_2) \\ &= \sum_{i=1}^{2} \left\{ \sum_{t=1}^{T} \frac{1}{(1+i_r)^t} \left[(p_i(t) - c_i) S_i(t) \right.\right. \\ &\quad \left.\left. - (h_i + c_{fi}) n_{fi}(t) \right] - (h_i + c_{fi}) n_{fi}(0) \right\}, \end{aligned} \tag{63.6}$$

where h_i is sample cost of the sample product, including labor costs, packaging costs, transportation costs, processing costs, etc. c_i is the unit cost of the product, c_{fi} is the unit cost of the sample product.

63.2.3 Model Group

After considering the dynamic change in potential market, sampling, and repeat purchase, we establish the optimization model group:

$$\max \pi = (\pi_1 + \pi_2), \tag{63.7}$$

subject to Equations (63.2) $\sim$ (63.6) where the decision variables are $S_i(t), N_i(t)$, $U_i(t), n_{fi}(t)$.

63.3 Numerical Analysis and Results

The model group established in this article belonging to a nonlinear optimization problem. Hence, this section will focus on analyse the impact of sampling and dynamic change in potential market to complementary products. According to relative literature [18], parameter values used in the model are as follows: $c_1 = 8$, $c_2 = 5$, $c_{f1} = 2$, $c_{f2} = 1$, $h_1 = h_2 = 1$, $a_1 = 0.03$, $a_2 = 0.02$, $b_1 = 0.38$, $b_2 = 0.35$, $\overline{N_1} = \overline{N_2} = 54$, $\sigma_1 = 0.05$, $\sigma_2 = 0.03$, $p_1 = 16$, $p_2 = 10$, $\gamma_{b1} = \gamma_{b2} = 0.1$, $\gamma_{u1} = \gamma_{u2} = 0.05$.

63.3.1 Analysis of Sampling

This section fully analyse the impact of dynamic change in the market to the diffusion of complementary product by analyzing the impact of sampling to adopters, cumulative adopters, sales volume as well as the net present value under dynamic change in potential market.

(1) The impact to the diffusion of adopters under dynamic change in potential market

Fig. 63.1 and Fig. 63.2, respectively, are adopters of main products and complementary products in the case of whether there is a sampling in each period under the dynamic change in potential market. As can be seen from Fig. 63.1, adopters of main products increase first and reach a peak, and then it gradually decreased until period 20, at last adopters of each period are closed to a fixed value which tends to be unchanged. In this case, the peak period of adopters appears at period nine (9). In the case of sampling, the adopters at period first (1) increase sharply because the impact of sampling, and then the adopters fell in the second (2) period. Then from period two (2) to period 30, the changing trend of adopters in every period is similar to the trend of no sampling-reach the peak first and then gradually reduced until it tends to a fixed value. However, sampling makes the occurrence of the peak period advanced. In the sampling case, the peak period of adopters appears at period five (5). Making peak period advanced can let more main products accepted by potential consumers earlier and promote the diffusion of the product.

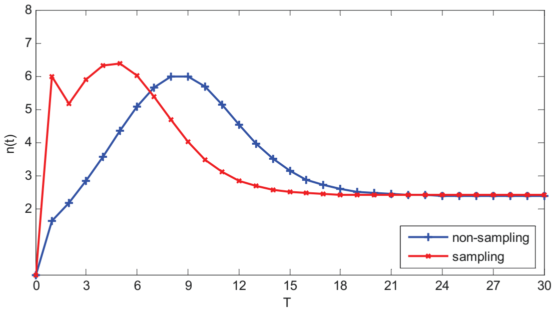


Fig. 63.1 The impact of sampling to main products under dynamic potential market

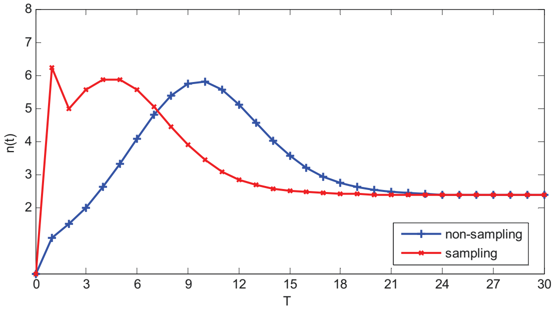


Fig. 63.2 The impact of sampling to complementary products under dynamic potential market

We can see from Fig. 63.2 that the changing trend of adopters in every period of complementary product is similar to the the trend of main product no matter whether sampling or not, so it is not detailed analyzed here.

(2) The impact of cumulative adopters

In this section, the article does comparative analysis that contain sampling or not and dynamic change in the marker or not to the cumulative adopters of the main product and complementary product.

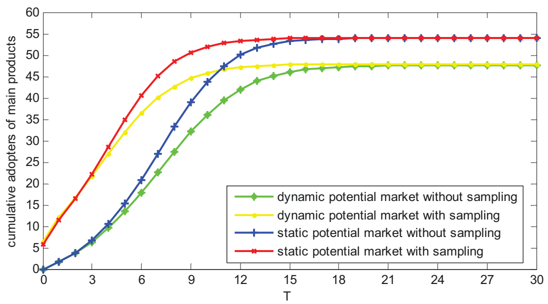


Fig. 63.3 The impact of sampling to cumulative adopters of main products

In the case of sampling and dynamic change in potential market, the first three period of the main product is similar to the trend without dynamic change in potential market. However, due to the impact of the changing rate γ_u, the growth of cumulative adopters is relatively slow down compared to the curve without dynamic change in the market afterwards and the cumulative adopters also reach a fixed value after period 14. It can be seen that the main product at this time does not completely diffused just as shown in the Fig. 63.3. The larger the changing rate γ_u is, the smaller the fixed value will be (the specific analysis see (2) in Sect. 63.3.2).

The trend of cumulative adopters that only considers dynamic change in potential market is similar to the trend that no sampling and no dynamic change in potential market, and then the cumulative adopters reach a stable value at period 17. From the curve (Fig. 63.3) we can see, the stable value is same with the situation that considers both dynamic change in potential market and sampling. Therefore, we know that: The sampling can speed up the diffusion of the adopters at early stage, but it can not change the final cumulative adopters of the product. Since the cumulative adopters of complementary products have the same trend with the main products', it is not detailed analyzed herein.

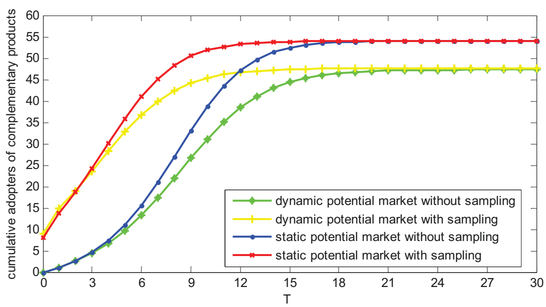


Fig. 63.4 The impact of sampling to cumulative adopters of complementary products

(3) The impact to sales volume under dynamic change in potential market

Fig. 63.5 and Fig. 63.6, respectively, are the impact to sales volume of main products and complementary products under dynamic change in potential market. As can be seen from Fig. 63.5, the sales volume of main product with sampling in the first 10 period is much higher than the same period with no sampling. But the gap of them gradually decreases with the increase the periods. At last, the sales volume of them becomes basically the same from period 17. As can be seen from Fig. 63.6, the trend of complementary products is similar to the trend of main products no matter it does sampling or not, but the sales volume of complementary products increases more significant than main products. It directs that the impact of sampling to sales volume is positive-more sampling, more sales volume. But because of the cost of sampling, the sampling rate of main products and complementary products can not very high considering profit maximization. Indeed, it is a value that can accelerate sales volume as well as control the sampling cost.

(4) The impact to NPV

Table 63.1 draw the optimal sampling strategy of enterprises through the analysis of the dynamic change in potential market as well as the impact of sampling to NPV.

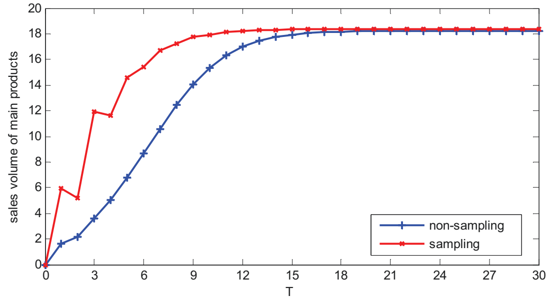


Fig. 63.5 The impact of sampling to sales volume of main products under dynamic potential market

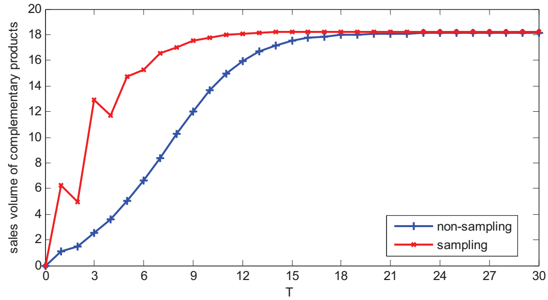


Fig. 63.6 The impact of sampling to sales volume of compliementary products under dynamic potential market

Table 63.1 The impact of sampling to NPV

Market	Non-sampling	Initial sampling		
	NPV	NPV	Sampling rate of main products	Sampling rate of complementary products
Dynamic potential market	4855.249	5330.637	0.120	0.166
Static potential market	4952.805	5303.647	0.108	0.149

From Table 63.1, we can draw the following three conclusions: ① Sampling is always an effective promotional way. It can always makes the NPV improves no matter there is dynamic change in potential market or not. ② The effect of sampling under dynamic change in potential market is better than the effect of sampling without dynamic change in potential market. ③ The dynamic change in potential market will improve the sampling rate of the product. This is due to part of the cumulative adopters will exit the potential market in every period. We must increase the sampling rate to ensure the internal impact effect of the product.

63.3.2 Analysis of the Changing Rate γ_u

Literatures about product diffusion often assumes that the potential market is a fixed value. In reality, the static potential market does not exist and the potential market is in dynamic change.

(1) The impact to final diffusion adopters and NPV

As can be seen from Table 63.2, the NPV value first increases and then becomes smaller gradually along with the changing rate γ_u increase gradually. This is because NPV of the product is main related to the adopters of each period and cumulative adopters, although the cumulative adopters will have a loss in each period, the increasing sampling rate can compensate for the loss of the cumulative adopters to some extent. Simultaneously, due to the changing rate increased, the unadopters of each period will increase to some extent. It can influence more unadopters transform into adopters in every period and increase the number of adopters in every period thereby. Therefore, the increasing effect of the adopters' accounts for dominant factor in the initial stage, so the NPV will increase a little at first. With the growing of the changing rate γ_u, the lossing effect of the adopters' accounts for dominant factor and NPV will reduce quickly.

Table 63.2 The impact of γ_u to final cumulative adopters and NPV

	NPV	Main product		Complementary products	
		Sampling rate	Final cumulative adopters	Sampling rate	Final cumulative adopters
$\gamma_u = 0$	5303.647	0.108	53.99998	0.149	53.99996
$\gamma_u = 0.02$	5333.504	0.113	51.55296	0.156	51.43528
$\gamma_u = 0.05$	5330.630	0.120	47.91368	0.166	47.61673
$\gamma_u = 0.1$	5204.859	0.129	41.95104	0.182	41.34843
$\gamma_u = 0.2$	4563.209	0.133	30.60667	0.209	29.38411

The final diffusion adopters of main products and complementary products will decrease gradually with the increase of the changing rate γ_u, this is because the new adopters and the quiting adopters will achieve a dynamic balance finally. The quiting adopters will increase with the increase of the changing rate γ_u,so the final diffusion adopters will decrease with the increase of the changing rate γ_u when they achive dynamic balance.

(2) The impact to sales volume

As shown in Fig. 63.7 and Fig. 63.8, the trend of main products and complementary products is basically the same in the previous five period with the increase of the changing rate γ_u. From period 5, however, the sales volume reduces more and more significant with the increase of the changing rate γ_u. This is due to the sales volume of the product is mainly affected by current adopters and accumulative adopters, just as described in the previous section, the lossing effect of the adopters become more and more evident with the increase of the changing rate γ_u, resulting a substantial reduction of sales volume in late stage of the diffusion process when γ_u increase.

Fig. 63.7 The impact of γ_{u1} to sales volume of main products

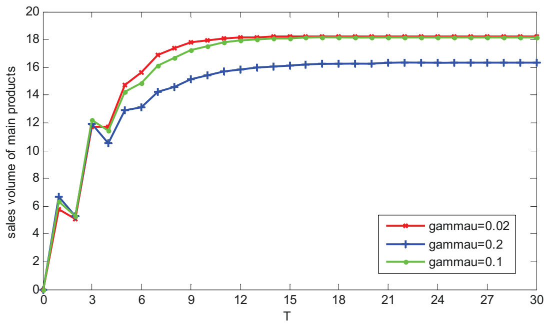
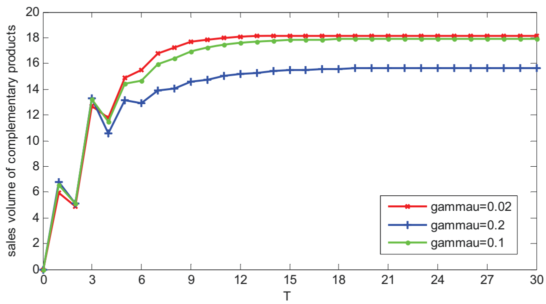


Fig. 63.8 The impact of γ_{u1} to sales volume of complementary products



(1) and (2) analyze the impact of the changing rate γ_u to the diffusion of the product. Therefore, how to control the changing rate γ_u is very meaningful. For example, we can control the changing rate γ_u through expanding suitable age range of the product.

63.3.3 Continuous Sampling Analysis

To compensate for the loss of the internal effect brought by part of the cumulative adopters quit the potential market in every period under dynamic change in potential market, there will be an increase in sampling rate. However, the companies will have a supply constraints due to limited production capacity of the sampling product. In this case, the continuous sampling occurs.

Comparative analysis of continuous sampling and initial sampling

This section will discuss continuous sampling of the product under conditions of limited production capacity of sampling products. We assume that the maximum production capacity of main sampling products is 20 and the maximum production capacity of complementary sampling products is 30 in each period.

Table 63.3 compares sampling product under supply constraints to sampling product without supply constraints with dynamic change in potential market. It can be seen from Table 63.3, both the sampling of main products and the sampling of complementary products appear continuous sampling under supply constraints. Both initial sampling and first period sampling of main products reach the maximum production capacity 20. However, sampling will no longer exist from second period because the impact of sampling is getting smaller and smaller together with the previously established "word-of-mouth" effect. On the other hand, the initial sampling of complementary products also reach the maximum production capacity 30, which further illustrates the great influence and role of the initial sampling. The first period sampling of complementary products reaches 19.94, and then sampling will not exist from period two.

Table 63.3 The sampling comparison of supply constraints and non-supply constraints in dynamic change potential market

Supply situation	NPV	Main product			Complementary products		
		Initial sampling	First period sampling	2-30 period sampling	Initial sampling	First period sampling	2-30 period sampling
Non-supply constraints	5330.637	64.97623	0	0	89.92490	0	0
Supply constraints	5213.614	20.00	20.00	0	30.00	19.94	0

63.3.4 Complementary Influential Factors Analysis

As can be seen from Table 63.4, the sampling rate of main product will increase with the increase of influential factor of main products to complementary products

δ_1. It is because more main products can not only promote the diffusion of itself but also can promote the diffusion of complementary products. It is precisely such dual effects that makes the sampling rate of main products increase with the increase of δ_1. At the same time, the sampling rate of complementary products will decrease with the increase of δ_1. This is because the influence of the diffusion of main products to complementary products will increases with the increase of δ_1 which lead to the relative decrease of the promoting effect of sampling. Therefore, the sampling rate of complementary products will decrease with the increase of δ_1. Finally, NPV, the final cumulative adopters of main products and complementary products will increase in varying degrees with the increase of δ_1. δ_1 is a factor promoting the diffusion of products, so it has a promoting role to all parameters.

Table 63.4 The impact of δ_1 to NPV and sampling rate

	NPV	Main product		Complementary products	
		Sampling rate	Final cumulative adopters	Sampling rate	Final cumulative adopters
$\delta_1 = 0$	5253.006	0.018	47.90641	0.315	46.76246
$\delta_1 = 0.01$	5265.993	0.032	47.90803	0.296	46.95356
$\delta_1 = 0.03$	5294.798	0.067	47.91101	0.245	47.30351
$\delta_1 = 0.05$	5330.630	0.120	47.91368	0.166	47.61673
$\delta_1 = 0.07$	5383.692	0.228	47.91609	0.010	47.89919

63.4 Concluding Remarks

The diffusion of complementary products widely exists in the product diffusion market mechanism. By systematic analysis to every factors in model group, this article draw the following conclusions creatively: (1) Potential market of main products and complementary products can not be achieved completely diffusion in the situation of dynamic changes in potential market. (2) For both main products and complementary products, the sampling effect under dynamic change in potential market is better than the static potential market. (3) The final cumulative adopters of main products and complementary products will gradually reduced with the increase of γ_u. (4) The sampling rate of main products and complementary products will gradually increase with the gradual increase of γ_u. (5) The NPV of main products and complementary products will first slightly increase and then accelerately decrease with the increase of γ_u. (6) There will appear the situation of continuous sampling under conditions of limited production capacity of sampling products. (7) The greater the influencial factors between main products and complementary products, the faster the diffusion progress will be.

This article assumes that the products are completely complementary products in order to discuss the essence of the problem. To not completely complementary products which means the situation that the potential markets of the two product is not the same, it is need to be analyzed further. Additionally, this article only consider the promotion of sampling, but many other promotions such as bundling sampling of complementary products are not reflected in this article. These will be considered and improved in the following studies.

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Chapter 64
Factors Which Affect the Sustainable Production of Cotton in Pakistan:A Detailed Case Study from Bahawalpur District

Abid Hussain Nadeem, Muhammad Nazim, Muhammad Hashim and Muhammad Kashif Javed

Abstract Pakistan is one of the most important cotton producing and consuming country in the World. The present study purpose is to explore the important factors affecting cotton production in Pakistan. A sample of cotton growing respondents was randomly selected from different villages of Punjab province. Some production function was employed to assess the effects of education, land fertilization, weather, land preparation, seed, irrigation, etc. On the productivity of cotton. Education, plant protection measures, fertilizer and land preparation were contributing towards higher cotton yield on the sampled respondents farms. So, there is a great need to educate the farmers on priority basis for adopting recommended practices. The extension staff can play a highly positive role in this regard. At the end, a detailed discussion is proposed to show the efficiency of the proposed model.

Keywords Factors affecting cotton yield · Cost of production · Cost benefit ratio · Bahawalpur district · Pakistan

64.1 Introduction

The purpose of this paper is to explore prospects and mechanisms for a transition to sustainable development of agri sector in Pakistan. The particular case examined here is cotton and cotton products, which together establish the largest economic sector in Pakistan, with appreciable trade exposure at every stage of production.

Pakistan is the fourth largest producer of cotton in the world after Peoples Republic of China, USA and India, the third largest exporter of raw cotton, the fourth largest consumer of cotton, and the largest exporter of cotton yarn.

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1.3 million farmers (out of a total of 5 million) cultivate cotton over 3 million hectares, covering 15 per cent of the cultivable area in the country. Cotton and cotton products contribute about 10 per cent to GDP and 55 per cent to the foreign exchange earnings of the country. Taken as a whole, between 30 and 40 per cent of the cotton ends up as domestic consumption of final products. The remaining is exported as raw cotton, yarn, cloth, and garments [2]. Cotton is a major fiber and cash crop of Pakistan and ranks at the top as foreign exchange earner. This crop provides livelihood to million of people engaged in its trade and textile industry. Moreover, it provides raw material for our local industry and stands at the top of our exports sharing 62.3% to our total export [9].

In 1947, production of cotton was only 1.23 million bales, whereas an all time record cotton production of 14.6 million bales was achieved in 2004-05, which was the highest in the history of Pakistan. The production process involves principle use of inputs including seed, pesticides, fertilizers and irrigation. There is a substantial increase in cotton production during the last decade but still potential yield has not yet been achieved. However, the use of advanced technologies and wise use of inputs at the subsidized rates can enhance the production of cotton.

Cotton is produced on large as well as small farms with significant differences in farming methods and access to technology. In Pakistan, cotton is grown on 3 million hectares mainly in the provinces of Punjab and Sindh. More than half of the farms are less than 2 hectares in area, although they cover only 11 per cent of the area. However, less than 2 per cent of the farms covering 24 per cent of the area are larger than 20 hectares in size. Key actors in this segment of the chain are the 1.3 million farmers, 20 pesticide companies, 114 seed companies, government seed corporations, government seed certification department, the agricultural extension system, the cotton crop research institutes, the irrigation department, commission agents, ginners, and agricultural credit companies. While some of these are more organized than others (eg the pesticide companies), it is not clear whether there is a governance structure to influence inputs and outputs. Cotton crop is more sensitive to disease and pest attacks, so, timely identification of such problems and appropriate measures to control such attack are the utmost important [3]. The literate farmers are in a position to tackle such problems in the most efficient ways. Raza and Ramachandran [5] also indicated that farmer education improves the management skills.

Different studies have been conducted to assure the factors which are responsible to increase the production and ultimately benefiting the farmers. Iqbal et al [7] and Bakhsh et al [3] observed that high cost of inputs, scarcity of financial resources, lack of access to the markets and untrained farmers are responsible for the low yield per hectare and ultimately reduction in the benefits to the farmers. Nabi [1] calculated that the use of inputs has a direct bearing on the production and profit of the farmers. He found that cultivation cost, sowing cost, seed, fertilizer, pesticide, irrigation and labour are the important variables in production of cotton. Plant protection and irrigation are the most important variables which affect the cost of production.

To break down the causal factors of cotton production, the present study is conducted in Bahawalpur district, a central area for the production of cotton in Pakistan.

64.2 Problem Statement

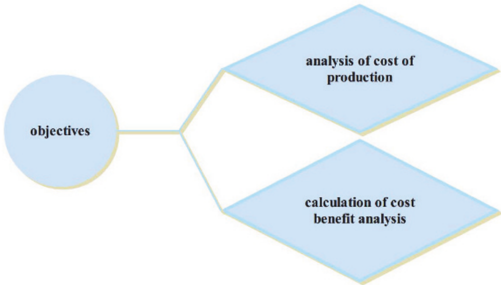
COTTON, which is also known as 'white gold', is an important crop in many developing countries. The yield of the crop is dependent upon the environment in which it is grown and the management practices of the cropping system.

In Pakistan Cotton yields are stagnant for the last several years. Factors responsible for the stagnant cotton production include: excessive rain at the time of sowing, high temperature at flowering stage, late wheat harvesting resulting in decline of area under the crop, leaf curl virus incidence, soil system, weather adversaries, pest attack and improper production technology in major cotton growing areas of Punjab and Sindh. There are many social as well as economic problems facing cotton production including, illiterate farming community, high cost of inputs, small land holdings, less adoptability of innovations by the farmers, lack of guidance to farmers, high cost of production and insecurity in the market, the cost of production being the most significant among them. In recent past two major factors had a significant impact on the economics of cotton production. They are extensive use of agrochemicals and yield stagnation. Among all agrochemicals, fertilizers and insecticides are of utmost importance. There are no efficient alternatives to synthetic fertilizers and cotton production has to bear the use of nutrient supplements in the form of inorganic fertilizers. The core of the problem facing the country cotton industry has been the absence of a recognized and scientifically devised standardization system. The marketing and pricing system had been based on cotton varieties and weight, which resulted in a variety of grades and staples. The government therefore decided to introduce standardization and a pricing system based on premiums/discounts to bring Pakistan cotton on a par with internationally accepted standards and to ensure better returns for cotton growers, ginners, spinners and the national economy [10]. Among pesticides, insecticides are group of agrochemicals which is extensively used on cotton. In the cottonwheat system of Pakistan, there are a considerable number of farms that are both technically and allocatively inefficient [4]. Cotton management in complex farming systems is influenced by time conflicts in the harvesting of preceding crops and the sowing of cotton and interactions due to residual effects on succeeding crops [6]. Iqbal et al [7] found that timely availability of inputs such as seed, fertilizer, weedicides and pesticides could enhance crop productivity. Insects, being living organisms, have adjusted with the injurious chemicals and learned to survive with insecticides. Consequently, insecticide use kept increasing causing a serious impact on the economics of cotton production. Currently, there is a greater need for new developments in production research but more and more researchers are confronted with maintaining the current status of yields in their countries. The cost of production has increased to unacceptable levels in many countries that threaten the economics of cotton production. There are different classes of the farmers for example small, medium, large, and there resources are also different. In this paper we study about the factors which affect the cotton crop and also why the large farmers gain more output than small or medium growers.

64.3 Objectives of the Study

- To analyze the cost of production for different classes of the farmers affecting cotton production.
- To calculate the cost-benefit analysis of cotton production.

Fig. 64.1 Obejectives of the study



64.4 Data and Methodology

The research is established on the primary data accumulated from the target area (Bahawalpur district) through a comprehensive questionnaire from 50 small growers (having 12.5 acres of land), 30 medium (having 12.5 acres but 25 acres of land) and 20 large growers (having 25 acres of land) in March, 2006. The growers were selected at random from two tehsils of district Bahawalpur namely Bahawalpur and Ahmedpur east. At the second stage of sampling, 10 villages from 5 union councils of these two tehsils were selected randomly. The number of sample growers of the district was proportionately distributed among the randomly selected villages based on the share of small, medium and large growers of the villages. At the third stage, farmer sample was selected from the list of the farmers of these villages. The major portion of samples comprised of small farmers followed by medium and large.

To estimate the cost of production of cotton crop, the crop budgeting technique was used. In this technique, different fixed and variable inputs are used. Land rent was the major fixed input while cultivation (LCC), fertilizer (LFC), irrigation including canal and tube-well (LIC), hoeing (LINTC), labour cost (LLC), plant protection (LPPC) and sowing cost (LSC) were taken as variable cost.

64.4.1 Parameters:

LnY : Dependent variable representing Yield/acre;
$Z1$: Cost of cultivation;
$Z2$: Cost of fertilizer;
$Z3$: Cost of Irrigation;
$Z4$: Hoeing cost;
$Z5$: Labour cost;
$Z6$: Cost of plant protection;
$Z7$: Cost of seed and sowing;
γ : Constant;
η : Coefficients to be estimated;
v : Random disturbance term;
Ln : Natural Logarithms.
Mathematically,

$$\text{CB ratio} = \text{GI}/\text{TC},$$

where, CB is Cost Benefit Ratio, GI is Gross Income, TC is Total Cost.

64.4.2 Results and Discussion

This study conducted to investigate the role of various inputs, the cost benefit ratio for the farmers.
(1) Cost of production

Per acre cost of production of the cotton crop is estimated in Bahawalpur for small, medium and large farmers and the results are reported in Table 64.1.

Table 64.1 Cost of production of seed cotton in Bahawalpur district (Rs/acre)

Operations	Small	Medium	Large	Overall
Cultivation cost	2000.69	2065.25	2085.68	2050.54
Sowing cost	1000.41	1049.16	1090.19	1046.58
Fertilizer cost	1700.02	2110.75	2660.45	2175.07
Irrigation cost	1800.07	1980.12	2020.06	1933.41
Interculture	2060.42	1820.15	1830.77	1903.78
Plant protection cost	3200.99	3480.59	3940.26	3540.61
Labor cost	3200.51	3260.07	3630.18	3363.58
Rent	6000	6000	6000	6000
Total cost per acre	20963.11	21766.04	23257.59	21995.58
Gross income	26852.02	28960.79	31324.60	29045.80
Net income per acre	5888.91	7194.75	8067.01	7050.22

The results show that in all categories of the farmers, cost of production of large farmers was higher over small and medium growers respectively. The net per acre return for medium and large farmer was higher than that of small farmers respectively. The small farmers suffered due to the scarcity of inputs and lack of adoption of advanced technologies.

(2) Cultivation cost

Coefficient for the variable of cultivation has positive relation between yields i.e. dependant variable and the number of cultivations. It shows that yield value per acre would increase if we increase the cultivation cost. This variable is found highly significant and has strong impact on cotton yield.

(3) Seed cost

The importance of seed in the cotton production is widely accepted. It has been proved through various studies that the role of seed in the cotton production is very significant. The data results for the district of Bahawalpur depicts that cotton production on per acre basis can be increases by increasing the expenditure on seed. The coefficient for this variable is statistically significant. The expenditure on seed means use of good quality seed and improved methods of sowing.

(4) DAP fertilizer

This is one of the important components of fertilizer. This component is mostly being used by the cultivators prior to germination of crop. DAP fertilizer is playing very important role in the cotton yield as it has been realized that it provides the support to the fruit of the plant. The dependent variable response to this variable is estimated as the cotton yield in rupees will be increases if there will be an increase in the use expenditure on DAP fertilizer. Statistically this variable is found highly significant showing the strong impact on cotton yield in the district of Bahawalpur.

(5) This is the second important component of fertilizer. It is the nitrogenous fertilizer and was found responsible for the vegetative growth of the plant. Farmers were found using this component of fertilizer after the germination of plant. In the district of Bahawalpur, this variable has also a huge significance, due to increase and proper use of urea fertilizer, cotton yield in this district is increasing.

(6) Irrigation

Irrigation means to apply water to the crop through different sources. Keeping in view the importance of this factor, farmers were found using different sources of irrigation. By increasing expenditure on irrigation, cotton yield could be increases. Statistically it also has huge significance. This variable has maximum importance as compared to other variables. Irrigation water and poor land quality weedicide cost and fertilizer are important constraints that affect badly crop productivity. The good management of these variables could increase production [8].

(7) Plant protection

Cotton crop is very sensitive to pests and diseases. In order to control the attack of pests and diseases farmers were using heavy pesticides. So the role of this factor is also important in the cotton production. Like other factors, the factor, productivity for this variable is also estimated, that cotton income on per acre basis could be increases in the district Bahawalpur by increasing the expenditure on plant protection. This factor is also playing very important role in the cotton production in the district of Bahawalpur.

(8) Hoeing

In the study area, most farmers were found practicing the intercultural practices to their crops. Most of the small farmers are doing this practice manually, while others are doing it mechanically. It is also a realized fact that intercultural practices plays important role in the cotton yield. This factor is also included in the model. it is also an important factor which plays a significant role to enhance the cotton production.

(9) Yield

Yield represented per acre cotton production. Yield levels for the different class of growers are given in Fig. 64.2 which describes that yield on per acre basis is increasing as the size of holding increased. It was found that 22.5%, 25%, and 28.5% (40 kgs per acre) are for small, medium and large farmers respectively in the study area.

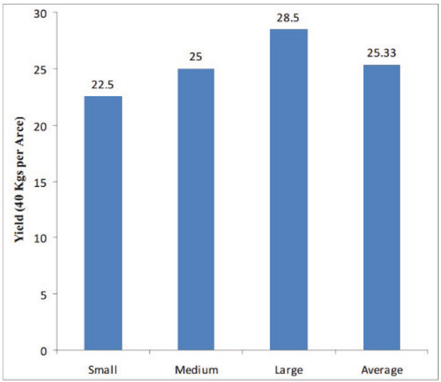


Fig. 64.2 Seed cotton yield in Bahawalpur district

Data Table 64.2 shows that yield on per acre basis is increasing as the size of holding increases. Results display that the large farmers are effective growers in district Bahawalpur. It is mainly due to the reason that large farmers have more technology and resource as compared to small and medium farmers.

(10) Cost benefit ratio

The cost benefit ratio for different categories of farmers is shown in Table 64.2.

Table 64.2 Cost-benefit ratio of cotton (per acre basis) in Bahawalpur district

Description	Gross income (Rs)	Total cost (Rs)	Net income (Rs)	Cost benefit Ratio
Small farmers	26852.02	20963.11	5888.91	1.28
Medium farmers	28960.79	21766.04	7194.75	1.33
Large farmers	31324.60	23257.59	8067.01	1.35
Overall farmers	29045.80	21995.58	21150.67	1.32

The analysis in Table 64.2 shows that cotton is more economical for the large farmers as CB ratio was maximum (1.35) as compared to medium (1.33) and small (1.28) growers.

64.5 Conclusion and Suggestions

There are many factors that effect the cotton production. In this paper we considered some important factors which have huge impact on cotton productivity. There are many factors which contribute towards higher output of cotton. In this study we concluded that there is need to enhance the resources to increase the production. Some major inputs contributing in higher yield of cotton are availability of resources, technology, water and important fertilizers. This study shows the average yield is going to increase as the size of land is increasing. It means the large farmer can get more out put than the small farmer, because large farmer is more resource and technology oriented than small farmer. So there is need to solve some important problem which can be cause of low yield. One of most important factor of low yield is lack of education in the farmers. Education plays a vital role to enhance the production. But unfortunately most of the farmers are illiterate and do not have enough knowledge and experience to tackle the problems and to enhance the yield. Second important this is preparation of land for production. It plays main role in production of any crop, cotton is a deep rooted and heavy feeding crop. It thus needs deeply tilled and well prepared soil but unluckily many farmers can not do this job in efficient way due to lack of knowledge and lack of resources. Irrigation is also one of important factor in cotton production as one% increase in number of irrigation could enhance yield of cotton crop up to 0.101%. Seed rate determines the plant population in a field. It is an important factor in determining yield. The coefficient of seed rate was positive, however, it was statistically nonsignificant. It may be due to the fact that the farmers were using seed according to recommended level. Accessibility of quality inputs such as seed, fertilizer, and their proper use play the a vital role in cotton productivity enhancement. Plant protection measures such as, hoeing and application of pesticide to control disease on cotton crop. Diseases on cotton crop is a growing problem in all cotton-growing areas of Pakistan. Effective plant protection measures increases cotton yield significantly. Proper and timely use of fertilizers contribute towards higher yield and the cotton growers could enhance their crop production. if above all variables could be manage and use properly the cost of production could be decreases and profit could be increases. This paper disclose that the small farmers, who are already resource deficient, cannot bear the burden of increasing cost of inputs. So, to overcome this problem the Government should provide subsidies on inputs for the small farmers, which will help to enhance cotton productivity, and improve the living standards of the small farmers.

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Chapter 65
An Inventory Control Model for Stone Industry under a Fuzzy Random Environment

Liming Yao, Jingjie Wang and Ling Wang

Abstract This paper proposes a bilevel optimization model with fuzzy random coefficients to tackle an inventory control problem for the stone industry with the aim of minimizing the inventory cost and the cost of quarrying and processing and ensuring meet the requirements of order. On the upper level, the goal of inventory department is to minimize the cost and inventory space at the same time. On the lower level, the quarrying management's aim is to minimize the cost of quarrying and processing and ensuring meet the requirements of order. A compromised point-based GA is proposed to solve the bi-level programming model with fuzzy random coefficients. Finally, a case study is presented to demonstrate the practicality and efficiency of the model.

Keywords Inventory control · Fuzzy random variable · Chance constraint · Genetic algorithm

65.1 Introduction

In recent years, the stone industry develops rapidly in China. Stone resources have been decreasing in the past time and they become rarer and rarer with the development of the stone industry. Generally speaking, the stone industry includes mining, geological exploration, transportation of raw materials, stone trade, stone processing, transportation of the product and sales installation and so on [1, 2]. Under the

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high demand of the stone resource, it gradually comes into a white-hot competition among stone enterprises. How to improve the competitiveness is the most immediate problem for the stone plant. Carrying out the scientific and technological research and focusing on scientific and technological innovation and progress to form the leading technology advantage and become a leading enterprise can improve the stone plant's competitiveness in some degree. On the other hand the management of investment and supply chain has an irreplaceable role for the development of the stone plant. How to control the inventory level and quantity effectively especially the cost and profit growth point is crucial for a stone plant facing such a cumbersome stone mining processing and an increasingly fierce competition [3].

As one of the most important link of the supply chain, inventory control is the process of management and control of all kinds of items, finished goods and other resources produced by manufacturing or service industry to keep it on economic reasonable level [5]. Inventory control is the method to control the inventory and get higher profit. It does its best to reduce the inventory levels, improve the efficiency of the logistics system and the market competitiveness of the enterprises through controlling the inventory level on the premise of meeting customers' service requirements [4]. Inventory control should consider several aspects, such as sales, delivery cycle, purchasing cycle, special requirements for special season and so on. Inventory control needs to record stock every time and have a function of making an inventory of goods in a warehouse by information means. The inventory value must be synchronization with the market price. We must have a production plan and arrange purchase according to production plan and purchasing cycle. Due to the special requirements and local conditions these variables often contain some uncertain factors and these goals and parameters are usually inaccurate such as fuzzy coefficients. If the goal is to pursue maximum profits and minimum inventory cost, the inventory cost and the price is not accurate. In these cases we need to consider put the fuzzy coefficients theories into the bi-level multi-objective inventory control in order to solve the problem more accurately [6, 10].

The following sections of this paper are organized as follows. In Sect. 65.2, the key problem about the bi-level structure and fuzzy random environment is described. A bi-level programming model with fuzzy random coefficients is developed in Sect. 65.3. In Sect. 65.4, a compromised point-based GA is proposed to solve the bi-level programming model with fuzzy random coefficients. In Sect. 65.5, a practical case is presented to show the significance of the proposed models and algorithms. Finally, conclusions are given in Sect. 65.6.

65.2 Key Problems Description

A bi-level optimization model is introduced to consider the inventory control by stone plants and the fuzzy coefficients product demand, production and inventory costs, etc.

65.2.1 Description of a Bi-level Structure

As shown in Fig. 65.1, the inventory control of stone resources is mainly under the charge of the mining department and retailing department. The mining department mainly mine different kinds of stone in mining area and delivery it to the warehouse after processing, while the distribution department is responsible for the transportation to different market according to the requirements. Due to the distribution department determines the sale of stone resources we consider it as the top decision makers, while the mining department is considered as the lower decision makers. Assume that a stone enterprise built a processing plant and the corresponding warehouse in a industrial park. There are many mining areas which can provide raw material for the enterprise, and their production capacity is different. For stone processing department, on the one hand, it need to transfer its product to amount of building materials market in accordance with the most reasonable route, and the most reasonable, namely the product storage must meet the demand of the market. On the other hand, considering the limited warehouse capacity, the storage fee and the product care costs will increase the company's total costs, warehouse department must make an appropriate inventory plan to decide the inventory of different products to meet the different demand of market for building materials.

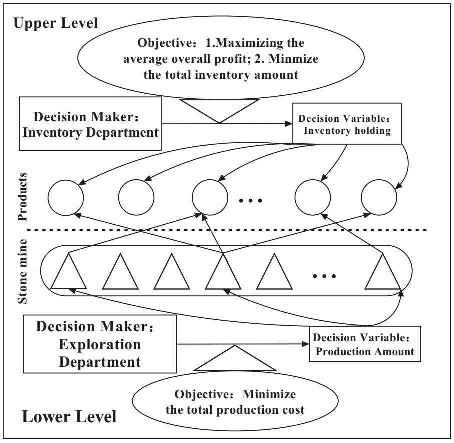

Fig. 65.1 Stone industry decision-making hierarchy

The mining department will formulate the corresponding mining plan when received the order form. Because of the large mining quantities and high equipment costs, if the exploited raw material cannot be bought by next buyers in time the company's operation cost will greatly increase. At the same time, the exploration of mine must meet the demand of stone processing enterprises. Because of the equipments, the texture of stone and other reasons, the mining efficiency of different mines is not consistent. Therefore the mining rate cannot exceed itself in the process of mining. In order to reflect the situation, we can use be used to solve the problem by bi-level model. The upper model identifies distribution planning for each stone material and the storage of stone resources products to ensure that the inventory cost and the inventory is the minimum; The lower model determines the best exploitation quantity for decision-making department of the company. It makes sure the lowest operation cost.

65.2.2 Fuzzy Random Environment

The source of the uncertainty mainly has three aspects in the supply chain of stone industry: the cost because of the mining and processing unit's variation; the punish coefficient of the stone plant's inventory; the market demand of the building materials. Stone mining, equipment failure and transportation delay often makes the mining uncertain. Uncertainty of stone processing plant mainly exists on the reliability of the production system, such as machine fault, executive deviation of plan, etc. So we usually find out the random law at first with the aid of sampling analysis on historical data when considering variable mining and processing costs. Then we can value it and form fuzzy random variable in the end with the help of experts' and production workers' experience.

Similarly, the cause of WIP inventory in the manufacturing process is the way of handling demand. Production planning is a kind of simulation to the production process based on the current production system and the future status. It is a management method which expresses simulation results in the form of plan and drives the production with plans. But the complexity of production process makes the plan can not reflect the enterprise's actual production condition and predict the change of the production environment accurately. It leads to deviation inevitably between plan and the actual execution. The effective measures of production control can correct the error in production in some degrees. But production control must base on real-time acquisition and processing of production information and make the information timely, accurately and quickly transformed into effective information for production control.

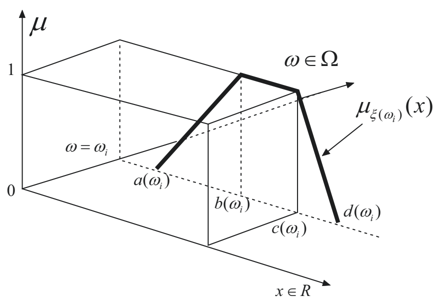

Fig. 65.2 A trapezoidal fuzzy random variable

The main reasons for the uncertainty of market demand are: the deviation of demand forecasting, purchasing power fluctuations, herd mentality and personality characteristics, etc. Usually there are some certain models or assumptions in methods of demand forecasting. Assumes that demand is in accordance with a certain law of operation and performance, but every prediction methods have some defects that cannot predict demand fluctuations and customers‘ psychological reaction precisely. Based on the three aspects of uncertainty above, using fuzziness instead of the specific data is the best way to obtain the closest to the target results. Fig. 65.2 shows a class of trapezoidal fuzzy random variables and the black line part is the membership function of trapezoidal fuzzy variable when the random variable is valued ω_i.

65.3 Model Building

Consider to build a bi-level model about inventory control of the stone enterprise under a fuzzy random environment. The mining department is the lower decision makers while the sales department is the upper decision makers. Due to the stone resource inventory control is relatively complex and it has some uncertain environment problem, we must make the following basic assumptions in order to establish the mathematical model:

- The corresponding inventory costs exist once the stone resource is transported into warehouse.
- There are multiple stone mining areas and each mine mainly output one kind of stone resource.
- There are multiple sales markets of stone resource, and each market may sell different kinds of stone resource.
- The market demand for stone resource and mining and processing costs of all kinds of stone resource is uncertain. It can be described by fuzzy random variables.

Indices

i : index of mining area, $i = 1, 2, \cdots, m$;
j : index of warehouse, $j = 1, 2, \cdots, n$;
k : index of stone resource products;
f : index of mining equipment;
r : index of stone resource types.

Parameters

C_{rfi} : the mining and processing costs when the stone products r is exploited with mining equipment f in the mining area i;
$\tilde{\tilde{V}}_{ri}$: the variable mining and processing costs when the stone products r is exploited in the mining area i;

tr_{rij} : the unit transportation cost of stone resource products r from mining area i to the inventory warehouse j;
tr_{rjk} : the unit transportation cost of stone resource products from inventory warehouse j to the stone market k;
h_{rj} : the unit inventory cost of stone resource products r in warehouse j;
$\tilde{\bar{\zeta}}_{rj}$: the penalty cost of stone resource products‘ r safety stock in inventory warehouse j;
$b_{rj}^{\min}$: the minimum safety stock of stone resource products r in inventory warehouse j;
$b_{rj}^{\max}$: the maximum safety stock of stone resource products r in inventory warehouse j;
$\tilde{\bar{Q}}_{kr}$: the market demand k of stone resource products r;
θ_{ij} : transformation rate when plant i produces product j.

Decision variables

Y_{ij} : the number of stone resource from the mining area i to the warehouse inventory j;
X_{jk} : the number of stone resource from inventory warehouse j to the stone market k;
λ_{rfi} : a binary variable; $\lambda_{rfi} = 1$ if the exploitation by equipment f of the stone plant r in mining area i, otherwise $\lambda_{rfi} = 0$.

65.3.1 Model Formulation

The bi-level multiobjective optimization model under a fuzzy random environment can be mathematically formulated as follows.
(1) Upper level

The sales department of stone plant is mainly responsible for the transportation of kinds of stone resource from inventory warehouse to the corresponding sales market according to different demand. And try to avoid the occurrence of inventory shortage. Decisions of sales department will base on the decisions of mining department. For example, decision of inventory strategy is based on the mining results. However sales department is the main control unit. It relates to whether the stone resource can meet the needs of market and this is the highest goal of the whole supply chain.
Objective function

The goal of sales department is to minimize the cost and inventory space at the same time. We use H to represent the upper decision maker‘s target namely minimizing total cost. We can know the target is consisted of cost of inventory, inventory punishment and transportation costs, etc. according to analysis.

As the upper decision makers, the sales departments’ goal is composed by three parts namely inventory costs, inventory penalty costs and transportation costs. The mathematical expression is as follows,

$$\sum_{i=1}^{I}\sum_{j=1}^{J}\sum_{r=1}^{R} h_{rj}Y_{rij} + \sum_{i=1}^{I}\sum_{j=1}^{J}\sum_{r=1}^{R} \tilde{\bar{\zeta}}_{rj}\left(\max\left\{0, \left(Y_{rij} - X_{rjk} - b_{rj}^{\min}\right)\right\}\right)$$
$$+ \sum_{i=1}^{I}\sum_{j=1}^{J}\sum_{r=1}^{R} X_{rjk}tr_{rjk}.$$

Since there are uncertain parameters in the objective function, namely fuzzy random variables $\tilde{\bar{\zeta}}_{rj}$ (inventory penalty coefficient), decision makers will be difficult to obtain the minimal cost accurately. Therefore, the decision makers usually only consider the average minimum cost based on the definition of fuzzy random expected value by Xu and Zhou [7] as follows,

$$\begin{aligned} \min H = \ & E\left[\sum_{i=1}^{I}\sum_{j=1}^{J}\sum_{r=1}^{R} h_{rj}Y_{rij} + \sum_{i=1}^{I}\sum_{j=1}^{J}\sum_{r=1}^{R} \tilde{\bar{\zeta}}_{rj}\left(\max\left\{0, \left(Y_{rij} - X_{rjk} - b_{rj}^{\min}\right)\right\}\right)\right. \\ & \left. + \sum_{i=1}^{I}\sum_{j=1}^{J}\sum_{r=1}^{R} X_{rjk}tr_{rjk}\right]. \end{aligned} \tag{65.1}$$

Constraints

• the inventory level can meet basic inventory requirements, namely, all kinds of all kinds of stone resource products can supply the market at any time.

$$\sum_{j=1}^{J} X_{rjk} \geq E_d\tilde{\bar{Q}}_{kr}. \tag{65.2}$$

Because the market has great volatility and it is decided by many uncertain factors. The market demand $\tilde{\bar{Q}}_{kr}$ usually has objective randomness and subjective fuzziness at the same time. It is get by industry professionals according to market analysis. Therefore it is difficult to guarantee its founding precisely because of the constraints above. But decision makers often want to satisfy the above condition as far as possible.

$$Ch\left\{\sum_{j=1}^{J} X_{rjk} \geq E_d\tilde{\bar{Q}}_{kr}\right\}(\theta) \geq \delta, \tag{65.3}$$

where θ expresses the possibility of meeting the constraint condition hold by decision makers. δ expresses the probability of meeting the condition itself according to survey of market environment. According to the fuzzy probability measure [7], the constraints are converted to as follows:

$$Pr\left\{Pos\left\{\sum_{j=1}^{J} X_{rjk} \geq E_d\tilde{\bar{Q}}_{kr}\right\} \geq \theta\right\} \geq \delta. \tag{65.4}$$

• The freight volume of all kinds of stone resource products from warehouse to the market is not less than 0, namely, $X_{rjk} \geq 0,\ \forall r \in R, j \in J, k \in K$.

(2) Lower level

The sales department of the stone plant is mainly responsible for whether to quarry a certain type of stone resource or not and deciding how much stone resource should be transported to the corresponding inventory warehouse. Of course, the decision of quarrying department also is affected by the decision of sales department. For example, the quarrying quantity of a certain type of stone resource also depends on the current inventory of this kind of stone resource.

Objective function

The quarrying management's aim is to minimize the cost of quarrying and processing and ensuring meet the requirements of order. We found the total cost of the lower decision target is consisted of several parts: the variable cost of quarrying and processing, the fixed cost of quarrying and the transportation cost of stone resource from the mining area to the corresponding inventory warehouse.

As the quarrying department of stone-material plants, the overall cost (it consists of the variable cost of quarrying and processing, the fixed cost of quarrying and the transportation cost of stone resource from the mining area to the corresponding inventory warehouse) they have to consider can be represented as follows,

$$\sum_{i=1}^{I}\sum_{f=1}^{F}\sum_{r=1}^{R} C_{rfi}\lambda_{rfi} + \sum_{i=1}^{I}\sum_{f=1}^{F}\sum_{r=1}^{R} \tilde{\bar{V}}_{ri} Y_{rij} \sum_{i=1}^{I}\sum_{j=1}^{J}\sum_{r=1}^{R} tr_{rij} Y_{rij}. \tag{65.5}$$

Due to uncertain parameters in the objective function, namely the fuzzy random variable $\tilde{\bar{V}}_{ri}$(unit variable cost of quarrying and processing), policy makers are hard to obtain the smallest cost accurately. For the cost of quarrying department, the decision makers of stone-material plants usually have a quarrying and processing budget $\bar{f}_1$. Because the cost of unit change in quarrying and processing is uncertain, decision makers usually want to control it within the budget as far as possible [7], namely the greatest relative chance. So the above target can be expressed as follows,

$$\max\{\alpha\}, \tag{65.6}$$

subject to

$$\begin{aligned} Ch\Bigg\{&\sum_{i=1}^{I}\sum_{f=1}^{F}\sum_{r=1}^{R} C_{rfi}\lambda_{rfi} + \sum_{i=1}^{I}\sum_{f=1}^{F}\sum_{r=1}^{R} \tilde{\bar{V}}_{ri} Y_{rij} \\ &+ \sum_{i=1}^{I}\sum_{j=1}^{J}\sum_{r=1}^{R} tr_{rij} Y_{rij} \le \bar{f}_1 \Bigg\}(\beta) \ge \alpha, \end{aligned} \tag{65.7}$$

where $\bar{f}_1$ is the production budget. This defined objective function means it can get the maximize probability α which can make the mining cost less than the budget.

Constraints

• The quantity of stone resource transported to inventory warehouse should be less than or equal to the maximum capacity of stock warehouse. At the same time, the quantity of transport stone resource must less than or equal to the quantity of quarrying. Its constraints can be expressed as follows,

$$\sum_{k=1}^{K} X_{rjk} \le \sum_{i=1}^{I} Y_{rij} \le b_{rj}^{\max}. \tag{65.8}$$

• The quantity of stone resource transported to inventory warehouse should be larger than or equal to 0, namely,

$$Y_{rij} \ge 0. \tag{65.9}$$

(3) Bi-level model

The upper decision makers and lower level decision makers need to consider both the goals and constraints, then change their information and make decisions aiming at bi-level system of sales and quarrying department of the stone-material plants. Therefore, we can get the following bi-level multi-objective programming model with fuzzy random coefficients as follows,

$$\begin{cases} \min H = E\left[\sum_{i=1}^{I}\sum_{j=1}^{J}\sum_{r=1}^{R} h_{rj}Y_{rij} + \sum_{i=1}^{I}\sum_{j=1}^{J}\sum_{r=1}^{R} \tilde{\bar{\zeta}}_{rj}\left(\max\left\{0, \left(Y_{rij} - X_{rjk} - b_{rj}^{\min}\right)\right\}\right)\right. \\ \qquad\qquad \left. + \sum_{i=1}^{I}\sum_{j=1}^{J}\sum_{r=1}^{R} X_{rjk}tr_{rjk}\right], \\ \text{s.t.} \begin{cases} Pr\left\{Pos\left\{\sum_{j=1}^{J} X_{rjk} \ge E_d\tilde{\bar{Q}}_{kr}\right\} \ge \theta\right\} \ge \delta, \\ X_{rjk} \ge 0,\ \forall r \in R, j \in J, k \in K, \\ \max_{y,\lambda}\{\alpha\}, \\ \text{s.t.} \begin{cases} Ch\left\{\sum_{i=1}^{I}\sum_{f=1}^{F}\sum_{r=1}^{R} C_{rfi}\lambda_{rfi} + \sum_{i=1}^{I}\sum_{f=1}^{F}\sum_{r=1}^{R} \tilde{\bar{V}}_{ri}Y_{rij} \right. \\ \qquad \left. + \sum_{i=1}^{I}\sum_{j=1}^{J}\sum_{r=1}^{R} tr_{rij}Y_{rij} \le \bar{f}_1\right\}(\beta) \ge \alpha, \\ \sum_{k=1}^{K} X_{rjk} \le \sum_{i=1}^{I} Y_{rij} \le b_{rj}^{\max}, \\ Y_{rij} \ge 0, \\ \lambda_{rfi} \in \{0,1\},\ \forall i \in I, j \in J, f \in F, r \in R. \end{cases} \end{cases} \end{cases} \tag{65.10}$$

65.4 Solution Approach

In some cases, the membership function of fuzzy random variable $\tilde{\bar{\zeta}}_{rj}, \tilde{\bar{V}}_{ri}, \tilde{\bar{Q}}_{kr}$ is difficult to determine and the objective function also contains a nonlinear function of $\max\left\{0, \left(Y_{rij} - X_{rjk} - b_{rj}^{\min}\right)\right\}$. So it is difficult to acquire the model (65.10) clearly by change of equivalent form. It is almost impossible to solve it by traditional methods. We can design a genetic algorithm based on fuzzy random simulation (Fu-

Ra-GA) aiming at the situation that it is hard to change to clear equivalent model (65.10). First of all, we should abstract the model (65.10) to the general mathematical model as follows,

$$\begin{cases} \max\limits_{x}[E[F_1(x,y,\xi)],E[F_2(x,y,\xi)],\cdots,E[F_m(x,y,\xi)]], \\ \text{s.t.} \begin{cases} Pr\{Pos\{G_r(x,y,\xi)\leq 0\}\geq\theta_1\}\geq\delta_1, r=1,2,\cdots,p_1, \\ x\geq 0, \\ \text{where } y \text{ is solved by} \\ \begin{cases} \max\limits_{y}\{\alpha\}, \\ \text{s.t.} \begin{cases} Pr\left\{Pos\left\{f(x,y,\xi)\leq\bar{f}\right\}\geq\beta\right\}\geq\alpha, \\ Pr\{Pos\{g_r(x,y,\xi)\leq 0\}\geq\theta_2\}\geq\delta_2, \\ y\geq 0. \end{cases} \end{cases} \end{cases} \end{cases} \tag{65.11}$$

The compromise method can overcome the difficulty through compromise solutions. For multi-objective programming problem, the ideal point or the positive ideal point $z^* = (z_1^*, z_2^*, \cdots, z_q^*)$ is defined as, $z_j^* = \sup\{f_j(x)|x \in S\}, j = 1,2,\cdots,q$, where S represents a feasible region of multi-objective programming problems. Because z^* usually cannot be achieved and if there is no other s alternative to solve the conflict between objectives, we have to compromise. Given a feasible solution $z \in Z$, the regret function can use the following distance function $r(z) = \|z - z^*\|$ to approximate.

If the importance of each target function is different the weight vector $w = (w_1, w_2, \cdots, w_q)$ can be assigned to signal different degrees of importance. Now there is the following weighted L_p-norm:

$$r(z,p,w) = \| z - z^* \|_{p,w} = \left[\sum_{j=1}^{q} w_j^p |z_j - z_j^*|^p\right]^{1/p}.$$

There is a special case that how to identify individual adaptive value according to multiple targets when using a genetic algorithm to solve multi-objective programming problem. Adaptive value distribution mechanism has been widely researched in the past 10 years and several methods have been proposed and tested. For example the vector evaluation method, the method of summing weight, the method based on Pareto, a compromise method and the goal programming method, etc.

Adaptive value distribution method based on compromise is proposed by Cheng and Cheng. This method can obtain a compromise solution rather than all the efficient solutions [12]. It is very difficult to ascertain the ideal point z^* of decision makers in a lot of complicated problems. Therefore Gen and Cheng introduced the concept of the proxy ideal point and use it to replace the real ideal point. The proxy ideal point is the corresponding ideal point in current generation instead of the ideal point of a given problem. Let P denotes the current set of chromosomes and the proxy ideal point $[z_1^{\max}, z_2^{\max}, \cdots, z_q^{\max}]$ can be defined as,

$$z_j^{\max} = \max\{z_j(x)|x \in P\},\ j = 1,2,\cdots,q.$$

The ideal point is easy to obtain in each generation. With evolutionary progress, the proxy ideal point will gradually approximate to the real ideal point. The smaller the individual regret value is the better. so we need to transform the regret value into adaptive value to ensure that the excellent individual has higher adaptive value. Let $r(x)$ denote the regret value of individual x, $r_{\max}$ the maximal regret value, and $r_{\min}$ the minimum regret value in the current generation. The transformation is given as follows:

$$\mathrm{eval}(x) = \frac{r_{\max} - r(x) + \gamma}{r_{\max} - r_{\min} + \gamma}.$$

The γ is positive real number and it is usually limited in the open interval $(0,1)$.

The genetic algorithm are given as follows [8, 9]:

Step 1. Initialize pop_size chromosomes $x^{(1)}, x^{(2)}, \cdots, x^{(pop\_size)}$ whose feasibility may be checked by fuzzy random simulation.

Step 2: Calculate the efficient solution $x^{(j)}$ of the lower decision makers for each feasible $y(x^{(j)})$.

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

Step 4. Compute the fitness of each chromosome on the basis of the regret value.

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

Step 6. Repeat the third to fifth steps for N times.

Step 7. Return to the best chromosome x^*.

Step 8. Calculate $y(x^*)$.

Step 9. Return $(x^*, y(x^*))$.

65.5 A Case Study

In the following sections, we will illustrate the complete modeling process and algorithm process with an example of a stone plant in the west and prove its effectiveness.

65.5.1 Data and Computation

The stone resource of Yingjing is mainly the granite. There is 10 billion cubic meters for the exploitation and it is mainly distributed in 7 towns. The Kaiquan has 5 exploitation right of mineral resources and it plan to set up inventory center in 3 parks which mainly shipped to Ya'an, Chengdu, Chongqing and Xi'an the four major sales market. Now, the company mainly produces natural granite plate, granite gravel and artificial composite material. Therefore, Kaiquan mainly products 4 kinds of stone resource products. Due to the different shape, material, processing procedure, transportation of all kinds of products, their various cost value is different. Table 65.1 lists the unit inventory cost of various types of products in 3 warehouses and the

Table 65.1 Transport cost from mine area to warehouse for stone products

Warehouse No.	Stone products	Mine area				
		Shizhi	Fengyi	Xinmiao	Sanhe	Xinjian
1 #	NPCC	85	86	43	40	88
	GSl	6.7	6.5	2.3	2.2	7.1
	GSa	1.2	1.5	0.3	0.2	1.6
	MmCS	1.8	2.0	1.0	0.8	2.2
2 #	NPCC	42	41	83	82	78
	GSl	2.1	2.0	6.2	6.8	5.8
	GSa	0.4	0.3	1.3	1.4	1.2
	MmCS	0.9	0.7	1.4	1.7	1.2
3 #	NPCC	80	83	81	82	42
	GSl	6.0	6.2	6.3	5.9	2.3
	GSa	1.2	1.3	1.2	1.1	0.3
	MmCS	1.6	1.5	1.7	1.5	0.6

NPCC=Nano Calcium Carbonates; GSl=Granite Slabs; GSa=Granite Sand; MmCS=Man-made Composite Slabs.

Table 65.2 Transport cost from warehouse to market for stone products

Warehouse No.	Stone products	Market			
		Ya'an	Chengdu	Chongqing	Xi'an
1 #	NPCC	164	268	285	364
	GSl	7	15	17	25
	GSa	4	13	14	18
	MmCS	6	15	17	24
2 #	NPCC	166	271	290	371
	GSl	6	13	15	24
	GSa	5	11	14	20
	MmCS	6	14	16	23
3 #	NPCC	163	265	283	367
	GSl	5	15	16	25
	GSa	7	12	13	21
	MmCS	5	13	17	25

Table 65.3 Demands of different markets $\tilde{\tilde{Q}}_{kr}$

Plants	DC			
	Ya'an	Chengdu	Chongqing	Xi'an
NPCC	$(\tilde{Q}_{11}$-10,$\tilde{Q}_{11}$,$\tilde{Q}_{11}$+20) $\tilde{Q}_{11} \sim N(150,10)$	$(\tilde{Q}_{12}$-25,$\tilde{Q}_{12}$,$\tilde{Q}_{12}$+20) $\tilde{Q}_{12} \sim N(420,20)$	$(\tilde{Q}_{13}$-30,$\tilde{Q}_{13}$,$\tilde{Q}_{13}$+25) $\tilde{Q}_{13} \sim N(450,30)$	$(\tilde{Q}_{14}$-25,$\tilde{Q}_{14}$,$\tilde{Q}_{14}$+22) $\tilde{Q}_{14} \sim N(550,30)$
GSl	$(\tilde{Q}_{21}$-3,$\tilde{Q}_{21}$,$\tilde{Q}_{21}$+5) $\tilde{Q}_{21} \sim N(35,1)$	$(\tilde{Q}_{22}$-11,$\tilde{Q}_{22}$,$\tilde{Q}_{22}$+15) $\tilde{Q}_{22} \sim N(112,5)$	$(\tilde{Q}_{23}$-8,$\tilde{Q}_{23}$,$\tilde{Q}_{23}$+9) $\tilde{Q}_{23} \sim N(135,6)$	$(\tilde{Q}_{24}$-7,$\tilde{Q}_{24}$,$\tilde{Q}_{24}$+8) $\tilde{Q}_{24} \sim N(105,9)$
GSa	$(\tilde{Q}_{31}$-5,$\tilde{Q}_{31}$,$\tilde{Q}_{31}$+6) $\tilde{Q}_{31} \sim N(58,4)$	$(\tilde{Q}_{32}$-3,$\tilde{Q}_{32}$,$\tilde{Q}_{32}$+8) $\tilde{Q}_{32} \sim N(25,1)$	$(\tilde{Q}_{33}$-2,$\tilde{Q}_{33}$,$\tilde{Q}_{33}$+6) $\tilde{Q}_{33} \sim N(32,2)$	$(\tilde{Q}_{34}$-3,$\tilde{Q}_{34}$,$\tilde{Q}_{34}$+5) $\tilde{Q}_{34} \sim N(15,2)$
MmCS	$(\tilde{Q}_{41}$-12,$\tilde{Q}_{41}$,$\tilde{Q}_{41}$+18) $\tilde{Q}_{41} \sim N(85,4)$	$(\tilde{Q}_{42}$-15,$\tilde{Q}_{12}$,$\tilde{Q}_{42}$+23) $\tilde{Q}_{42} \sim N(142,6)$	$(\tilde{Q}_{43}$-12,$\tilde{Q}_{43}$,$\tilde{Q}_{43}$+22) $\tilde{Q}_{43} \sim N(158,10)$	$(\tilde{Q}_{44}$-15,$\tilde{Q}_{44}$,$\tilde{Q}_{44}$+21) $\tilde{Q}_{44} \sim N(105,6)$

penalty coefficient when the inventory level is not conformity with the provision. The penalty coefficient is fuzzy random variables. Table 65.1 and Table 65.2 lists the unit freight fee of 4 kinds of products from the stone mining area to warehouse and from the warehouse to market. Table 65.3 lists the number of market demand of 4 kinds of products and the quantity of demand is fuzzy random variables.

Put the values into the bi-level multi-objective programming model with fuzzy random coefficients ECDC mentioned in the front part and solve it with a genetic algorithm based on fuzzy random simulation. The algebra of fuzzy random simulation expected value is 500. The algebra of fuzzy random related chance constrained simulation is 500. The algebra of fuzzy random related chance simulation is 1000. The algebra of genetic algorithm is 500. The upper and lower level‘s initial population size is 20. The crossover probability is 0.4 and the mutation probability is 0.6. For the sake of convenience, all the upper and lower confidence levels is set to a value of 0.85.

65.5.2 Result Analysis

When the confidence level value is 0.6, the total production of quarrying department is 70000 m^3. The primitive chance that the quarrying department does not exceed the cost budget is 0.92 and the specific decision scheme is in Table 65.3. The primitive chance that every department does not exceed the initial budget is 0.82. The primitive chance of ideal values is 0.56, 0.68, 0.86, 0.65, 0.76, 0.78. When the confidence level value is 0.7, the total production of quarrying department is 68000 m^3. The primitive chance that the quarrying department does not exceed the cost budget is 0.77. The primitive chance of ideal values is 0.52, 0.65, 0.81, 0.61, 0.70, 0.72. It can be seen from Table 65.4 that with the increase of the confidence level, the feasible region is decrease and the optimization effect is poor. This also reflects a fundamental truth that the income of taking conservative strategy is relatively low.

Table 65.4 The optimal solution when the confidence level is 0.6

	Shizhi	Fengyi	Xinmiao	Sanhe	Xinjian
NPCC	400	365	–	280	626
GSl	260	170	397	–	870
GSa	88	87	127	114	–
MmCS	35	66	103	102	–

65.6 Conclusions

In this paper, we have developed a bi-level optimization model with chance constraints under the fuzzy random environment. In the model, the inventory department is considered as the leader level for minimizing the inventory level and then exploration department is considered as the follower level for minimizing the cost of quarrying and processing and ensuring meet the requirements of order. Then we propose an algorithm GA to solve the model. Finally, a practical case proves that the proposed model and algorithm are efficient.

Although the model proposed in this paper should be helpful for solving some real-world problems, it is only dealt with by the chance constraints. If DM has different purposes such as maximizing the possibility that the predetermined goals are achieved, we can apply dependent-chance constraint to deal with it. In further research to be under taken, a detailed analysis will be given.

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